ABSTRACT

THE DEVELOPMENT OF AN EVALUATIVE INSTRUMENT FOR SELECTING INNOVATIONS AND THE TESTING OF THIS INSTRUMENT BY COMPARING THE OPERATIONAL OBJECTIVES OF THE SCIENCE FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS AND THE STATED OBJECTIVES OF INTRODUCTORY PHYSICAL SCIENCE

By

Margaret Annette James

Implicit in the wealth of new material being produced for the junior high school is the need for some viable decision-making process whereby an administrator can choose which of the many options open to him best fits the needs of his students. Organizations such as the ASCD, NASSP, and NSTA have published lists of criteria for judging new science programs. The NEA has challenged school systems to develop a framework for decision-making.

One of the state departments which has responded to this challenge is that of California, which has recently completed a study of the junior high schools in the state. In addition, a framework of science objectives in the California schools is being developed.

The research hypothesis of this study was: It is possible to develop an instrument for the pre-evaluation of innovative programs through the matching of the stated

objectives of a program against the framework of the criteria decided upon by a school system.

In order to test this theory, Science Framework for California Public Schools was examined and those objectives which were analogous to those which the Task Force for the Study of Junior High Schools of California had decided were of paramount importance were extrapolated and became the model for the instrument.

As an example of a new junior high school science program, Introductory Physical Science was arbitrarily selected and their general objectives were translated into operational form to make them isomorphic with those of the model.

This instrument was submitted to a jury of administrators who decided that the objectives of IPS met the criteria of the model. In summarizing the data, the jurors' decision leads to the conclusion that the instrument developed in the present study possesses judgmental validity and the rather favorable acceptance on the part of the jurors seems of proportions as to indicate that further experimental study and field testing are warranted, especially in other subject areas and with other models.

From the research and analysis of the data, a number of recommendations have emerged from this study:

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It is recommended that the new science "packages" for junior high school science be adopted where needed, if their objectives fit the criteria of the school system, as a stop-gap measure until a developmental, spiral, K-12 science program is available.

It is recommended that the writers of new curriculum material in all subject areas recognize the mandate for defining their objectives in specific behavioral terms in order to provide both internal validity for their programs and a means of pre-evaluating them. If this has not been done, it should be done ex post facto.

It is recommended that state departments and school districts define their objectives in operational terms in all subject fields and set up criteria for evaluating innovative programs. These goals should be defined by groups of teachers, curriculum specialists, administrators, and lay people and disseminated widely.

It is recommended that teachers play a more important role in the decision-making process.

It is recommended that teacher education institutions become more concerned with both pre-service and in-service education of junior high school teachers to help them become adapted to rapid change.

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It is recommended that more effective recruitment of junior high school teachers is also a responsibility of the teacher education institutions.

Finally, it is recommended that the National Science Foundation fund more summer and academic year institutes specifically planned to acquaint elementary and junior high school teachers with new programs.

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CHAPTER I

THE PROBLEM

The National Science Teachers Association publishes each year a bibliography of courses of study, textbooks, and curriculum projects in science.[1] The information, current as of November, 1967, shows approximately 142 different courses of study and curriculum projects for junior high school science have been published since 1962.

The problem confronting administrators, science curriculum coordinators, and science teachers in choosing a course of study that best fits the needs of their students is evident. Two contingent questions immediately come to mind: (1) Who has the time and energy to sift through this welter of material to make a decision? (2) What criteria should be used in discriminating between the many choices available? The "trial and error" method is too costly both in terms of money and staff and student energy. Faced with

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[1] National Science Teachers Association, Bibliography of Science Courses of Study and Textbooks for Grades 7-12 (Washington: The Association, 1968).

such a dilemma, many schools understandably are staying with the status quo or modifying existing programs.

For example, Conant found, in his 1966 survey,[2] that out of 2,023 medium-size comprehensive high schools reporting, 49.5 per cent were offering a program in "new" physics; 64.9 per cent in "new" biology; and 47.6 per cent in "new" chemistry. The remaining approximately one-half of the total schools responding had presumably either tried the new programs and discarded them or had not yet changed from the traditional course of study.

Fewer junior high schools than senior high schools had adopted the new science programs for seventh, eighth, and ninth grades, according to Gruhn's 1965 survey of the junior high schools.[3] In the approximately 1,227 schools responding, 289 schools offered general science in the seventh grade and 49, other science (14.5 per cent); in the eighth grade, 319 offered general science and 72, other science (18 per cent); while in the ninth grade, 30 schools had moved biology from the senior high school to the junior high school, 23 offered earth and space science, 26 had

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[2]James Bryant Conant, The Comprehensive High School: A Second Report to Interested Citizens (New York: McGraw-Hill, 1967), Appendix, Table III B, p. 89.

[3]William T. Gruhn and Harl R. Douglass, A Survey of Practices in Junior High School Education, II. Science (1965), p. 3. (Complete science survey is included in the Appendix to this study, pp. 122-123.)

chosen another new science program, and 105 were still offering the traditional general science (43 per cent).

One of the reasons senior high schools lead the junior high schools in adopting new science programs could be that the earliest efforts to upgrade the curriculum were aimed at the senior high schools. A supporting factor is that the physics, chemistry, and biology projects have benefited from training programs for senior high school teachers in the form of summer or academic year institutes which are financed by the National Science Foundation. The Physical Science Study Committee (PSSC) has had four thousand teachers trained in its program in six years; one thousand teachers have been trained in Biological Sciences Curriculum Study (BSCS) in three years. Ralph Tyler, in 1964 the Director of the Center for Advanced Study in the Behavioral Sciences at Stanford, estimated that the federal government had spent or committed up to that time $200 million to support summer institutes where science teachers could increase their training in modern science.[4] Projecting this figure to the present time, it can be estimated that the cost to the American taxpayers has been about $500 million. To this should be added the $100 million which the National Science

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[4]Ralph W. Tyler, "Forces Redirecting Science Teaching," in Revolution in Teaching: New Theory, Technology, and Curricula, ed. by Alfred de Grazia and David A. Sohn (New York: Bantam Books, 1964), pp. 187-188.

Foundation has testified to having contributed to the national curriculum projects in eleven years.[5]

Until recently, junior high school teachers who attended such institutes were there to upgrade their knowledge or to familiarize themselves with the "new" chemistry, physics, or biology projects. Few institutes, other than those in earth science, are designed specifically to aid junior high school teachers in making a choice from among the new programs available or to help them implement one in their schools.

A cursory look at the 1968 list of summer institutes[6] bears out this fact. Out of 242 summer institutes offered, fifty-five are in earth science and only eleven offer either a specific junior high school project, such as Introductory Physical Science (IPS) or a potpourri.

Without the help of junior high school teachers, many of whom have neither the knowledge nor the time to sift through the literature of science projects, the decision has fallen by default to the curriculum coordinator or administrator and the second question raised earlier assumes

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[5] Joe L. Evens, Chairman, Hearings before a Subcommittee on Appropriations, House of Representatives, 89th Congress, Independent Offices--Appropriations for 1967, National Science Foundation (Washington: U.S. Government Printing Office, 1966), Doc. #6-473, pp. 234-235.

[6] National Science Foundation, Summer Institutes for Secondary School Teachers of Science and Mathematics, 1968 Directory (Washington: The Foundation, December 1967).

greater importance: On what basis should a decision be made?

Need

Evidence of a need for some instrument to assist in decision-making can be read into the concern of professional organizations such as the Association for Supervision and Curriculum Development (ASCD),[7] the National Association of Secondary School Principals (NASSP),[8] and the National Science Teachers Association (NSTA),[9] all of which have recently published lists of criteria for judging new science curricular programs.

The National Education Association (NEA) has shown its deep concern about the many innovations and the decision-making process. In a recent article, the NEA raises the question:

> Is the innovation in line with the goals of the school system? In all too many school systems this question may receive little attention. But emphasis on categorical goals, although not new, is gaining recognition from educators. The reason for this is simple: Until a task has been defined, one cannot effectively develop procedures and practices to accomplish it.

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[7]Richard E. Haney, The Changing Curriculum: Science (Washington: ASCD, 1966), p. 36.

[8]Gordon F. Vars, ed., Guidelines for Junior High and Middle School Education: A Summary of Positions (Washington: NASSA, 1966), pp. 4-8.

[9]Summary Report NSSA-NSTA Workshops on Behavioral Objectives (Washington: The Associations, 1967), pp. 1-33.

> School systems should list goals and develop a framework for innovative decision making. Within this framework, teachers can measure each innovation in terms of its prospective effectiveness as it relates to the objectives and procedures defined by the school system.
>
> The teacher must know the goals as well as the framework, and he must have a voice in their implementation.[10]

The State of California, with which this study is concerned, has sponsored a survey of California's junior high school programs. The committee charged with this task by the State Department of Education made specific recommendations based on the needs of today's adolescents. These recommendations,[11] which are discussed in Chapter III of this study, form the system within which the framework of the model used in this study is constructed. A revision of the Junior High School Handbook is now being prepared under the direction of W. Earl Sams, Consultant in Secondary Education, Bureau of Educational Programs and Subject Specialists for the California State Department of Education.

The model for this study is a preliminary edition of a framework for science in the California public schools which is being prepared by the State Advisory Committee on

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[10]National Education Association, "Framework for Developing Criteria," Special Journal feature on educational decision-making, NEA Journal, LVI (December, 1967), 26-28.

[11]California State Department of Education, How Can Tax Dollar$ Make Good Adolescents? A Report on a Study of California's Junior High School Programs, ESEA Title V-826 (Sacramento: The Department, June 1966).

Science Education.[12] The Committee defines the objectives of the ideal junior high school science program in operational terms and also suggests criteria for the selection of a new program.

A search of the literature also reveals the concern of the United States Office of Education (USOE) in its funding of university studies to find some viable means for helping secondary school administrators choose the new program which best fits the needs of their students. One project which parallels this study is being conducted at Rutgers University by Bruce W. Tuckerman.[13] The USOE has also published two checklists for pre-evaluation of science programs.[14]

The Center for Urban Education, New York City, is supporting a parallel study in evaluating programs for

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[12] California State Department of Education, Science Framework for California Public Schools, Preliminary (Sacramento: The Department, 1968), pp. 42-46.

[13] Bruce W. Tuckerman, The Development and Testing of an Evaluation Model for Vocational Pilot Programs, Preliminary Report of Progress, Rutgers University, New Brunswick, N.J., April, 1967, Grant OEG-1-7-008355-2039; abstracted in ERIC (April, 1968), ED 014 567.

[14] Evidences of a Good Science Program, prepared by Specialists for Science, Elementary and Secondary Education, Bureau of Educational Research and Development (Washington: U.S. Department of Health, Education, and Welfare, Office of Education, September 1963); and A Suggested Checklist for Assessing a Science Program, Report No. OE-29034-A (Washington: USOE, January 1964).

disadvantaged students.[15] A concern for choosing a suitable program for the gifted child motivated a similar study by Joseph S. Renzulli of the University of Connecticut.[16]

Another study was done by Metfessel and Michael, whose purpose was to develop an eight-step procedural outline of the evaluation process in the form of a flow chart and to furnish a detailed listing of multiple criterion measures that may be used in the evaluation of specific behavioral objectives. The first is a model which can be followed in evaluation of school programs and the latter has potential utility in the instrumentation phase of the evaluation process.[17]

Finally, John W. Lombard and William B. Owen have compiled a guide to the development of an assessment program in science education which was prepared for the Exploratory Committee on Assessing the Progress of Education, in which they list the desired goals of science education in the form

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[15] Charles M. Long, Project To Develop a Curriculum for Disadvantaged Students in Intermediate (Middle) Schools (New York: Center for Urban Education), abstracted in ERIC (October, 1967), ED 011 534.

[16] Joseph S. Renzulli, "The Evaluation of Programs of Differential Education for the Gifted," abstract of a doctoral dissertation completed in August 1966, Education Review, V (1967), 45-48.

[17] Newton S. Metfessel and William B. Michael, "A Paradigm Involving Multiple Criterion Measures for the Evaluation of the Effectiveness of School Programs," Educational and Psychological Measurement, XXVII (Winter, 1967), Part 2, pp. 931-943.

of behavioral objectives.[18]

These examples which are reviewed in Chapter II of this study point to a growing awareness on the part of professional organizations, State Departments of Education, the USOE, local school districts, colleges and universities, and individuals that something must be done to develop an instrument for curricular choice.

Purpose

The purpose of this study is to develop and test an instrument for the selection of a junior high school science program.

Implications of the Study

Through the development of the instrument, it is hoped that this study might prove useful to administrators in their selection of a pilot program at any level and in any subject matter area; to State Departments of Education (especially that of California) and local school districts who are setting up criteria for judging innovations.

The method used in the instrument, matching the behavioral goals of the innovative program against the criteria of the school system, should indicate to those who are responsible for determining these criteria the need for

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[18]John W. Lombard and William B. Owen, The Objectives of Science Education (Chicago: Science Research Associates, Inc., December 1965), pp. 1-22 and bibliography.

specificity if the goals are to be useful. The method should also demonstrate to those committees who are now in the process of developing new programs in any subject area the need to first identify their goals in specific behavioral terms before writing begins. In cases where this has not been done, as with IPS, translation of general objectives into behavioral terms should be done ex post facto.

Through the testing of the method, using IPS as an example, it is hoped that this study might prove useful to administrators of junior high school science who might be considering this particular program for their schools; to school districts (especially those in the Bay Area, California) who may wish to consider the introduction and implementation of IPS in their junior high schools; to the Far West Regional Laboratory, Berkeley, California, which is concerned with the dissemination of information about IPS; as well as to teachers who might want to know more about the project.

Methodology

This study will develop an instrument for the pre-evaluation of innovations prior to their adoption in the schools. The method used will be the matching of the stated objectives of the new project against the framework of the criteria decided upon by a school system.

The method used for testing this evaluative instrument is the system-theory model which was used by Eichorn in his construction of a theoretical model of a middle school to meet the changing needs of adolescents.[19] The model used in testing this instrument is built from the stated operational objectives for the science programs of the junior high schools in the Bay Area, California, as they relate to the broader objectives of the California junior high schools. The new science project used in this test is the IPS program.

The source of the data is a jury, composed of school administrators from a random variety of school districts, who are judging the two sets of objectives. Members of the jury number seventy-two.

The procedure for collecting the data is to send the materials to the directors of seminars for science supervisors and conferences of school principals. The materials (samples of which are found in the Appendix) consist of:

Cover letter sent with the instrument, p. 124.

Professional Data Sheet (to test demographic hypotheses), p. 126.

A Ballot on which the juror indicates whether the objectives of Y SCIENCE PROGRAM meet each of the four criteria of X DISTRICT, p. 127.

The criteria for selection of a science program for the junior high schools of X DISTRICT (The Model - Bay Area, California), p. 128.

The objectives of Y SCIENCE PROGRAM (IPS), p. 131.

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[19]Donald H. Eichorn, The Middle School (New York: The Center for Applied Research in Education, Inc., 1966).

The data are interpreted in this manner: (1) the main hypotheses are tested by an analysis of jury ballots; (2) the demographic hypotheses are analyzed by inspection. Recommendations are made on the basis of both research and analysis of the data.

Main Hypotheses

H_1 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal I of the model (SCHOOL DISTRICT X).

H_2 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal II of the model (SCHOOL DISTRICT X).

H_3 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal III of the model (SCHOOL DISTRICT X).

H_4 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal IV of the model (SCHOOL DISTRICT X).

Demographic Hypotheses

H_a The age of the juror is related to his decision.

H_b The sex of the juror is related to his decision.

H_c The degree held by the juror is related to his decision.

H_d The title of the juror is related to his decision.

H_e The number of years a juror has held his present position is related to his decision.

H_f The number of graduate courses he has taken in administration, curriculum, or physical science is related to the juror's decision.

H_g His past experience in education is related to a juror's decision.

H_h His school's enrollment is related to a juror's decision.

H_i The percentage of his student body who elect chemistry and physics is related to the juror's decision.

H_j His satisfaction with the present science program in his district is related to the juror's decision.

H_k The willingness of his science teachers to try new programs is related to a juror's decision.

H_l The attitude of his student body toward innovations is related to the juror's decision.

H_m The attitude of his community toward innovations is related to the juror's decision.

H_n The willingness of his school board or diocese to fund experimental programs is related to the juror's decision.

Theory

The theory underlying this study is that school districts or state departments should define their objectives in operational form as the NEA has urged and that committees who are writing new programs should translate their broad objectives into specific behavioral terms so that an administrator could compare these two sets of objectives and arrive at a decision about whether he should recommend a particular program for a pilot study or further investigation by his faculty.

Scope of the Study

This study is limited to the junior high school. This refers to the seventh, eighth, and ninth grades in any organizational pattern. This study is not concerned with the problem of grade organization, nor with the present controversy over the merits of the middle school.

This study is limited to the science curriculum for these grades and the science program as it relates to the broad objectives of the total school program. It is beyond the scope of this study to be concerned with innovations within the school such as core or block-of-time studies, flexible or modular scheduling, non-gradedness, or the new programs in other subject matter areas. This study, however, is concerned with all the pupils in the science programs of the seventh, eighth, and ninth grades and in that context is interested in the choice of a program that will meet the needs of pupils who will elect more science courses in the senior high school, the provision of a science experience within the general education program of the average pupil, and the provision of a meaningful terminal science course for those of low ability.

This study is limited to the junior high schools of the Bay Area, California, mindful of the fact that the objectives of the schools in this area are typical of those throughout the state, and probably that there is high correlation between what the State of California wants for its pupils and the aims of the state departments of the other states.

This study is limited to Introductory Physical Science, an arbitrary choice. No attempt is made to extol the virtues of this program over any of the other new programs which have been developed or are in the process of being written for junior high school science, nor is any attempt made to compare the various programs.

This study is further limited by the selection of items chosen for the instrument as well as by the administration of the instrument. A further limiting factor is the sample, though it is not felt that the drawing of the sample from conferences sponsored by the National Science Foundation biased the study. (Identification of groups from which the sample was drawn may be found in the Appendix, p. 121.)

Overview

In Chapter II of this study, selected related literature is reviewed, a rationale is set up for the internal evaluation of the new science programs through the writing of behavioral objectives, and the method proposed by this study of using these objectives for pre-evaluation of innovations is explained.

The subject of Chapter III is the model. In this chapter the background of the model is given and the criteria for the selection of an innovation are listed together with examples of each criterion.

In Chapter IV a brief history of IPS is followed by a summary of the content. The operational objectives of the IPS program are listed together with illustrations of each goal. The method used in testing the instrument and a description of the trial run are included.

The main subject of Chapter V is the description of the sample and the correlation of the data. The main hypotheses and demographic hypotheses are analyzed and conclusions are drawn and discussed. A summary of the entire study is included, and the implications for future research and recommendations conclude the study.

One of the premises on which this study is based is that there is a need for a change in the junior high school science curriculum. A review of selected literature expressing such a need comprises the first section of Chapter II.

DEFINITION OF TERMS

AAAS - American Association for the Advancement of Science.

Administrator - Superintendent, Principal, Supervisor, or Curriculum Coordinator.

Affective - having to do with attitudes, feelings, or appreciations.

ASCD - Association for Supervision and Curriculum Development.

Bay Area - See map in Appendix, p. 134.

BSCS - Biological Sciences Curriculum Study.

Cognitive - having to do with recall or the recognition of knowledge; the development of intellectual abilities and skills.

Conceptual Theme - a related set of major generalizations.

Data (scientific) - raw material, such as observations, that has been processed in some way.

Domain - sphere of action (here used to classify concepts, attitudes, and skills).

Experiment - the rational use of observable operations employed to verify a hypothesis.

Hypothesis - hunch, belief, assumption, or notion.

Inquiry - inductive learning, discovery learning, critical thinking, or problem solving.

IPS - Introductory Physical Science, a project of Educational Services, Inc., 55 Chapel Street, Newton, Mass. 02160, supported by the National Science Foundation and directed by Dr. Uri Haber-Schaim.

Isomorphic - similar elements, having a similar relationship to the system or model.

Junior High School - grades seven, eight, and nine, regardless of the organizational pattern.

Jury - a group of randomly selected administrators who will decide whether the objectives of IPS meet the criteria of the model.

Model - a theoretical prototype of an ideal junior high school science program for the Bay Area of California, based on the stated criteria decided upon by the State Advisory Committee on Science Education at the direction of the California State Board of Education.

NASA - National Association of School Administrators.

NASSP - National Association of Secondary School Principals.

NEA - National Education Association.

NSTA - National Science Teachers Association.

Objective - something toward which an effort is directed; an aim; a goal.

Behavioral - aims of instruction stated as specific behavior of students anticipated as a result of learning opportunities.

Operational - (in education) descriptions of behavior that students may achieve as a result of structured learning opportunities.

PSSC - Physical Science Study Committee.

Psychomotor - having to do with the acquisition of skills.

Taxonomy - system of classification; here used to establish a hierarchy of cognitive and affective behavior.

USOE - United States Office of Education.

CHAPTER II

REVIEW OF LITERATURE

The basic premise of this study is the need for change in the junior high school science curriculum and how this need can be met. A review of the literature indicates that critics have now focused on this problem. Selected comments have been included in this chapter to indicate the general feeling about the present junior high school science curriculum and what should be done to remedy it.

Another premise undergirding this study is that in order to make a desired change in the junior high school science program, criteria must be established for choosing among the many options open to administrators. Several writers have called attention to the dilemma of the administrator in attempting to make such a choice and passages have been included to document the need for an evaluative instrument to assist him.

The Need for a Change in the Junior High School Science Curriculum

Science, as it is now being taught in the junior high schools, has been the subject of expressions ranging from concern to scathing criticism from science educators.

Frank B. Lindsay, retired Chief, Bureau of Secondary Education of the California State Department, when he was a member of a panel who appeared before the American Association for the Advancement of Science (AAAS) at the December, 1965, convocation in Berkeley, said, "The ill effects of failure to recognize that the fabric of learning is a closely interwoven pattern is nowhere more evident than in the junior high schools. Efforts to introduce and maintain appropriate science instruction in grades seven through nine have been faltering, fumbling, and feeble."[1] Lindsay felt that the new textbook adoptions for elementary science in 1967 in California would provide elementary pupils with a better science "base." He continued, "This may help within a few years to resolve the dilemma of junior high school science. It is time to end capricious vacillation."[2]

Robert Carleton, Executive Secretary of the NSTA, vehemently attacked the junior high school science curriculum. Leafing through several general science textbooks, he noted such chapter headings as "Science and Our Water Supply," "The Air Around Us," "Our Insect Friends and Foes," "Transportation - Land, Sea, and Air," and "Foods, Medicines and Your Health." He deplored the fact that general science

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[1]Frank B. Lindsay, "Junior High School Science in California: Emerging Directions of Development," <u>Journal of Secondary Education</u>, XLVI (March, 1966), 124.

[2]<u>Ibid</u>., p. 127.

textbooks "haven't changed for the last two or three decades."

> For eighty to ninety percent of all United States pupils, almost the total emphasis has been on description, utilitarian uses, technology, and memorization - with little or no laboratory work. Teachers have been poorly prepared and there has been a high turnover of junior high school teachers.
>
> Traditional general science has killed off interest and has done little or nothing to advance scientific literacy; it has failed to present science as one of man's humanistic endeavors; and it has failed to differentiate between science and technology.[3]

Carleton warned also:

> Much of the science that was formerly taught in the junior high school will now be taught in the elementary school. This fact constitutes a force pushing with increasing pressure upon the science program of the junior high school. To ignore this by failing to take immediate steps to plan a developmental sequence in science beyond the sixth grade will seriously limit the effectiveness of the secondary school science program.[4]

Another force acting upon the junior high school curriculum is that of the senior high school programs. Modern courses in biology, chemistry, and physics have been introduced into the senior high schools and teachers expect greater sophistication in concepts, attitudes, and skills of the students entering these programs.

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[3]Robert H. Carleton, "Science Education in the Middle or Junior High School Grades," Science Teacher, XXXIV (December, 1967), 25.

[4]Robert H. Carleton and others, "Improving Secondary School Science," in Rethinking Science Education, Fifty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), p. 155.

Jerome S. Bruner, in his book The Process of Education,[5] stated that there is a need for research on general science and that certain approaches to science should be taught as an introduction to a full course of scientific study.

Francis Keppel, former United States Commissioner of Education (1962-66), in his book The Necessary Revolution in American Education,[6] said that the stage education is in at present is marked by a concern about educational opportunities for all pupils. New research in educational psychology has helped educators understand better how children learn so that a more individualized curriculum can be constructed. In the past ten years schools have moved from a concern for the "gifted child" to the "creative child" to the "disadvantaged child." Now, perhaps it is time to fix concern on all children.

J. Stanley Marshall, editor of the chapter "The Improvement of Science Education and the Administrator" in a 1962 report of the AAAS, said:

> It has been pointed out on a good many occasions that the new courses are oriented primarily toward the more academically able students: those who typically elect science courses in high school. This is perhaps more true for the physics and chemistry courses

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[5] Jerome S. Bruner, The Process of Education (New York: Vintage Books, 1960), p. 27.

[6] Francis Keppel, The Necessary Revolution in American Education (New York: Harper & Row, 1966), p. 1.

> than it is for biology. There is no doubt that an organized effort to develop a series of science courses designed for the less academically able is urgently needed. It is to be hoped that some distinguished group will address itself to this problem in the near future.[7]

Paul Brandwein said that since junior high school students represent a wide range of abilities and experiences, the science curriculum must be both corrective of impoverished experience and adaptive to a wide range of abilities.[8]

Carleton said that there are twelve or so major junior high school science projects now in progress. "The sad thing," he said, "is that right now ninety-five percent or more kids in grades seven to nine in the United States are still studying general science and it will be five to ten years before as many as fifty percent of the kids are affected by the innovations."[9]

The need has been shown for a change in the junior high school science curriculum. The curriculum committees have turned their attention now to the elementary and junior high schools. In their haste, many committees have not been specific enough about their objectives and have based the

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[7] The New School Science: A Report to School Administrators on Regional Orientation Conferences in Science (Washington: AAAS, 1962), p. 9.

[8] Paul F. Brandwein, Building Curricular Structures for Science: With Special Reference to the Junior High School (Washington: NSTA, 1967), p. 10.

[9] Carleton, "Science Education in the Middle or Junior High School Grades," p. 26.

evaluation of their programs on packaged achievement tests and subjective judgments of pupils and teachers. It has been suggested that behavioral objectives be written ex post facto as reported in the May, 1968, newsletter of the Intermediate Science Curriculum Study Project at Florida State University: "Because of their lack of confidence in the achievement tests available, many psychologists now recommend that instructional research workers establish 'behavioral objectives' for their projects on which to base their evaluation."[10] A committee, headed by Dr. Robert Gagné, met this spring (1968) to set in motion the writing of behavioral objectives for the ISCS project.

The Need for Internal Evaluation Through Behavioral Objectives

Fletcher Watson and William W. Cooley stated, "The evidences of effective learning must appear in changed behaviors of the learners."[11] This pupil behavior is observable and measureable both quantitatively and qualitatively. These authors continued, "Unfortunately, the objectives of teaching science are often grandiose terms;

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[10] Intermediate Science Curriculum Study, Newsletter No. 4 (Tallahassee: Florida State University, May 1968), p. 8.

[11] Fletcher G. Watson and William W. Cooley, "Needed Research in Science Education," in Rethinking Science Education, Fifty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), p. 304.

rarely are they in terms of specific observable learned behavior."[12]

Examination of many lists of objectives for science programs revealed broad, sweeping statements such as "The student will learn the processes of science involved in problem solving."[13] General objectives such as this, though worthy goals for planning science programs, are not measureable and therefore are useless in making a judgment about the effectiveness of the program. If objectives are listed for individual units within the program, they are usually not quite as general, but are equally meaningless as far as being an evaluative tool for the teacher is concerned.

Watson and Cooley had this to say: "Without specificity, we lack criteria by which we can determine whether our instruction made the most of the possibilities afforded by the material."[14]

A unit objective analogous to the program objective cited above might be: "The student will understand the scientific method of problem solving so well that he can use this method in solving his personal problems." No observable behavioral change will take place when he understands, and there is no way of measuring either his understanding of the method or his use of it.

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[12] Ibid.

[13] Earl J. Montague and David P. Butts, "Behavioral Objectives," Science Teacher, XXXV (March, 1968), 33.

[14] Watson and Cooley, op. cit., p. 304.

Mager suggested that a behavioral objective should have three components: (1) observable pupil behavior; (2) conditions under which the behavior will be observed; and (3) criteria for measuring the change in behavior.[15] The original general objective, translated into behavioral terms, could be stated: "Suppose you have saved $25 and you wish to start an aquarium. List the quantity, kind, and price of the plants and animals you would buy and the size of the aquarium. You may use the catalogues in the back of the room and you may 'buy' other equipment for your aquarium if you wish, as long as you stay within the amount you have saved. Explain how you arrived at your decisions. The class will decide whether your aquarium will be balanced or not." If this were the objective, terminal behavior would be observable and measureable because conditions have been defined and criteria have been set up for determining whether the student can apply the problem-solving method to a specific problem.

Bloom divided behaviors into three categories or domains: (1) the cognitive, (2) the affective, and (3) the psychomotor. The first taxonomy,[16] published in 1956, presented a classification system for conceptual behaviors

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[15]Robert F. Mager, Preparing Instructional Objectives (San Francisco: Fearon Publishers, 1962), p. 52.

[16]Taxonomy of Educational Objectives, Handbook I: Cognitive Domain, ed. by Benjamin S. Bloom (New York: David McKay Co., 1956), pp. 201-207 (appendix).

ranging from the lowest, simple recall, up through understanding which implies making relationships, interpreting, applying, evaluating, and generalizing, to the highest, critical thinking.

A second taxonomy,[17] published in 1964, suggested a classification of the affective domain, the lowest being awareness of conditions; next, acceptance of values; then, preference for values; and finally, the formulation of a value system. There is no taxonomy of the psychomotor domain.

The rationale for developing the taxonomies is described in the second handbook:

> The Taxonomy has been used by teachers, curriculum builders, and educational research workers as one device to attack the problem of specifying in detail the expected outcomes of the learning process. When educational objectives are stated in operational and detailed form, it is possible to make appropriate evaluation instruments and to determine, with some precision, which learning experiences are likely to be of value in promoting the development of the objective and which are likely to be of little or no value.[18]

Montague and Butts defined a behavioral objective as "A goal for, or a desired outcome of, learning which is expressed in terms of observable behavior (or performance, if you prefer) of the learner. If each of us plans

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[17] Taxonomy of Educational Objectives, Handbook II: Affective Domain, by David R. Krathwohl and others (New York: David McKay Co., 1964), pp. 176-185 (appendix).

[18] Ibid., p. 76.

instruction in terms of expected student outcomes, our planning will be more specific and more student-centered."[19]

Ralph Tyler, Chairman of the Exploratory Committee for Assessing the Progress of Education, described the process used to determine science objectives. It could be summarized as follows: Educational Testing Service was responsible for bringing together science teachers, curriculum specialists, and scientists to formulate statements of objectives. To clarify the meaning of each objective, the contractor (testing) was required to include prototype exercises which, in the opinion of the science teachers and scientists, would give the student the opportunity to demonstrate the behavior implied by the objective.[20]

Goodlad emphasized the need for precise objectives and the need to check the "Relationship of these objectives to more remote aims of education. Needed is thorough appraisal of functions thought to be appropriate for each successive phase of schooling, translation of these functions into specific educational objectives, and allocation of human and material resources specifically pertinent to attainment of these objectives."[21]

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[19]Montague and Butts, op. cit., pp. 33-34.

[20]Ralph Tyler, "Assessing the Progress of Education in Science," Science Teacher, XXXIII, No. 6 (September, 1966), 12.

[21]John I. Goodlad, "Direction and Redirection for Curriculum Change," in Curriculum Change: Direction and Process (Washington: ASCD, 1966), pp. 5 and 8.

Like most of the new programs, the writers of IPS have stated the goals in general terms. Behavioral objectives for the program were not identified before the committee started writing; therefore, the achievement tests included in the program are not a valid tool for internal evaluation of the program.

Watson and Cooley said: "Test items need to be developed which sample more of the behaviors generally believed to be desirable outcomes of science instruction. We shall not be able to determine whether or not science courses are achieving such goals . . . unless reliable and valid evaluation instruments are available."[22]

Pelham, in an article based on a Ph.D. study done at Columbia in 1955, wrote:

> The analytical method is based on a fundamental observation . . . it must be possible to look at the plans for conduct of the course and find what, of general education value, they are supposed to accomplish.
>
> All this says is that a course designer tries to do what he sets out to do. . . . Intended outcomes are those things . . . a course designer intends will happen to or for a student as a result of his going through specific planned educational experiences--this is different from objectives.
>
> Course objectives can be stated before the course is designed. Intended outcomes must, however, have a source--an intended outcome cannot be obtained unless there are plans for student experiences.[23]

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[22]Watson and Cooley, op. cit., p. 305.

[23]W. F. Pelham, "Analysis of Science Courses Designed for General Education," Science Education, L (October, 1966), 337-38.

Henry H. Walbesser was in charge of an evaluation study of the new curriculum materials for elementary school science being developed by the Commission on Science Education of the AAAS. In an article,[24] he reported on the design and rationale for the study. The first step was to specify the curriculum objectives as behaviors. Next, the Commission developed a checklist against which they immediately measured each of these specified behaviors. Three different pupils were selected at random by AAAS each month to be "checked." The Commission also established a hierarchy of learning set from which they could obtain a profile of an individual--not one compared to a mythical national norm, but one which related to behaviors requisite for the final task that the individual has performed. The method, sometimes called the "systems approach," of specifying goals, designing content to induce the desired behaviors, setting up criteria, and finally measuring terminal pupil behavior against the criteria provides a valid means of determining the internal evaluation of a program.

As was mentioned earlier, haste in writing new junior high school programs may have caused some writing teams to fail to follow the "systems approach." Walbesser suggested another reason:

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[24]Henry H. Walbesser, "Curriculum Evaluation by Means of Behavioral Objectives," Journal of Research in Science Teaching, I (1963), 296, 298.

> However, if measurement is to be possible, the instructional objectives must be specified in terms of behaviors which are observable. If the desired capability of the learner cannot be specified in such terms, it should be painfully obvious that such a capability cannot be measured.
>
> There exists a class of curriculum designers who do not wish to be (as they contend) 'pinned down' to specific behavioral changes. As a direct consequence of the lack of commitment to a behavioral description they frequently do not specify the performance they expect the learner to accomplish.
>
> It has been contended that placing such severe constraints upon the system of experimental curriculum construction may tend to inhibit the 'creativity' of those involved in writing the materials. However, since the proponents of this thesis have, as yet, presented no experimental evidence to support their claim, it has not affected this strategy for curriculum evaluation.[25]

If specific objectives were not identified before a new program is written, it should be done afterwards, as the review of the literature indicated, to establish criteria for internal evaluation of the program. The stated objectives of IPS had to be translated into behavioral terms and divided into the three domains suggested by Bloom: cognitive, affective, and psychomotor. A hierarchy of behaviors has also been established.[26]

Another reason for the identification of behavioral objectives is the use of them for external evaluation of new programs. A review of the literature pertinent to this point has been included in the section which follows.

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[25] _Ibid_., pp. 297, 299.

[26] The hierarchy may be found in the Appendix, pp. 139-146.

The Need for an Instrument for External Evaluation of New Programs

The junior high school administrator is confronted with a difficult dilemma. Faced with the large number of science programs which have been developed or are now being written for junior high schools, he must have some criteria for evaluating them and making a choice. The obvious method is to study evaluations of the appropriate projects. It has been pointed out in the previous section that internal evaluations of the new programs are based on subjective judgment and standard achievement tests. It is understandable that administrators have been swayed by other considerations.

Noojin Walker, Chairman of the Division of Special Education at Pensacola (Florida) Junior College, said, "Although it does seem that some properties of an innovation are likely to affect its adoption and continued use, educational innovations are almost never installed on their own merits."[27] He listed some of the factors which may have influenced an administrator in making a curricular choice:

1. The prestige of the innovating group (people like Zacharius, Seaborg, Campbell and Brandwein lend considerable weight).

2. Because the focus of change is usually on content, the "bandwagon effect" is operative.

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[27] Noojin Walker, "Innovations in Science: Do We Dance to the Piper's Tune?" Clearing House, XLI (May, 1967), 529-532, passim.

3. As mentioned before, some of the projects have built in their own success by providing for the pre-training of teachers.

4. Low cost to the school and little disruption to the total school program as a result of its adoption.

5. Publicity. Some of the projects have built-in publicity in the form of newsletters, progress reports and reports of pilot studies which emphasize the positive and conceal the negative.

These are certainly not valid reasons for choosing a new program.

John Goodlad was asked by the Fund for the Advancement of Education to analyze the curriculum materials which have been prepared by a fast growing number of projects in all subject areas. In the Overview, Goodlad said:

> It would be reassuring to believe that school districts use the products of one curriculum study group in preference to another because they have carefully examined them and found them better suited to those aims of education to which the districts are committed. But this is rarely the case. Few state departments, even fewer school districts have seriously tried to determine the precise purpose of their schools and the objectives to be achieved.[28]

In a section titled "Problems and Issues" in the same pamphlet, Goodlad continued:

> What is needed are evaluative criteria in the form of educational objectives that have been agreed upon, quite apart from the specific claims to virtue made by this or that approach to curriculum organization. Curriculum planners, in general, have been delinquent in stating their educational objectives with precision.[29]

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[28] John I. Goodlad, The Changing School Curriculum (New York: The Fund for the Advancement of Education, 1966), p. 17.

[29] Ibid., p. 94.

The ASCD has been mentioned in Chapter I as having made some constructive moves recently in helping the administrator solve the problem of choosing an innovation. At the 1966 Convention in San Francisco, Broudy said, when he addressed the ASCD members:

> Consider, for example, what happens when a school system is confronted with a proposal to adopt a new mathematics or physics curriculum. Let us assume that the proposal already has had a great deal of publicity behind it, and that some influential parents have already urged the school privately or not so privately to try it. On what grounds does one divert--and often it does mean diversion--funds from other allocations to make the proposed change? The proponents of the new course are content to rest their claims on the superiority of the content, viz. that it is 'good' mathematics or physics, and 'better' mathematics or physics than that now being taught. As to other values which the proposed innovation would facilitate or jeopardize, the proponents say little and apparently care less.
>
> One would feel better about it all, if one could be reasonably confident that the school's administrators had better knowledge of these consequences, but there is little ground for such confidence because the total curriculum is a hodgepodge. . . . The administrator's resistance, therefore, if it exists, arises from considerations of expediency, comfort, or even survival, rather than from reasoned judgments about the merits of the innovation.
>
> The administrator and staff have no simple way of judging how good the proposal is--even on its own claims. There is no impartial Consumer's Guide to tell them, nor do many school systems have a testing laboratory of their own. Under analogous circumstances, no hospital would adopt a new drug for general use, whereas schools often do jump on whatever bandwagon happens to be playing the loudest tune.[30]

To aid the administrator in making decisions, ASCD has established a Commission on Current Curriculum Developments

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[30]Harry S. Broudy, "Needed: A Unifying Theory of Education," in Curriculum Change: Direction and Process (Washington: ASCD, 1966), p. 19.

and the first in a series of booklets, The Changing Curriculum: Science, by Richard E. Haney, included this charge in the Foreword which was written by Arthur W. Combs, President of ASCD:

> Being a curriculum worker these days is no easy task. As American education goes through the growing pains of revitalization and adaptation to new social goals, curriculum workers are confronted with a bewildering array of innovations, each with its champions and critics, all loudly proclaiming their points of view. In addition, providing school materials has become a most lucrative business and schools everywhere are finding themselves the target of hard and soft sell by American industry as never before. As a consequence, curriculum decisions have been made much more difficult than ever and it is hard for a conscientious worker to know who and what to believe. More than ever there is a need for careful, objective, professional review and discussion of current developments.
>
> To meet this need, the Association for Supervision and Curriculum Development established its Commission on Current Curriculum Developments and charged it with the responsibility for maintaining liaison with curriculum studies and defining standards for and evaluating curriculum innovations.[31]

Haney has listed six objectives to provide a basis for evaluating curriculum projects. All objectives, according to Haney, indicate the desirability of cognitive, affective, and psychomotor learnings in the science program:

1. The pupil should acquire knowledge which he can use to explain, predict, and control natural phenomena.

2. The pupil should grow in his ability to engage in the processes of science and to apply these processes in appropriate situations as he confronts them in his daily life.

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[31] Richard E. Haney, The Changing Curriculum: Science (Washington: ASCD, 1966), p. v.

3. The pupil should acquire the attitudes of scientists and learn to apply these attitudes appropriately in his daily experiences.

4. The pupil should come to understand the various interrelationships between science and society.

5. The pupil should learn numerous useful manipulative skills through the study of science.

6. The pupil should acquire a variety of interests that may lead to hobbies and possibly to a vocation.[32]

Haney continued:

> One of the most difficult tasks, from the standpoint of curriculum development, is that of evaluating a new instructional program to determine the feasibility of incorporating it into the existing curriculum. The following is a list of criteria which may be used for that purpose. Several of the items could be termed external criteria because they are used to evaluate the relationships of the proposed course to the total program. Others are internal criteria because they are used to judge the internal consistency of the new course itself. These are concerned with how well the new program lives up to the publicity it has received from its authors.[33]

One of the external criteria listed by Haney was the one chosen for the rationale of this study:

> Objectives:
>
> a. Are the objectives adequately defined in terms of all the learning outcomes desired?
>
> b. Are the aims consistent with the general objectives of the total science program of the school district?
>
> c. Are the objectives consistent with the general aims of education as they apply to the grade levels in question?[34]

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[32] *Ibid.*, p. 24.

[33] *Ibid.*, p. 35.

[34] *Ibid.*, p. 36.

Two other professional groups mentioned in Chapter I as being concerned about establishing criteria for selection of new innovations were NSTA and NSSA. In June of 1967, a joint planning conference was held in Washington for the purpose of exploring the feasibility of developing a list of terminal behaviors which might be expected of high school seniors or what the goals of science education for the general student should be, stated in behavioral terms. Because the group was aware that other groups had developed objectives in the cognitive domain, they concentrated on the affective domain, formulating behavioral statements concerning such things as attitudes, interests, and appreciations.

At this meeting, plans were made to hold five regional meetings in Philadelphia, Berkeley, Chicago, Wichita, and Atlanta and about fifteen science supervisors were invited to each meeting. Each supervisor was provided with Mager's Preparing Instructional Objectives and an NSTA paper entitled "Developing Categories for Behavioral Objectives."[35]

At each regional meeting, the groups divided into subgroups and worked on writing behavioral objectives in the affective domain. The product of the groups differed and some of the groups attempted to establish criterion levels and to write evaluation items. The objectives of

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[35]"Developing Categories for Behavioral Objectives," a six-page leaflet distributed by NSTA (Washington: NSTA, September 1967).

the five groups are incorporated into a summary report[36] which has provided a valuable set of criteria for the evaluation of innovations.

The NEA was concerned enough about the problem confronting administrators that they devoted a special issue of the NEA Journal to educational decision-making. In the article, "Framework for Developing Criteria,"[37] quoted in Chapter I, they call upon state departments of education to establish a framework of categorical goals within which innovations can be measured.

The framework which the California State Department of Education has established has been used as the model for this study and is described fully in Chapter III.

In July, 1965, Science Research Associates was appointed by the Carnegie Corporation, the original sponsors of the Exploratory Committee on Assessing the Progress of Education, to delineate the objectives of science education in the United States. These objectives were to reflect what the schools currently consider the important goals of science education with the expectation that they might serve as a guide for assessing the attainments of representative nine-year-olds, thirteen-year-olds, seventeen-year-olds, and adult high school graduates.

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[36] Summary Report NSSA-NSTA Workshops on Behavioral Objectives, pp. 1-33, passim.

[37] NEA Journal, LVI (December, 1967), 26-28.

John W. Lombard and William B. Owen have compiled these objectives into a guide, and in the introduction they described the method of derivation:

> (1) a study of the literature,
> (2) statements of members of the Committee of Consultants, and
> (3) comments by reviewers of the preliminary draft of objectives.
>
> The method used was to study the published literature and solicit opinions, write material, have it reviewed by qualified people, rewrite it, and have it further reviewed. The Committee of Consultants provided overall guidance and reviewed two preliminary versions of the objectives, interjecting their own ideas at each stage. In addition, more than 150 other people actively concerned with improving science education were given the opportunity to review the preliminary draft of objectives. These included scientists; professors of science education; officers of national, state, and local science teachers associations; science curriculum specialists; directors of NSF-sponsored curriculum projects; state, county, and city school superintendents; and experienced science teachers at all grade levels.[38]

The result is a comprehensive list of behavioral objectives categorized according to the four age levels to undergo assessment and classified according to the _Taxonomy of Educational Objectives_, Handbook I: _Cognitive Domain_, and Handbook II: _Affective Domain_.

A search of the literature has revealed four studies similar to this one. The first study was sponsored by the USOE at Rutgers University. Bruce W. Tuckerman has recently published a progress report of this study which revealed that he has developed a "Curriculum Hierarchy for the

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[38]Lombard and Owen, _op. cit._, p. 3.

Evaluation of Course Knowledge" along with a "check" technique. This technique is based upon a model which initially necessitates translating the learning processes and objectives into easily identifiable behavioral responses. This process is described in the progress report.[39]

The second parallel study is one by Metfessel and Michael,[40] whose purpose was to develop an eight-step procedural outline of the evaluation process in the form of a flow chart and to furnish a detailed listing of multiple criterion measures that may be used in the evaluation of specific behavioral objectives. The first is a model which can be followed in evaluation of school programs, and the latter has potential utility in the instrumentation phase of the evaluation process.

The third study was one reported by Charles M. Long,[41] which was supported by the Center for Urban Education, New York City. The Board of Education of New York City appointed a task force in the spring of 1966 to develop a program for the disadvantaged student within the framework of the objectives for the middle school which had already been determined. One of the subjects was science.

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[39]Tuckerman, op. cit.

[40]Metfessel and Michael, op. cit.

[41]Long, op. cit., ERIC microfiche, ED 011 534.

A Center for Urban Education Research Team, composed of professors from Brooklyn College, evaluated the materials produced by the task force within the framework of specially prepared guidelines and the previously stated objectives established for the middle schools, as well as the broad objectives of the Board of Education of New York City.

The Renzulli study, "The Evaluation of Programs of Differential Education for the Gifted," considered this problem:

> The difficulty of validly appraising the effectiveness of educational programs poses a serious and long-standing problem for those persons who have undertaken the responsibility of educating the nation's youth. In the area of education for the gifted, the problem of formal program evaluation is compounded by the absence of appropriate means which are explicitly designed to evaluate the particularized objectives that guide and direct the learning experiences of fortunately endowed individuals.
>
> The literature on the gifted reveals a striking contrast between a nearly universal plea for program evaluation and a near dearth of analytical and procedural studies attempting to bring this problem into manageable proportions.[42]

The design of the study was to identify key features of a program for the gifted, to submit these to a panel of judges who rank-ordered the features which they considered to be most necessary and sufficient to a worthy program. An experimental evaluative instrument was constructed using

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[42]Renzulli, op. cit., pp. 45-46.

each of the five key features identified by the panel of judges, followed by objectives descriptive of each feature. Finally, a scale value was assigned to each and the instrument was submitted to the panel of judges to determine whether each of the program requirements and scale standards was sufficiently well conceived and structured to allow differentiation in use by qualified observers in the process of evaluating programs for the gifted.

These four studies, though similar in their use of an evaluative instrument or a model or a panel of judges, or behavioral objectives, differ from this study which combines all of these features in the development and testing of an instrument for pre-evaluation of innovative programs in junior high school science.

Discussion of Previous Research

Senior high school science was first to feel the impact of the curriculum reform movement. Next, in response to critics such as Lindsay, Carleton, Bruner, Marshall, and Brandwein, the project writers have turned their attention to the junior high and elementary science curricula.

In their haste, or because of what Walbesser calls their fear of losing their creativity, the project writers neglected to provide viable criteria for internal and external evaluation in the form of specific operational objectives, leaving administrators who must choose from a large amount of innovative material in a dilemma.

Statements by Watson and Cooley, Blough, Tyler, and Goodlad supported the need for such criteria for internal validity while Goodlad, Broudy, Combs, and Haney together with the USOE and professional organizations such as NEA, ASCD, NSTA, NASA, NASSP, and AAAS[43] have called for criteria for external evaluation of the new programs. Some of the above organizations have sponsored workshops, studies, position papers, and monographs in which models have been developed incorporating specific aims of the science curriculum and calling for a method of choosing a program to meet these goals. Four studies were reviewed which proposed to help administrators choose programs for the vocational and general students, the disadvantaged students of New York City, and the gifted student.

The City of New York and the California State Department of Education were cited as examples of urban and state educational systems which have established criteria for science programs in the middle and junior high schools.

The California State Department of Education's <u>Science Framework for California Public Schools</u> (1968) has been used as the model for this study and is described in Chapter III. The operational objectives of this model have been used to construct an instrument for the evaluation of innovations. The rationale for the use of the model is explained in the next chapter.

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[43]Acronyms are defined on pp. 17 and 18.

CHAPTER III

THE MODEL

The use of a model in an experimental study has been employed often to provide a base against which to test the researcher's hypotheses. Eichorn[1] used a model to show that a middle school could meet the needs of adolescents better than a seventh-eighth-ninth grade organization. A replication of his system-theory model has been used in this study.

Rationale for the System-Theory Model

This study used the model to conceptualize a functional junior high school science program for all students in grades seven, eight, and nine in the Bay Area of California.

For purposes of clarification, Griffiths described system-theory: "A 'system' is simply defined as a complex of elements in mutual interaction. System is a construct which has been used for a long period of time."[2]

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[1]Eichorn, op. cit.

[2]Daniel E. Griffiths, "Some Assumptions Underlying the Use of Models in Research," in Educational Research: New Perspectives, ed. by Jack A. Culbertson and Stephen P. Hencley (Danville, Ill.: The Interstate Printers and Publishers, Inc., 1963), p. 129.

The elements which composed the system in this study were the objectives agreed upon by a group of science educators which, if attained, could theoretically contribute substantially toward meeting the needs of adolescents.

Now that the system-theory has been defined, the elements identified, and the geographical location of the model established, a further word is in order to clarify the process.

Allport extended the definition of the system-theory by defining it as "Any recognizably delimited aggregate of dynamic elements that are in some way interconnected and interdependent and that continue to operate together according to certain laws and in such a way as to produce some characteristic total effect."[3]

The aggregate dynamic elements in this case are the objectives of the junior high school science program. These elements are interconnected and interdependent, and although they are a part of the general objectives of the total junior high school, they are distinguishable in operation.

Tyler supported the validity of using a model against which to test an untried program when he defined it thus: "This development of a formal model provides a way of viewing the complex phenomena in a fashion which permits

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[3]Floyd H. Allport, Theories of Perception and the Concept of Structure (New York: John Wiley and Sons, Inc., 1955), p. 469.

scientific study. Models serve to simplify a process which appears on the surface to be too varied or complex or haphazard to be understood."[4] The area about which little was known in this study was the IPS program and the jury tested this program against the laws (objectives) of the model.

A condition for using a model in this fashion is isomorphism of the elements. Griffiths described the relationship in this way:

> If X is a model of Y, it is so because X is isomorphic to Y. Two conditions are necessary for this to obtain. First, there must be a one-to-one relationship between elements of X and the elements of Y. Second, the elements of X must bear the same relationship to one another as do the elements of Y. If all the elements bear the same relationship to one another, then the isomorphism is complete.[5]

Brodbeck, a leading analyst of the model research approach, extended the isomorphic discussion by relating the following:

> In other words, not only must the terms of the two areas correspond, but the connections among these concepts must also be preserved, if the model is to be of any use. One area, either part or all of it, can be a fruitful model for another only if corresponding concepts of the model also can be shown to connect their corresponding concepts in the second area.[6]

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[4]Ralph W. Tyler, "The Contributions of the Behavioral Science in Educational Research," in First Annual Phi Delta Kappa Symposium on Educational Research, ed. by Frank W. Banghart (Bloomington, Ind.: Phi Delta Kappa, 1960), p. 57.

[5]Griffiths, op. cit., p. 123.

[6]May Brodbeck, "Logic and Scientific Method in Research on Teaching," in Handbook of Research on Teaching, ed. by N. L. Gage (Chicago: Rand, McNally & Co., 1963), p. 90.

This study used the objectives of the model (X) against which to test the objectives of the program (Y), thus fulfilling the conditions of a one-to-one relationship between the elements of X and the elements of Y. The objectives of the model and the objectives of the program bear the same relationship to each other in that the individual objectives in each instance constitute a set of general objectives; hence Griffiths' second condition was met in this study.

To satisfy Brodbeck's condition, the stated objectives of IPS had to be translated into operational terms to correspond to those of the model. The process for doing this is outlined in Chapter IV.

Having established the validity of the use of the model as a research tool, the system to which the model relates, the junior high schools of the Bay Area of California, will be described in the next section together with recent changes which have made an impact on the science program.

The System--The Junior High Schools of California

The recent passage of Senate Bill 1 (D-Miller) has already had an effect on the junior high schools and particularly the science programs which have been in the planning stages. This bill provides for local autonomy in curriculum beyond the minimum mandated essentials. Educators have long advocated this step to provide more flexibility in local districts whose problems are indigenous to the community and to clear the way for experimentation and change.

The San Mateo district is an example of those districts, restricted in the past by the mandated curricula, which have already initiated the necessary in-service planning for nongraded secondary schools and modular scheduling, two innovations which were not compatible with legislative requirements.

One of the problems faced by teachers of science as well as home economics, shop, physical education, art, and music has been the lack of flexibility in a schedule which has not allowed enough time for preparation and cleaning up. Specifically, one of the reasons that the new projects with their emphasis on laboratory experience for junior high school science students have not been adopted is because of the limitations of the fifty-minute period. This legislation plus the availability of NDEA funds for the purchase of laboratory equipment has made it possible for junior high school students to have more vicarious experiences and less teacher demonstrations.

With the freedom to innovate has come more decision-making at the local level. It was explained in Chapter I that the ultimate responsibility for making curricular decisions rested with the administrator. To assist him, a recent study of the junior high schools was authorized by the California State Board of Education from funding under provisions of Title V of ESEA, V-826, which was sponsored by the State Department of Education. A report of the study,[7] dated June, 1966, contained a Foreword by Max Rafferty, Superintendent of Public Instruction and Director of Education, in which he outlined the need for such a study. (See the Appendix, p. 147.) Rafferty also suggested the recommendations be used as a model.

Mr. Loyd Prante, recently retired principal of Mt. Gleason Junior High School of Los Angeles, was coordinator of the project, and Mr. W. Earl Sams, Consultant for the Bureau of Elementary and Secondary Education, was director of the project. The _ad hoc_ committee which reviewed the programs offered by the junior high schools of California was composed of administrators, laymen, representatives of professional organizations, teachers, representatives of Parent-Teacher organizations, and curriculum specialists. It had as consultants representatives of the State Department of Education, California Association of Secondary School Administrators, the State Board of Education, and college professors.

The recommendations that came out of the study were coded to show which of the following agencies were responsible for their implementation:

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[7] _How Can Tax Dollar$ Make Good Adoles¢ents?_ p. ii.

1. Junior High School
2. Local School District
3. County School Superintendent Staff
4. California Association of Secondary School Administrators
5. State Colleges, Universities, and other Teacher Education Institutions
6. State Department of Education
7. State Board of Education
8. State Legislature
9. Regional Educational Centers
10. All Educational and Governmental Agencies.[8]

The recommendations which have special significance for this study have been extrapolated and examined in the light of the need for change in the junior high school science curriculum which was explored in Chapter II of this study.

Recommendations of the Task Force Relating to the Specific Area of the Model

One theme which ran through the study of the junior high school programs of California was that the junior high school is a place for the adolescent to find out who he is, what he is fitted for, to adjust to what does not fit him, and finally to make a good life for himself out of these findings. This places upon the junior high school the responsibility of providing the pupil with the climate for exploration--but exploration as an avenue to discovery.

It is not easy to provide a climate for exploration in the junior high school because of the tremendous

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[8] *Ibid*., p. viii.

differences in early adolescents--not only the physiological differences of puberty, but also individual differences which are magnified by puberty. The awareness of the need to provide a rich experience for all the children was another theme of the report.

The ability span of the junior high school is far greater than the average lay person realizes. At no time in their lives, except in the first three years, is there such a wide range of abilities, interests, and skills. An individual program should, therefore, fit individual capacity. If, on one hand, the offering is unchallenging, disinterest, inattention, and often misconduct follow. If, on the other hand, the offering is unattainable, the program tantalizes and does not satisfy. Discouragement, interest loss, and rebellion result. The task force recommended that the junior high school curriculum be tailored to fit the needs of all students--the college-bound, the average child, the slow learner, and the exceptional child.

Another strong theme running through the report was the need for an experiential curriculum. Young people of this age are active, naturally curious, and enjoy manipulative tasks. The task force recommended that these characteristics of adolescents be encouraged and that a climate be provided in the junior high schools which will foster the spirit of inquiry.

The nurturing of creativity is another important task of the junior high schools. Research indicates that every child has some degree of creative ability, and the junior high school teacher must recognize and encourage this quality. In making this recommendation, the task force stated, "Creative thinking is at this time a more important tool in California junior high schools than at any time in history."[9]

The last, but by no means the least important, theme of the report of the task force was that of change, which was also the theme of Chapter II of this study.

> Junior High School educators are aware that two areas of change confront them: (1) Changes in children, and (2) Societal change. . . . Educators realize that the two must mesh to produce a valuable learning experience. <u>It is evident too that each may affect curriculum</u>. . . . <u>Great change is occurring at the local level</u>. It is represented by experiment and discard, by experiment and acceptance.[10]

The task force called attention to changes in the science curriculum:

> Junior high school science is a striking example of what has come about in curricular change. These middle school pupils are making headlines in newspapers and television, with space projects and startling research. Today's junior high school performance exceeds by far, in content, creativity and imagination, that of many colleges a few short years ago.
>
> Not only are these projects spectacular and significant, but of equal importance is the fact that large numbers of young people are gaining <u>understanding</u> and

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[9] *Ibid.*, p. 32.

[10] *Ibid.*, pp. 28, 29.

> appreciation (much needed commodities) of the many and varied people and things about them.[11]

In summary, the task force recommendations for the junior high schools of California which have been extrapolated because of their significance for the model of this study were: (1) to provide a climate for exploration which would lead to discovery; (2) to provide a meaningful program for all pupils which is both attainable and challenging; (3) to allow the students the freedom to inquire and experience the curriculum; (4) to recognize and encourage creativity; and (5) to be flexible and willing to accept change.

It did not take some of the agencies cited on page 50 long to begin the implementation of the recommendations made by the task force. The following year, 1967, the California State Board of Education directed the State Advisory Committee on Science Education to act on the recommendations. The preliminary framework which follows is the result:

THE SCIENCE FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS

Preface

> The Science Framework for California Public Schools was prepared by the State Advisory Committee on Science Education at the direction of the California State Board of Education. It purports to set forth and define the essential ingredients and structure of an appropriate instructional program in science for kindergarten through grade twelve.

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[11] *Ibid*., p. 30.

> Recognizing that behind any such document there must be a rationale, the Committee carefully spelled out its philosophical position and described the unique nature of science as it relates to science education. Emphasis is placed on a system of curriculum development utilizing goals, operational objectives, instructional strategies and techniques inherent in any good science program. Prescriptive and definitive listings are avoided. While all listings are illustrative and open-ended, they are useful in designing a "model" for assistance to persons responsible for science curriculum and instruction, as well as writers and publishers of instructional materials.
>
> Without well-prepared teachers the best of materials can produce little. Accordingly, special attention is given to teacher preparation.[12]

From this framework of objectives for the K-12 science program in the schools of California, those goals which pertained to the junior high school were extrapolated and constitute the model used in this study.

Model for a Junior High School Science Program for the Bay Area, California

a. Goal I

The student develops those values, aspirations, and attitudes which underlie the personal involvement of an individual with his environment and with mankind.

Operational Objectives

(1) He is intrigued by phenomena in his environment.

Given samples of materials such as camphor and sulphur:

He points out similarities and differences in them.

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[12] Science Framework for California Public Schools, Preliminary, p. iii. This bulletin was in a preliminary form at the time of this study. Permission to use it is included in the Appendix, p. 148.

He initiates simple tests to more exactly determine their nature.
He wants to measure such characteristics as density and hardness to compare his results with those in reference sources.
He investigates novel features of the substance both in and out of the classroom.
He speculates on characteristics that are not testable with his resources.

(2) He states or exhibits a preference for processing data and for building theories.

Given the problem of verifying the value of "g," the acceleration due to gravity, as 32 ft/sec^2 or 9.80 meters/sec^2:

He generates data from experiments with falling objects and pendulums.
He collects data until he can show that potential errors will be minimized.
He perceives potential errors in his experiment.
He modifies techniques to minimize human and equipment errors.
He attempts to account for discrepancies between derived and accepted values.
He investigates the importance of exact "g" determinations in man's space and earth endeavors.

(3) He applies rational thought to discrepancies and their explanations and gives reasons for his choice.

Given one egg floating appreciably higher than a second egg in a beaker apparently full of ordinary tap water:

He investigates more closely the nature of the egg and the water.
He formulates hypotheses to explain the discrepancy.
He defends his hypotheses based upon his past experiences.
He submits his hypotheses to additional tests.
He modifies or retracts his hypotheses upon discovering new information.

(4) He seeks interaction with others.

He shares his data and ideas.

(5) He demonstrates personal integrity as a science investigator.

Given the opportunity to inhibit or accelerate his experiment:

He proposes to set up a carefully controlled series of experiments.
He controls his environmental variables as exactly as possible.
He records results faithfully and accurately.
He displays no prejudice toward preconceived notions.
He assumes responsibility for his mistakes and failures.
He incorporates a thorough analysis of his mistakes and failures in his written reports.

(6) He relates science to other human endeavors.

b. Goal II

The student develops the rational powers which underlie the scientific mode of inquiry.

Operational Objectives

(1) He senses the existence of a problem.

Given a discrepant event in which a round object rolls <u>up</u> an incline:

He points out elements in the event which are inconsistent with his previous experience that objects roll <u>downhill</u>.
He states a problem presented by the discrepancy such as: "How can this thing seem to go against the force of gravity and roll uphill?"

(2) He formulates tentative hypotheses to identify the causes of events.
He uses intuition and insight as a basis for tentative explanation.
He generates novel and personal ideas to explain the causes.
He applies existing theories to explain the cause.

(3) He generates data to verify or define a theory.
He proposes ways of testing the theory.
He sets up experiments to test the theory.
He compares predictions and results to determine whether his data verify his theory.

(4) He draws inferences from data gathered.
He manipulates formulas to achieve predictions.
He is disturbed by measurement and manipulation errors.
He shares data with classmates to plot graphs and establish trends.
He suggests formula modifications of the given formulas to achieve realistic results for his particular group.

(5) He predicts events based upon his theory.
He points out limitations of his predictions due to variables he cannot measure.
He seeks data beyond his immediate environment to reduce prediction errors.

(6) He forms generalizations from the usefulness of a theory, develops new ideas, and tests them.
He finds that they fit into a broader concept.

c. Goal III

The student develops fundamental skills in manipulating materials and equipment and obtaining, organizing, and communicating scientific information.

Operational Objectives

(1) He is skillful in constructing and using laboratory apparatus.
He follows directions for assembling and using apparatus.
He selects the most appropriate materials and equipment for each activity.
He maintains and stores equipment properly.
He designs and constructs apparatus for special purposes.
He handles materials, apparatus, and tools in a safe manner.

(2) He reads widely and accurately to obtain information.
He reads materials and instructions needed for conducting an investigation.

He obtains data from diagrams, charts, and graphs to apply to practical problems.
He reads formulas and scientific symbols with understanding.

(3) He observes natural and laboratory phenomena intelligently to obtain information.
He uses a variety of senses to detect exact characteristics of objects and events.
He reads scientific instruments to extract the highest degree of precision.
He compares properties of matter to distinguish gross and minute differences.

(4) He records and organizes observations and ideas in a precise and accurate manner to enhance their usefulness.
He keeps a written log of qualitative and quantitative observations.
He records quantitative data in tabular form.
He represents data graphically.
He uses precise and unambiguous language to describe observations.
He uses mathematical techniques to simplify and interpret data.
He categorizes lists of objects.

(5) He communicates with others in written and oral form, using terminology which is consistent with the conventions of science.
He describes an object or event clearly, accurately, and concisely to provide a clear mental picture for the listeners.
He formulates clear and pertinent questions and participates actively in group discussions.
He translates statements and ideas obtained from reading into his own words.

d. Goal IV

The student develops a knowledge of systematic facts, concepts, and generalizations which lead to further interpretation and prediction of the natural world.

(1) He demonstrates knowledge of specific facts.
He recalls that a single orange falls at the same rate as a bag of oranges does.
He uses the correct value of the speed of light in computation.
He recalls that water boils at 212^{o}F. at one unit of atmospheric pressure.

(2) He demonstrates knowledge of historical trends and sequences.
He demonstrates by means of examples that science provides power for technology to generate new tools which, in turn, aid in generating new knowledge.

(3) He demonstrates knowledge of criteria.
He quotes from published and verified sources to establish scientific authority for his arguments.

(4) He demonstrates knowledge of generalizations.
He cites crystal growth as an example of molecular structure.

(5) He demonstrates knowledge of conceptual themes.
He relates light and radar waves to each other in terms of their position in the electromagnetic spectrum.[13]

Summary

In this chapter the rationale for the use of a model in an experimental study was given together with supporting statements for the use of the model in the testing of unknown or untried programs.

Recent changes in the system, the junior high schools of California, within which the model operates, were explained on pages 47-48. Recommendations of the task force charged with improving the junior high schools of California were examined and those which applied to the science curriculum were summarized on pages 50-53.

The model used in this study, the operational objectives of the science program in the junior high schools of California, was developed. The research hypothesis of this

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[13] *Ibid.*, pp. 23-31, *passim*.

study is that it is possible to develop an instrument for the selection of innovations or new programs by comparing the operational objectives of a model and the stated objectives of the program under consideration.

In the next chapter, the IPS program is explained and the method of testing the statistical hypotheses of this study is given.

CHAPTER IV

THE PREPARATION OF THE EVALUATIVE INSTRUMENT

The Introductory Physical Science program was chosen to test the hypotheses of this study. The reason for choosing this program rather than one of the other new junior high school science programs was a random decision. The instrument developed can be used to evaluate any innovative program in any subject area. Most of the new projects publish a list of objectives which are either in operational terms or can be translated into observable pupil behavior. The matching of this set of objectives against those of the model constitutes the test to determine whether the new program would meet the criteria of the model school system.

History of IPS

The Introductory Physical Science project was started in 1963 by Educational Services, Incorporated, 55 Chapel Street, Newton, Massachusetts. ESI was organized in 1958 by the founders of the Physical Science Study Committee at Watertown, Massachusetts. After the development of PSSC from its organization in 1956 to the commercial release of its materials in 1963, the Committee decided to extend curriculum innovations beyond the scope of high school physics and start work on a junior high school program which they called "Introductory Physical Science."

ESI is a nonprofit organization which now sponsors about twenty other projects both in this country and in foreign countries.[1] ESI is financed mainly by grants from private foundations, although IPS is now supported by the National Science Foundation.

The reason given for initiation of the project was: "To develop basic attitudes and skills with regard to science and to offer students insight into the means by which scientific knowledge is acquired, as well as offering students a beginning knowledge of physical science."[2]

Evidence that the purpose behind IPS is to meet the needs of all students can be found in the following statement:

> And so, out of requests from teachers in the field came the call to start something to serve as a common foundation for the later courses in the senior high schools. This means not only a foundation of subject matter, but also an attitude of inquiry coupled with experimental and mathematical skills.
>
> Some students have no science at all in senior high school. Unfortunately, many can even get through college with no additional science, and will be ill-equipped to understand a world dominated by the

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[1]Frederick A. Diazgranados , "IPS in Uruguay," Science Teacher, XXXIV (January, 1967), 53-54.

[2]AAAS, Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments, ed. by J. David Lockard (College Park: University of Maryland, 1968), p. 267.

> terminology and implications of science and technology. Therefore, our new course must also serve as a terminal course in physical science for many students, as well as provide a foundation for future work.[3]

This goal echoes the concern of the task force recommendations in Chapter III of this study for a program for the junior high schools of California which will meet the needs of all the youth.

The original writing team for the IPS project was composed of teachers, science educators, and scientists. They had completed two-thirds of the course in the first year. During the school year 1963-64, it was given a tryout by ten teachers who had been on the writing team. On the basis of their feedback, a revised edition was prepared. In 1964, the first brochure, "A Brief Description of a New Course," appeared.[4]

During the school years 1964-65 and 1965-66, pilot studies were run on the revised two-thirds of the course (the first eight chapters) by sixty teachers of 2,300 eighth and ninth grade students, covering a wide range of ability and background. The feedback from this group, both written and oral, was thoroughly analyzed and further revision took place.

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[3] Introductory Physical Science: Objectives and Content of the Course, p. 2.

[4] This brochure is out of print and could not be included.

In addition to the pilot group, new pilot schools were added during 1965-66, adding 25,000 students. California schools in this group included Flintridge Preparatory School in Pasadena and Fresno High School in Fresno.

During 1966-67, a total of 125,000 students used a preliminary edition of the text, including Chapters IX and X. In 1967, the completed edition of the text (Chapters I through XI) was published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey, along with the Teacher's Guide and Achievement Tests. The contract for the manufacture of laboratory equipment and apparatus went to Prentice-Hall and to Macalaster Scientific Corporation, 60 Arsenal Street, Watertown, Massachusetts.

Ten NSF Summer Institutes were held during the summer of 1967, one of which was co-sponsored by ESI and Wellesley College, designed specifically for science supervisors and master teachers who conducted local workshops during the following year in their districts. The project strongly urges school districts or cooperating districts to sponsor such workshops. They recommend five full days just before school starts and the equivalent of ten full days during the school year.[5] In both NSF Institutes and workshops, teachers do the experiments, pool their results with others to reach a conclusion, work HDL (Home, Desk, Lab)

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[5]IPS: Objectives and Content, p. 13.

problems, defend their answers, and in general follow an accelerated development of the course in much the same way as their students will.[6]

The importance of in-service training of teachers has been recognized by other agencies. One of the products of the study, titled "Implementing New Science Curricula," which is being funded by the National Science Foundation and conducted by the Far West Laboratory for Educational Research and Development, 1 Garden Circle, Hotel Claremont, Berkeley, California, will be mini-courses or self-contained in-service education courses in IPS. Dr. Sylvia M. Obradovic, NSF Project Director, and her staff plan to utilize micro-teaching techniques to train teachers in the skills needed for effectively teaching new science curricula.[7]

During the school year 1967-68, several schools in the Bay Area of California were among those offering the IPS program on either the eighth or ninth grade level to students of a wide range of background and ability.[8]

Stated Objectives of IPS

The objectives of the IPS program were described in the following paragraphs:

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[6] *Ibid.*, p. 12.

[7] *Implementing New Science Curricula*, a brochure distributed by Far West Laboratory for Education Research and Development to explain the project (Berkeley: The Laboratory, n.d.), unpaged.

[8] A list of these schools is included in the Appendix, p. 149.

> Thus we must have a program to serve two purposes: on the one hand to be a sound foundation for future physics, chemistry, and perhaps biology courses; and on the other hand to furnish sufficient nourishment in the essence, the spirit, and the substance of physical science to be a good terminal course for those who will not study physical science later on.
>
> We believe that there are certain values and skills that can and should be taught in junior high school science. First, we want to give a feeling for the kind of human effort that is involved in the development of science. We want to put across the point that the root of all science is phenomena and that the names come later. We should like the student to get his information from the original source, from nature itself. This calls for real investigation in the laboratory. But science is not all laboratory work. We have to correlate and generalize our observations. We have to construct models or theories which can be manipulated logically and which will raise new questions. Later we do other experiments to seek the answers to these questions.[9]

The stated objectives of IPS contained in these two paragraphs are certainly important goals for a junior high school science program, but they are too general. A search of the student handbook and laboratory manual as well as the teacher's guide did not reveal any specific aims of the program expressed in terms of observable pupil behavior.

Internal evaluation is built into the IPS program by including chapter quizzes in the teacher's manual and making available standard achievement tests which have been validated on students in pilot programs. Feedback is encouraged.[10] No external evaluation of IPS has been attempted.

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[9] IPS: Objectives and Content, pp. 2, 3.

[10] Feedback samples are included in the Appendix, pp. 150-152.

Chapter II of this study documented the belief of educators that unless goals are specified in terms of observable pupil behavior, both internal and external evaluation of a program are invalid.

Content of the Course

The criteria used by the writing committee for the selection of topics centered around two questions: (1) How much will the student benefit from learning this? (2) How useful will it be later in the development of the story? If any topic appeared only once, it was discarded by the committee because of lack of "mileage." There is an overall purpose to the course and once a skill is learned, the student is given the opportunity to practice it over and over until it becomes a part of him.

The conceptual theme of IPS is the introductory study of matter. "If we look around us we see a bewildering variety of matter; we can try to bring order into this seeming chaos by breaking up the components into a pattern. If we cannot build a pattern, then we can only catalogue things as a collector catalogues stamps."[11]

The method used in the program is scientific inquiry. The students begin by distilling wood which arouses immediate interest, as well as introducing them to laboratory techniques and the inquiry approach.

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[11] IPS: Objectives and Content, p. 4.

Instead of classifying matter in the conventional way by observing similarities, students are encouraged to look for differences in matter and then by treating two different samples in the same way, determine whether they react the same or differently.

The importance of quantity is introduced early together with the concepts of volume and mass. Students practice determining the volume or mass of a variety of samples and in so doing discover the greater precision of the latter measurement.

The concept of density follows naturally and once the student learns to find the density of a liquid, he then uses that knowledge to find out information about the fractions he obtains from the fractional distillation of a solution.

The Metric System is used exclusively, but is introduced casually by the teacher's use of it. The students learn it by following the teacher's example; there are no conversions to remember, but, through use, the students gain skill in handling both these and the powers-of-ten notation as well as negative numbers and significant figures.

The next step leads the students to look for properties of matter which are independent of quantity and appearance such as density, solubility, or boiling point. They learn accuracy in reading thermometers and scales and estimation when judging density, for example, by hefting.

The students record their data in a notebook or log and very often graphical representation is called for. This gives them frequent opportunity to develop concepts of direct variation, indirect variation, interpolation, extrapolation, choice of units, labeling axes, and general interpretation of graphs.

They come naturally, thereby, to the concept that some properties can be combined to build a model or theory as they note the similarity in the behavior of gases and the diversity in the behavior of liquids and solids. At this point they return to the identification of the products of the distillation of wood, their first investigation.

Ratios are used, for example, in noting the ratio of the volume and mass of hydrogen and oxygen in the decomposition of water. By working with ratios, the students gain an understanding of the composition of compounds.

The students next attempt to separate substances according to their properties. They do paper chromatography and graph the solubility of sodium chloride and sodium chlorate, for comparison. They discover that some substances will not separate, and by inductive reasoning, arrive at the conclusion that these are pure substances--elements. (It should be noted here that "labels" as such are not stressed in the course. If a student is curious, he might ask or find out what things are called. Also, no definitions are learned to be parroted back.)

From breaking down substances, the class turns to synthesis and tries to put them back together. For example, the students synthesize zinc chloride, with each station using a different mass of zinc and the same amount of HCl. Each station calculates the ratio of the mass of zinc with the mass of zinc chloride obtained. When the calculations of all stations are plotted on a histogram, the Law of Constant Proportions is obvious. Each student feels the satisfaction of knowing that his data are an important part of the histogram.

In all their observations and calculations the students learn accuracy because as each station reports its findings, a cluster begins to appear and deviations from the norm are most apparent. The class then discusses whether these are errors in observation, calculation, or laboratory technique. If there is too much diversity they may decide to repeat the investigation.

The students are now ready to comprehend the more sophisticated properties, and they do flame tests and spectral analyses to determine the composition of a variety of samples.

Chapter VII of IPS deals with the radioactive property of some elements. Here again, incidentally, as a part of the theme running through the program, a brief historical survey is included in the student handbook. If a student becomes interested, he might well be motivated by this to find out more on his own; if not, it is not essential to the conceptual theme.

It is recommended by the IPS writing committee that with a class of low ability the teacher might pace the work more slowly and end the program with Chapter VII. This, of course, is optional.

The program now goes from the concrete to the abstract which involves a higher level of cognition, as explained in Chapter II of this study. The remainder of the IPS program is concerned with building an atomic model of matter, based on the concepts the students have already learned.

The "black box" of CHEM Study fame is used here to sharpen perception and help the students understand the concept of a theoretical model. In constructing the model of an atom from what they have learned, they develop the Law of Multiple Proportions. In the "Mass of Atoms" film, the only one developed especially for the program, students see how it is possible to measure the mass of atoms.

The next phase is to "let the atoms move" and the students learn the concept that molecules and atoms in a hot substance move faster than in a substance when it is cold. This leads them to the concept of thermal energy.

In the final chapter of IPS, thermal energy is measured in calories by its effect on water. Specific heats are determined; then heats of reaction, solution, fusion, and vaporization are investigated. These latent forms of heat, not associated with molecular motion, are related to the arrangement of atoms in chemical reactions, solution, and changes of state.

In summary, a thorough examination of the teacher's manual, the student handbook-laboratory manual, the achievement tests, and the equipment and materials catalogues for the IPS course led to the following conclusions about the content of the program: (1) The conceptual theme, the introductory study of matter, is adhered to. (2) The material is well organized so that the student is able to understand simple concepts first and build on them in gaining insight into those which are more complex. (3) Concrete ideas are presented before the student is introduced to the abstract or theoretical. (4) Once a skill is learned, opportunities are introduced for continued practice in the skill. (5) Investigations occur naturally in the student handbook. (6) The content is interesting and well written.

A study of the history, stated objectives, and content of the course was not sufficient to write operational objectives. It was necessary to observe pupil behavior in the classroom. A list of schools in the Bay Area where IPS was being taught was obtained and during the spring of 1968 as many observations as possible were made. Dr. Sylvia M. Obradovic, NSF Project Director of "Implementing New Science

Curricula," made available the library of video-tapes and facilities at the Far West Regional Laboratory, Berkeley, California.

A typical teacher workshop in IPS, sponsored by NSF, was visited at Wayne State University where a group of Detroit teachers were observed going through the same program as their students would start in the fall.

The Education Development Center, Physical Science Group, Newton, Massachusetts, offered to open their feedback and test files on IPS, but time did not permit a visit to Massachusetts. Some feedback was obtained through the project at Far West Regional Laboratory, through talking with teachers, and through published statements (summarized in the Appendix, pp. 150-152).

The next step was the preparation of the IPS objectives for the instrument. The procedure followed is described in the next section.

Preparation of IPS Objectives for the Instrument

The stated objectives of IPS, quoted on pages 65 ff. of this study, were too general to be of use in evaluating the program. It was pointed out in Chapter II of this study, citing Goodlad and others, that in order to be useful, objectives must be stated in terms of observable pupil behavior and that if curriculum planners had been negligent in stating their objectives precisely, the omission should be remedied before any evaluation of the program can take place.

Mager's book on the preparation of educational objectives which was reviewed in Chapter II of this study proved useful in translating the general objectives listed by the IPS program writers into operational terms. The report of the NSSA-NSTA Workshops on Behavioral Objectives, also reviewed in Chapter II of this study, was helpful in considering attitudinal objectives. The operational objectives which were derived from each of the three major general objectives of IPS are located in the Appendix, pp. 128-130.

The next step in preparing the IPS program objectives for the instrument was to arrange them in domains, according to Bloom's taxonomies which were reviewed in Chapter II of this study, and following Gagné's plan, to establish a hierarchy of objectives in the cognitive and affective domains, with those in the psychomotor domain also listed. This hierarchy of objectives for the IPS program is found in the Appendix, pp. 139-146.

In Chapter III of this study, when establishing the rationale for the system-theory model of research, it was pointed out by Griffiths and Brodbeck that the elements of the model and the elements of the program to be tested must be isomorphic. The objectives of the model used in this study, the science program in the junior high schools of the Bay Area, California, were already stated in operational form. Therefore, the next step, to conform to Griffith's and Brodbeck's conditions, was to select from the total list of translated objectives for IPS those which were felt to be most representative and to list them in the same operational terms as those of the model. These IPS objectives, together with those of the model, make up the instrument and are found in the Appendix, pp. 128-130.

The Instrument

In preparing the instrument, the theory behind it was that, given a set of objectives of a model school district and a set of objectives of an innovative program which are isomorphic to those of the model, an administrator could determine whether the objectives of the program fit the needs of the model school district. The statistical hypotheses are:

H_1 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal I of the model (SCHOOL DISTRICT X).

H_2 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal II of the model (SCHOOL DISTRICT X).

H_3 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal III of the model (SCHOOL DISTRICT X).

H_4 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal IV of the model (SCHOOL DISTRICT X).

To test the demographic hypotheses, a Professional Data Sheet (Appendix, p. 126) was included.

Before the final form of the instrument was determined, a pilot study was run. Dr. Henry O. Hooper, Department of Physics, Wayne State University, kindly consented to secure a reaction to the instrument from a group of science teachers from the Detroit area who were attending a National Science Foundation workshop at the University from June 24 through August 16, 1968.

Mr. Frank Pavia, who was in charge of the workshop, agreed to distribute the instrument to the teachers and collect them, and the materials were turned over to Mr. Pavia on July 17, 1968. The teachers had been working with the IPS program for approximately three weeks and were familiar with it. Casual conversation with a few of them revealed their enthusiasm for the program and a strong motivation to try it in their schools. Some of the teachers had already used IPS materials prior to coming to the workshop.

A total of thirteen teachers out of a possible forty responded. A breakdown of their verdict on the instrument is shown in Table 1.

TABLE 1

BREAKDOWN SHOWING RESULTS OF PILOT STUDY

Criteria of Model	Verdict of Pilot Group	
	Yes	No
Goal I	11	2
Goal II	12	1
Goal III	12	1
Goal IV	13	0
Would you choose this program for your district?	13	0

It was difficult to draw any conclusions about the demographic hypotheses because of the small number of people in the pilot study. However, suggestions were solicited for improving the instrument and they were summarized as follows:

1. It is difficult for teachers to recall the number of students who go to college from their school or district. (This item was eliminated from the revised questionnaire.)

2. It is difficult for teachers to recall the percentage of students who elect physics and chemistry. (This item was retained because of the important implication it had for choosing IPS, one of the purposes of which is to prepare students for PSSC and CHEM study.)

3. It was suggested that the attitudinal items be placed on a continuum. (This was done on the revised questionnaire.)

4. It was suggested that it would be easier to compare objectives if the instrument had them lined up parallel. (This was not realistic because an administrator, considering a new program, would have to use the stated objectives of the innovations as he found them and try to match them to his own criteria.)

5. One person felt that the objectives of X District were a paraphrase of those of Y Program and that it was a "waste of time." (This was not the case. The X objectives are stated verbatim from a list (as yet unpublished) of operational objectives for California science programs and were quite independent from the stated objectives of Y, disseminated two years ago by IPS.)

6. (A lack of enthusiasm on the part of the teachers for the task was indicated by the few who responded.)

After the pilot run, the instrument was revised, incorporating the suggestions of the pilot teachers and those of faculty members of Michigan State University. The instrument was now ready for the test.

Summary

The procedure followed in preparing the instrument for testing is reviewed in outline form below:

1. The history of the IPS project was studied in the preface of the student handbook, the summary of the program by the AAAS Clearinghouse at the University of Maryland, and the brochure, _IPS: Objectives and Content of the Course_.

2. The general objectives of the IPS project were found in the brochure, _IPS: Objectives and Content of the Course_.

3. A thorough knowledge of the content of the course was gained by studying the student handbook and laboratory manual, the teacher's manual, and the catalogues of materials and supplies.
4. The procedure for internal evaluation of the program was explained in the teacher's manual. A thorough study was made of the chapter tests contained in the manual. Samples of the achievement tests available from Prentice-Hall were studied. Feedback is another method used for internal evaluation of the project, so an effort was made to talk to teachers and students and to examine samples of feedback in School Science and Math from teachers who were using IPS and also feedback from teachers and students collected at Far West Regional Laboratory. The University of Maryland Clearinghouse stated that there were no control groups and a search of the literature revealed no research had been done on the IPS project.
5. The method used to study student behavior was through classroom visitation and the viewing of videotapes.
6. The general objectives of IPS were translated into behavioral terms, following Goodlad's and Mager's suggestions.

7. The IPS objectives, now in behavioral terms, were separated into three domains and the objectives in the cognitive and affective domains were arranged in hierarchies, as suggested by Gagné and Bloom.
8. The IPS objectives were now isomorphic with those of the model. This isomorphism of elements conformed to the rules for use of the model in research made by Griffiths and Brodbeck. To make the instrument manageable, a choice had to be made of a few representative examples under each broad categorical goal. In each case a random choice was made by drawing cards on which objectives had been typed.
9. A pilot test of the instrument was made at Wayne State University. Revisions were made and the instrument was ready for testing.

CHAPTER V

TESTING THE INSTRUMENT AND ANALYSIS OF THE RESULTS

Population

The population used for testing the instrument was any junior or senior high school administrator (broadly defined as anyone in a decision-making position) in any school district in the United States.

Sample

The sample was randomly drawn from conferences of science supervisors and principals at Wayne State University, Florida State University, and the University of Colorado, and from a workshop for high school principals at the University of New Hampshire. The administrators, numbering seventy-two, were from all parts of the country. Characteristics of the sample are presented in Tables 2 through 6 which follow.

TABLE 2

SUMMARY OF THE AGE AND SEX OF THE SAMPLE

Age Range	Number of Males	Number of Females	No Response	Total
Under 30	2	0		2
30-40	26	0	1	27
40-50	27	3		30
50-60	8	4		12
Over 60	0	0		0
No response		1		1
Total	63	8	1	72

TABLE 3

SUMMARY OF HIGHEST DEGREES HELD BY JURORS

Degree	Number of Jurors
Ph.D.	3
Ed.D.	2
M.Ed.	16
M.S.	14
M.A.	24
M.A.T.	3
B.S.	3
B.A.	2
Specialist	3
No response	2
Total	72

TABLE 4

SUMMARY OF PRESENT POSITION AND LENGTH OF SERVICE OF JURORS

Present Title of Juror	Number of Jurors	Average Length of Service (years)
Teacher and/or Dept. Head	6	8.0
Teacher, Helping	1	1.0
Science Supervisor, Director, or Coordinator	24	4.17
Curriculum Associate, Science or Math/Science	2	1.0
State Science Supervisor	1	3.0
Educational Consultant	1	2.0
Director, Secondary Education	2	2.0
Director, Curriculum Development	1	1.0
Principal, Assistant	4	3.33
Principal	24	5.86
Principal, Township	1	2.0
College, Supervising Teacher	2	7.0
College Instructor	1	3
College, Associate Professor	2	8
Total	72	(Avg.) 3.7

TABLE 5

SUMMARY OF NUMBER OF COURSES IN ADMINISTRATION, CURRICULUM, AND PHYSICAL SCIENCE TAKEN BY THE JURORS

Field	Average Number of Courses
Administration	6.92
Curriculum	5.90
Physical Science	7.9

TABLE 6

SUMMARY OF EDUCATIONAL EXPERIENCE BEFORE PRESENT POSITION

Additional Experience	Average Number of Years
Teacher (Grades 7-9)	3.9
Teacher (Grades 9-12)	8.25
Science Teacher	6.57
Jr. High School Administrator	1.07
Sr. High School Administrator	5.47

Other responsibilities previous to their present positions which were listed by the jurors included: Science Supervisor, Biology Coordinator, Head of Science Department, Night School Science Teacher, College Biology Instructor, College Supervising Teacher, Junior College Teacher, Director of Curriculum, Director of Secondary Education, Guidance Counselor, Elementary Principal, and Elementary Teacher.

The size of the schools from which the jurors came ranged from a school with an enrollment of 300 to a district with an enrollment of about 750,000. Other large districts represented were one of 290,000, one of 130,000, and another of 100,000, with most of the enrollments ranging between the two extremes.

The characteristics of the sample have been summarized in the foregoing tables. The decision of the jury is presented in the next section.

Decision of Jury

The members of the jury (N = 72) were asked to compare the operational objectives of Y SCIENCE PROGRAM with the operational objectives of the model (X SCHOOL DISTRICT) and to decide whether the objectives of the science program met each of four main criteria of the model. They were then asked to respond to the question, "Therefore, if you were the administrator of X SCHOOL DISTRICT and these were your goals for the science program in the junior high schools, judging on the basis of the stated objectives for

Y SCIENCE PROGRAM (disregarding other variables), would you choose this program for your district?"

The main hypotheses which were tested by the decision of the jury were:

H_1 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal I of the model (SCHOOL DISTRICT X).

H_2 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal II of the model (SCHOOL DISTRICT X).

H_3 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal III of the model (SCHOOL DISTRICT X).

H_4 Given the stated objectives of Y SCIENCE PROGRAM, the majority of the jury will decide that they meet the criteria included under Goal IV of the model (SCHOOL DISTRICT X).

The verdict of the jury is summarized in Table 7 which shows the positive and negative decisions for each goal and the responses to the question.

TABLE 7

SUMMARY OF JURY DECISION

Criteria	Yes	No	No Response
Goal I	50	20	2
Goal II	59	11	2
Goal III	65	6	1
Goal IV	56	15	1
Final Decision	54	16	2

The majority of the jurors decided in favor of H_1, the hypothesis which tested whether the objectives of IPS met Goal I of the model. This goal was: "The student develops those values, aspirations, and attitudes which underlie the personal involvement of an individual with his environment and with mankind."

The majority of the jurors decided in favor of H_2, the hypothesis which tested whether the objectives of IPS met Goal II of the model. This goal was: "The student develops the rational powers which underlie the scientific mode of inquiry."

The majority of the jurors decided in favor of H_3, the hypothesis which tested whether the objectives of IPS met Goal III of the model. This goal was: "The student develops fundamental skills in manipulating materials and equipment and obtaining, organizing, and communicating scientific information."

The majority of the jurors decided in favor of H_4, the hypothesis which tested whether the objectives of IPS met Goal IV of the model. This goal was: "The student develops a knowledge of systematic facts, concepts, and generalizations which lead to further interpretation and prediction of the natural world."

The final decision of the jury was 54 decisions in favor of IPS, 16 decisions opposed to IPS, with 2 jurors not responding.

Interpretation of Demographic Hypotheses

In this section, each demographic hypothesis is stated. A table follows each hypothesis showing the percentage of "Yes" and "No" decisions for comparison. An interpretation of the relationship between the demographic characteristic and the verdict of the jurors follows each table.

H_a The age of the juror is related to his decision.

TABLE 8

RELATIONSHIP BETWEEN AGE AND DECISION OF JURORS

	Percentage of Decisions	
Age of Juror	Yes	No
Under 30	3.7	.00
30-40	43.6	18.75
40-50	34.5	68.75
50-60	18.2	12.5
Total	100.0	100.0

No conclusions can be drawn about the youngest group because of the small number (2) of jurors in that age bracket. More than 43 per cent of those who decided favorably were in the next age group, 30-40, compared to about

19 per cent of those whose verdict was negative. However, 69 per cent of those who decided against IPS were between the ages of 40 and 50 compared to approximately 35 per cent of those who decided in favor of the program. In the oldest age bracket, a greater percentage decided Yes than No. The conclusion which can be drawn is that there seems to be a relationship between the age of the juror and his decision, with the older jurors tending to react negatively.

H_b The sex of the juror is related to his decision.

TABLE 9

RELATIONSHIP BETWEEN SEX AND DECISION OF JURORS

	Percentage of Decisions	
Sex of Juror	Yes	No
Male	87.3	93.75
Female	12.7	6.25
Total	100.0	100.0

A slightly larger percentage of males decided No than decided Yes, but more than twice as many females decided Yes than decided No. There is a tendency for females to react favorably, so there appears to be a relation between the sex of the juror and his decision.

H_c The degree held by the juror is related to his decision.

TABLE 10

RELATIONSHIP BETWEEN DEGREE AND DECISION OF JUROR

Highest Degree Held	Percentage of Decisions	
	Yes	No
Ph.D.	1.9	12.5
Ed.D.	1.9	6.25
M.A.	33.3	37.5
M.Ed.	24.1	18.75
M.S.	22.2	12.5
M.A.T.	5.5	0.0
A.B.	1.9	6.25
B.S.	5.5	0.0
Specialist	3.7	6.25
Total	100.0	100.0

A significantly greater percentage of jurors with doctoral degrees decided No than decided Yes. A greater percentage of jurors holding master's degrees reacted favorably than negatively. It is interesting to note also that the jurors holding science degrees tended to decide Yes rather than No. It appears that there is a relationship between the degree held by the juror and his decision.

H_d The title of the juror is related to his decision.

TABLE 11

RELATIONSHIP BETWEEN HIS TITLE AND THE DECISION OF THE JUROR

Title of Juror	Percentage of Decisions Yes	Percentage of Decisions No
Teacher and/or Dept. Head	10.7	0.0
Teacher, Helping	1.78	0.0
Science Supervisor, Director or Coordinator	41.1	6.25
Curriculum Associate, Science or Math/Science	3.6	0.0
State Science Supervisor	1.78	0.0
Educational Consultant	1.78	0.0
Director, Secondary Education	1.78	6.25
Director, Curriculum Development	1.78	0.0
Principal, Assistant	5.4	6.25
Principal	23.2	68.75
Principal, Township	0.0	6.25
College Personnel	7.1	6.25
Total	100.0	100.0

Approximately 45 per cent of the jurors who decided in favor of IPS were science supervisors, directors, coordinators, or curriculum associates, whereas only 6 per cent of those who decided against the program held positions in the science field. Seventy-five per cent of those who decided negatively were principals, in contrast to the 29 per cent of those principals who reacted favorably. There would seem to be a relationship, therefore, between the position of the juror and his decision.

H_e The number of years a juror has held his present position is related to his decision.

TABLE 12

RELATIONSHIP BETWEEN NUMBER OF YEARS IN HIS PRESENT POSITION AND THE DECISION OF A JUROR

Number of Years in Present Position	Percentage of Decisions	
	Yes	No
0-5	73.0	68.8
6-10	21.0	25.0
Over 10	6.0	6.2
Total	100.0	100.0

Approximately 4 per cent more of the jurors who decided favorably had held their present positions for less than five years than those who decided negatively. However, the percentage was reversed in the next category, those who had held their present positions for between six and ten years. The percentage difference in each case is not considered significant enough to show a relationship.

H_f The number of graduate courses he has taken in administration, curriculum, or physical science is related to the juror's decision.

It was impossible to calculate percentages for this characteristic because some of the jurors reported semester or credit hours instead of number of courses.

H_g His past experience in education is related to a juror's decision.

TABLE 13

RELATIONSHIP OF PAST EXPERIENCE IN EDUCATION TO A JUROR'S DECISION

Past Experience	Percentage of Decisions*	
	Yes	No
Teacher, Junior High	42.0	50.0
Teacher, Senior High	78.0	81.0
Science Teacher	57.0	44.0
Junior High Administrator	7.0	38.0
Senior High Administrator	35.0	69.0
Other Science Experience	17.0	6.0

*Percentages do not total 100% because several jurors had experience in more than one category.

In comparing the percentages of Yes and No decisions it can be noted that there was a higher percentage of No decisions for all categories except those who had been science teachers or had had related science positions. A decisive number of jurors who decided against IPS had been administrators. There appears to be a relationship between the past educational experience of a juror and his decision.

H_h His school's enrollment is related to a juror's decision.

It was impossible to calculate percentages for this characteristic of the jurors because some of them reported district enrollment and others reported school enrollment, in many cases not specifying which it was.

H_i The percentage of his student body who elect chemistry and physics is related to the juror's decision.

TABLE 14

RELATIONSHIP OF PERCENTAGE OF STUDENT BODY WHO ELECT CHEMISTRY AND PHYSICS TO JUROR'S DECISION

Percentage of Students Electing Chemistry and Physics	Percentage of Decisions	
	Yes	No
10 or less	33.3	27.3
11-20	20.8	27.3
21-30	25.0	18.1
30-40	8.3	0.0
40-50	6.3	27.3
Over 50	6.3	0.0
Total	100.0	100.0

Almost 80 per cent of the jurors who decided in favor of IPS were from districts or schools where fewer students would elect more science courses in the senior high school. However, 72 per cent of those who decided against IPS were from districts where IPS could serve as a terminal course. It is not possible, therefore, to determine the relationship between the number of students in their school who elect chemistry and physics and the decision of the jurors.

H_j His satisfaction with the present science program in his district is related to the juror's decision.

TABLE 15

RELATIONSHIP OF JUROR'S SATISFACTION WITH SCIENCE PROGRAM AND HIS DECISION

	Percentage of Decisions	
Continuum	Yes	No
1) Very Satisfied	3.6	0.0
2)	1.8	6.7
3)	10.9	20.0
4)	10.9	20.0
5) Satisfied	18.2	0.0
6)	16.4	20.0
7)	20.0	20.0
8) Dissatisfied	14.6	0.0
9)	3.6	13.3
Total	100.0	100.0

Grouping the above percentages into three categories, approximately 27 per cent of those who decided against IPS are satisfied with the present science program, compared to 15 per cent of those who decided in favor of IPS. In the lowest category, approximately 43 per cent of the jurors who decided No are dissatisfied with the science program, compared to 39 per cent of those who responded favorably. There does not appear, therefore, to be a strong relationship between the juror's satisfaction with the present science program in his school and his decision.

H_k The willingness of his science teachers to try new programs is related to a juror's decision.

TABLE 16

RELATIONSHIP OF ATTITUDE OF SCIENCE TEACHERS TO JUROR'S DECISION

Continuum		Percentage of Decisions	
		Yes	No
1)	Very Enthusiastic	2.0	6.7
2)		11.0	13.3
3)		13.0	20.0
4)	Enthusiastic	9.0	20.0
5)		33.0	6.7
6)		8.0	20.0
7)	Apathetic	15.0	0.0
8)		7.0	13.3
9)		2.0	0.0
Total		100.0	100.0

Grouping these percentages into three main categories, it is found that approximately 37 per cent of the jurors who decided against IPS came from districts where the science teachers were anxious to try innovations and 19 per cent had science teachers who were apathetic about innovations. The group who responded favorably were about evenly divided between the two extreme ends of the continuum. No relationship is evident between the attitude of his science teachers toward innovations and the decision of the juror.

H_1 The attitude of his student body toward innovations is related to the juror's decision.

TABLE 17

RELATIONSHIP BETWEEN ATTITUDE OF STUDENT BODY AND A JUROR'S DECISION

Continuum		Percentage of Decisions: Yes	Percentage of Decisions: No
1)	Very Cooperative	9.0	6.7
2)		21.4	20.0
3)		21.4	33.2
4)	Cooperative	16.0	20.0
5)		26.8	6.7
6)		3.6	6.7
7)	Non-cooperative	0.0	6.7
8)		1.8	0.0
9)		0.0	0.0
Total		100.0	100.0

It is apparent that their student bodies are more amenable to change than their science teachers, but there does not appear to be any strong relationship between this attitude and the decisions of the jurors.

H_m The attitude of his community toward innovations is related to the juror's decision.

TABLE 18

RELATIONSHIP BETWEEN COMMUNITY ATTITUDE AND THE JUROR'S DECISION

	Percentage of Decisions	
Continuum	Yes	No
1)	2.0	6.7
2) Eager to try	20.0	0.0
3)	18.0	26.7
4)	20.0	20.0
5) Conservative	33.0	20.0
6)	7.0	6.7
7)	0.0	6.7
8) Nonaccepting	0.0	13.2
9)	0.0	0.0
Total	100.0	100.0

The community, also, appears to be more anxious to try innovations than the teachers. No relationship is apparent between the attitude of the community toward innovations and the decision of the juror.

H_n The willingness of his school board or diocese to fund experimental programs is related to the juror's decision.

TABLE 19

RELATIONSHIP BETWEEN AVAILABILITY OF FUNDS AND THE JUROR'S DECISION

Attitude of Board or Diocese	Percentage of Decisions	
	Yes	No
Willing to fund	80.0	88.0
Not willing to fund	20.0	12.0
Total	100.0	100.0

Boards or dioceses appeared to be willing to fund innovative programs, but the availability of money to try new programs did not appear to have much relationship to a juror's decision.

Discussion of the Data

Examining the verdict of the jurors, it was interesting to note that of the four goals on which they made decisions, the goal which received the highest number of favorable responses was Goal III, "The student develops fundamental skills in manipulating materials and equipment and obtaining, organizing, and communicating scientific information." This goal is largely related to the psychomotor domain and was probably more obvious as far as the matching of objectives was concerned.

The goal which received the least favorable response of the jurors was Goal I, "The student develops those values, aspirations, and attitudes which underlie the personal involvement of an individual with his environment and with mankind." This goal dealt with attitudinal changes which are more subtle and more difficult to match up by inspection.

Thirteen of the sixteen jurors who decided No on the final question were principals. Table 2 shows 45 per cent of the Yes decisions came from science supervisors, directors, coordinators, and curriculum associates. Also, Table 13 shows a relationship between past experience in science teaching or supervision and the decision of the juror. Table 10 also bears this tendency out by showing a relationship between those jurors with an M.S. or B.S. degree and their decision. We can assume that familiarity with science terminology probably made the task easier for those jurors with a science background, but the fact that they decided favorably cannot be considered as due to a bias. Familiarity with the objectives of both the model and the new program would be considered an asset in using the instrument.

Another interesting thing was noted in examining the ballots. Several of the principals decided favorably for two or more of the four goals and rejected the total program. It would appear from this that even though they felt some of the objectives of IPS matched the criteria of the model, they were not in favor of the method of selecting a new program.

There appeared to be a relationship between the age of the juror and his decision. Table 9 shows a tendency for those jurors in the 40-50 age range to decide negatively. There was also a tendency for more females to respond favorably than negatively. Three out of five jurors with doctoral degrees decided against IPS.

There did not appear to be any significant relationship between the attitudinal demographic characteristics and the decisions of the jurors. The questionnaires indicated that the attitude of the students was more accepting of change than any of the groups listed, which probably reflects the natural enthusiasm of youth for anything new and different. The responses to the questionnaires also indicated the communities from which the jurors came are interested in innovations.

In considering the attitude of the administrators toward the present science program in their schools, there were a few who were satisfied and others who expressed themselves as being completely dissatisfied, but this feeling did not seem to affect their decisions. This seems to suggest that even if an administrator is convinced that a change is needed, he is cautious about choosing an unknown program even though it might look good on paper.

A few comments on the questionnaires indicated that administrators wanted it on record that they would not make a decision to try an innovation without the advice and full consent of their teachers.

In summarizing the data, the jurors' decisions lead to the conclusion that the instrument developed in the present study possesses judgmental validity and the rather favorable acceptance on the part of the jurors seems of such proportions as to indicate that further experimental study and field testing are warranted.

Major Summary of the Study

Professional writing teams composed of science educators, curriculum specialists, and teachers have now turned their attention to the development of new science programs to fill the needs of the junior high schools both in the preparation of students for the more sophisticated senior high school science concepts and to help the terminal student acquire desired cognitive, attitudinal, and skill objectives.

Implicit in the wealth of new material being produced is the need for some viable decision-making process whereby an administrator can choose which of the many options open to him best fits the needs of his school system.

ASCD, NASSP, and NSTA have published lists of criteria for judging new science programs. The NEA has challenged school systems to develop a framework for decision-making. The USOE has published two checklists for the pre-evaluation of science programs. All of these organizations have urged that goals be made specific in terms of observable pupil behavior.

One of the state departments which has responded to this challenge is that of California, which has recently completed a study of the junior high schools in the state. In addition, a framework of science objectives in the California schools is being developed.

One of the criticisms leveled at the new programs by psychologists and educators is that their stated objectives are too general, and unless they take steps to define them in terms of pupil behavior, neither internal nor external evaluation is valid.

The research hypothesis of this study was: It is possible to develop an instrument for the pre-evaluation of innovative programs through the matching of the stated objectives of the project against the framework of the criteria decided upon by a school system.

In order to test this theory, Science Framework for Public Schools was examined and those objectives which were analogous to those which the task force for the study of the junior high schools of California decided were of paramount importance were extrapolated. The four main goals with appropriate operational objectives for each goal became the model for this test.

As an example of a new junior high school science program, IPS was arbitrarily selected to be put to the test. After examining the stated objectives of IPS, it was found necessary to translate them into behavioral terms to make them isomorphic with those of the model.

These two sets of objectives thus became the instrument. It was felt that if this instrument were submitted to a jury, the majority of the jury would decide that the objectives of IPS did meet Goals I, II, III and IV of the model. Therefore, it was hypothesized that the majority of the jurors would decide that this program, IPS, should be considered by an administrator of the model school district.

The design of the study was to submit the instrument to a panel of jurors for a decision on whether the IPS objectives met the criteria of the model. One of the premises of the study was that although it was desirable for teachers to be a part of the decision-making process, realistically the role usually fell to administrators. Therefore, the sample was drawn from a population of secondary principals, science supervisors, and curriculum coordinators. The sample (N = 72) was drawn from conferences of science supervisors and principals at the University of Colorado and Wayne State University, a seminar of science supervisors at Florida State University, and a workshop for high school principals at the University of New Hampshire. (A list of conferences and seminars is included in the Appendix, p. 121.)

The decision of the jurors was 54 in favor of IPS, 16 negative, and 2 abstentions. By inspection of the Professional Data Sheets, it would appear that in the present sample of 70 people selected from throughout the United States, chronological age and scientific background were two factors which seemed in some way to be identified with the reaction of the total group.

Implications for Further Study

Generalizations can be drawn only for the program tested by the instrument, the IPS science program. It would be interesting to test other new programs, not only in science, but in other subject matter areas as well. It has been pointed out, for example, that committees are at work writing approximately forty new social studies programs. The same problem of choosing from among these materials a program that fits the needs of his school will confront the administrator soon.

An extension of the present study would be to measure the objectives of IPS against the framework of criteria of another school system, or to weigh the objectives of alternate junior high school science programs against the framework of the model used in the present study.

Time, also, did not permit a comparison between IPS and another new junior high school science program.

The study is replicable by developing an instrument made up of the operational objectives of any school system and the objectives of any program or innovation and submitting the instrument to a test.

Generalizations can only be drawn regarding the sample used in this study. It would be interesting to test the same instrument with a different jury and compare results. It is recognized that the task of matching objectives is time-consuming and is high on the hierarchy of cognitive skills, but it is preferable to most of the methods now in use for choosing an innovation.

It is suggested that two items be eliminated from the questionnaire, the enrollment of the school or district of the juror, and the number of courses in administration, curriculum, and physical science he has taken. These are difficult for some jurors to recall and there is a confusion in reporting both of these demographic characteristics.

It is questionable whether the attitudinal characteristics on the questionnaire are of significant value, also. While interesting, these items did not reveal any relationship with the decision of the juror as they were constructed and interpreted.

Finally, it is clear that there is an obligation for the writers of new materials first to define their objectives in terms of pupil behavior and then add content which will provide an atmosphere in which such behavioral change can take place. This method will provide a means of evaluating the content and techniques suggested by the program and will also provide a means of pre-evaluating the project.

Recommendations

From the research and analysis of the data, a number of recommendations have emerged from this study:

1. It is recommended that the new science programs for junior high school science be adopted where needed and their objectives fit the criteria of the school system as a stop-gap measure until a developmental K-12 program is available.
2. It is recommended that new developmental science programs are needed in the junior high school to be an integral part of a planned K-12 spiral curriculum which will build on the simple concepts learned in the elementary school and at the same time prepare students for senior high school science. The science curriculum of the junior high school must meet the needs of all the students.
3. It is recommended that the writers of new curriculum material in all subject areas recognize the mandate for defining their objectives in specific behavioral terms in order to provide both internal validity for their programs and a means of

pre-evaluating them. If it has not been done, it should be done ex post facto.

4. It is recommended that state departments and school districts define their objectives in operational terms in all subject fields and set up criteria for evaluating innovative programs. These goals should be defined by groups of teachers, curriculum specialists, administrators, and lay people and disseminated widely.
5. It is recommended that teachers play a more important role in the decision-making process. Time should be made available for them to visit other school systems and observe a variety of programs in operation before coming to a decision. Meetings should be held during school time or during the summer, for which time the teacher would be recompensed.
6. It is recommended that teacher education institutions do more pre-service and in-service education of junior high school teachers. Few teacher education institutions are doing much today in the way of educating teachers specifically for the junior high school or to help them become adapted to rapid change.
7. More effective recruitment of junior high school teachers is needed also. This is a responsibility

of teacher education institutions. In the seventh, eighth, and ninth grades where research shows the very best teachers are needed, very often there drift in, for a variety of extraneous reasons, teachers who lack the knowledge of young people of pre-adolescent age and the flexibility for helping them.

8. It is recommended that the National Science Foundation fund more summer institutes and academic year institutes specifically planned to acquaint elementary and junior high school teachers with new programs.

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APPENDIX

IDENTIFICATION OF GROUPS FROM WHICH SAMPLE WAS DRAWN

1. A conference of science supervisors in biology at Wayne State University. Dr. Kaz Mayeda, Director.

2. A National Science Foundation Seminar for science supervisors at Florida State University. Dr. Jack Hopper, Associate Director.

3. A National Science Foundation Workshop for High School Principals at the University of New Hampshire. Dr. Roland B. Kimball, Director.

4. A National Science Foundation Principals' Conference at the University of Colorado. Dr. Hazlett H. Wubben, Co-Director.

GRUHN'S SURVEY OF JUNIOR HIGH SCHOOL SCIENCE

II. Science

A. Science in Grade 7

1. Do you offer science in grade 7?
   Yes 351; no 59; no response 9

   What science?
   General science 289; other science 49; no response 13

2. Is it required? 333; elective? 11; no response 7

   Semesters:
   One 89; two 213; others 3; no response 46

   Periods weekly:
   five 277; four 17; three 20; two 9; one 0; others 8;
   no response 20

3. Honors classes in science grade 7?
   Yes 90; no 208; no response 53

B. Science in Grade 8

1. Do you offer science in grade 8?
   Yes 401; no 9; no response 9

   What science?
   General science 319; other science 72; no response 10

2. Is it required? 366; elective? 28; other 1;
   no response 6

   Semesters:
   one 59; two 254; others 6; no response 82

   Periods weekly:
   five 308; four 17; three 18; two 8; one 1; others 12;
   no response 36

3. Honors classes in grade 8?
   Yes 118; no 195; no response 88

C. Science in Grade 9

1. Do you offer science in grade 9?
Yes 400; no 7; no response 12

What science?
General science 105; biology 30; earth science 23; others 26; no response 1

2. Is it required? 206; elective? 176; others 9; no response 10

Semesters:
one 12; two 307; others 8; no response 73

Periods weekly:
five 346; four 10; three 1; two 0; one 0; others 9; no response 34

3. Do you have honors science in grade 9?
Yes 170; no 195; no response 35

What science do these pupils take?
General science 34; biology 93; earth science 27; others 22; no response 5

D. Changes in Science Program in your school since 1957

1. Have you increased semesters offered?
Yes 136; no 246; no response 37
If yes, what grades?
7 75; 8 89; 9 47; no response 1

2. Have you increased periods weekly for science since 1957? Yes 109; no 280; no response 30.
If yes, what grades?
7 77; 8 77; 9 27; no response 3

3. Have you improved science rooms since 1957?
Yes 309; no 87; no response 23

4. Have you improved science equipment since 1957?
Yes 372; no 18; no response 29

5. Have you introduced honors classes since 1957?
Yes 165; no 212; no response 42
If yes, what grades?
7 71; 8 89; 9 138; no response 14

COVER LETTER SENT WITH INSTRUMENT

W-36 Owen Hall
East Lansing, Michigan
July 31, 1968

Dear Principal:

As you well know, curriculum reform, which took off about the time of the launching of Sputnik, has snowballed in the past few years. There are approximately twenty different junior high school science projects completed or in the making; a total of more than forty different groups are revising the social studies curriculum; to say nothing of the other subject areas. With such a welter of innovative material being turned out, what is an administrator to do? How can he decide which of the programs or innovations will best fill the needs of his particular school and on what basis can he reach a decision?

In an article, "Framework for Developing Criteria," appearing in the December 1967 issue of the NEA Journal, we find this suggestion:

> "Is the innovation in line with the goals of the school system?
>
> In all too many school systems this question may receive little attention. But emphasis on categorical goals, although not new, is gaining recognition from educators. The reason for this is simple: Until a task has been defined, one cannot effectively develop procedures and practices to accomplish it. School systems should list goals and develop a framework for innovative decision making. Within this framework each innovation can be measured in terms of its prospective effectiveness as it relates to the objectives defined by the school system."

The purpose of my study is to design such an evaluative instrument which an administrator might use in making such a choice. School District X is a real school district which has determined the objectives to be achieved in their science program. Science Program Y is one of the new projects. I have translated their stated objectives into operational objectives to make them isomorphic with those of School District X.

We would like you, as a panel of jurors, to determine whether the objectives of Y Science Program meet Goals I, II, III, and IV of X School District. After making such a comparison, will you please indicate whether you would decide on this as a good program for further investigation or as a pilot project in your school.

I would appreciate your also taking the time to fill in the Professional Data Sheet. Thank you very much for your cooperation.

Sincerely,

Margaret A. James
Doctoral Candidate
Michigan State University

PROFESSIONAL DATA SHEET

a. Age (check one): Under 30___; 30-40___; 40-50___; 50-60___; over 60___

b. Sex: M___ F___

c. Degree(s) held: ______________________________

d. Title ______________________________

e. Number of years in present position____

f. Number of graduate courses in Administration___; Curriculum___; Physical Science___

g. Experience background: Years as Teacher (Gr. 7-9)___; (Gr. 9-12)___; Science teacher___; Jr. High Admin.___; Sr. High Admin.___; Other (specify)____________________

h. The enrollment of my school/district is approximately ________

i. The approximate percentage of students in my school/ district who elect courses in Chemistry____; Physics____

j. (Circle one) I am 1 2 3 4 5 6 7 8 9
very satisfied satisfied dissatisfied
with the science program in my school(s)

k. (Circle one) Our science teachers are
1 2 3 4 5 6 7 8 9
very enthusiastic enthusiastic apathetic
about trying new programs

l. (Circle one) The student body is
1 2 3 4 5 6 7 8 9
very cooperative cooperative non-cooperative
about experimenting with innovations

m. (Circle one) Our community is
1 2 3 4 5 6 7 8 9
eager to try conservative non-accepting
with respect to innovations

n. The school board/diocese in my district (is; is not) willing to fund experimental programs.

DECISION OF JUROR

After examining the stated objectives of Y PROGRAM, do you feel that they meet the goals of MODEL X junior high school science program? Please respond YES or NO to each of the four goals.

Goal I ____

The student develops those values, aspirations, and attitudes which underlie the personal involvement of an individual with his environment and with mankind.

Goal II ____

The student develops the rational powers which underlie the scientific mode of inquiry.

Goal III ____

The student develops fundamental skills in manipulating materials and equipment and obtaining, organizing, and communicating scientific information.

Goal IV ____

The student develops a knowledge of systematic facts, concepts, and generalizations which lead to further interpretation and prediction of the natural world.

Therefore, if you were the administrator of X SCHOOL DISTRICT and these were your goals for the science program in the junior high schools, judging on the basis of the stated objectives for Y SCIENCE PROGRAM (disregarding other variables), would you choose this program for your district? Please respond YES or NO ____

OPERATIONAL OBJECTIVES FOR THE JUNIOR HIGH SCHOOL SCIENCE CURRICULUM OF X DISTRICT

Goal I

The student develops those values, aspirations, and attitudes which underlie the personal involvement of an individual with his environment and with mankind.

OPERATIONAL OBJECTIVES

(1) He is intrigued by phenomena in his environment and points out similarities and differences in them.

(2) He states or exhibits a preference for processing data and for building theories.

(3) He applies rational thought to discrepancies and their explanations and gives reasons for his choice.

(4) He seeks interaction with others, sharing data and ideas.

(5) He demonstrates personal integrity as a science investigator.

(6) He relates science to other human endeavors.

Goal II

The student develops the rational powers which underlie the scientific mode of inquiry.

OPERATIONAL OBJECTIVES

(1) He senses the existence of a problem.

(2) He formulates hypotheses to identify the causes of events.

(3) He generates data to verify or define a theory.

(4) He draws inferences from data gathered.

(5) He predicts events based upon his theory.

(6) He forms generalizations from the usefulness of a theory, develops new ideas, and tests them. He finds that they fit into a broader concept.

Goal III

The student develops fundamental skills in manipulating materials and equipment and obtaining, organizing, and communicating scientific information.

(1) He is skillful in constructing and using laboratory apparatus.

(2) He reads widely and accurately to obtain information.

(3) He observes natural and laboratory phenomena intelligently to obtain information.

(4) He records and organizes observations and ideas in a precise and accurate manner to enhance their usefulness.

(5) He communicates with others in written and oral form using terminology which is consistent with the conventions of science.

Goal IV

The student develops a knowledge of systematic facts, concepts, and generalizations which lead to further interpretation and prediction of the natural world.

(1) He demonstrates knowledge of specific facts, for example:

(a) He recalls that a single orange falls at the same rate as a bag of oranges does.

(b) He uses the correct value of the speed of light in computation.

(c) He recalls that water boils at 212°F. at one unit of atmospheric pressure.

(2) He demonstrates knowledge of historical trends and sequences.

(a) He demonstrates by means of examples that science provides power for technology to generate new tools which, in turn, aid in generating new knowledge.

(3) He demonstrates knowledge of criteria.

(a) He quotes from published and verified sources to establish scientific authority for his arguments.

(4) He demonstrates knowledge of generalizations.

(a) He cites crystal growth as an example of molecular structure.

(5) He demonstrates knowledge of conceptual themes.

(a) He relates light and radar waves to each other in terms of their position in the electromagnetic spectrum.

STATED OBJECTIVES OF Y SCIENCE PROGRAM

1. To be a sound foundation for future physics, chemistry, and perhaps biology courses:

    a. The student has an opportunity to acquire basic laboratory skills.

        (1) The student follows directions in setting up his equipment and stores it after using.
        (2) The student shows a concern about fire hazards, dangerous chemicals and the need for accuracy and neatness in the laboratory.
        (3) The student habitually examines the working parts of his equipment and repairs it when necessary or designs equipment to solve a problem.
        (4) Given the opportunity to inhibit or accelerate an investigation, the student is willing to perform time-consuming procedures without attempting questionable short-cuts.

    b. The student uses all his senses in making observations, alert to subtle changes in color, temperature, movement, sound, or odor.

    c. The student records data neatly and accurately using graphs, ratios, written logs, diagrams, and charts.

    d. The student applies elementary mathematics to experimental results.

    e. The student follows the teacher's precedent in using the Metric System and power-of-ten notation when reporting his data for correlation with that of the rest of the class.

    f. The student practices correlating a concrete situation with an abstract idea.

        (1) The student discovers the composition of compounds through the determination of ratios (Ex.: two parts of H to one part of O in water).
        (2) The student discovers the concept of an element through his inability to separate some substances.

(3) The student discovers the law of constant proportions by studying the histogram of the ratios of the mass of zinc to the mass of zinc chloride reported by all the stations in the laboratory.

(4) The student demonstrates an understanding of the conceptual theme of the program--the introductory study of matter--by his ability to construct an atomic model.

g. The student practices estimation when feasible and accuracy when necessary.

2. To foster an attitude of inquiry coupled with experimental and mathematical skills.

a. When the class is faced with discrepancies in the cumulative data, the student suggests appropriate investigative strategies for the solution of the problem. The student offers alternatives.

b. Upon learning the results of a study, the student often suggests additional possibilities to investigate.

c. The student looks for data or evidence before acting and when faced with discrepancies in his own data, he often takes a second look.

d. The student retains a questioning attitude to permit adequate consideration of all possible options.

e. When confronted with a problem, the student has hunches which he then is anxious to prove or disprove.

f. The student is persistent in seeking answers from his own experiments, the experiments of others, books and references, teachers, peers, and his own observations. He asks different people the same question.

g. The answer to the student's question often brings forth another question.

3. To furnish sufficient nourishment in the essence, the spirit and the substance of physical science to be a good terminal course for those who will not study physical science later on.

a. The student enjoys science for intellectual stimulus and the pleasure of knowing about the interaction of science and technology.

b. The student shows an interest in the historical theme running through the course by asking questions, reading about the work of scientists, or trying to emulate the process they used in their discoveries.

c. The student works well with his partner (sharing tasks, ideas, and data).

d. The student demonstrates that he recognizes the importance of his data in the total picture by observing carefully and reporting accurately.

e. The student shows he is interested in the investigation because he is personally involved and the class is depending on his results.

f. The student can distinguish between causative and contributory data.

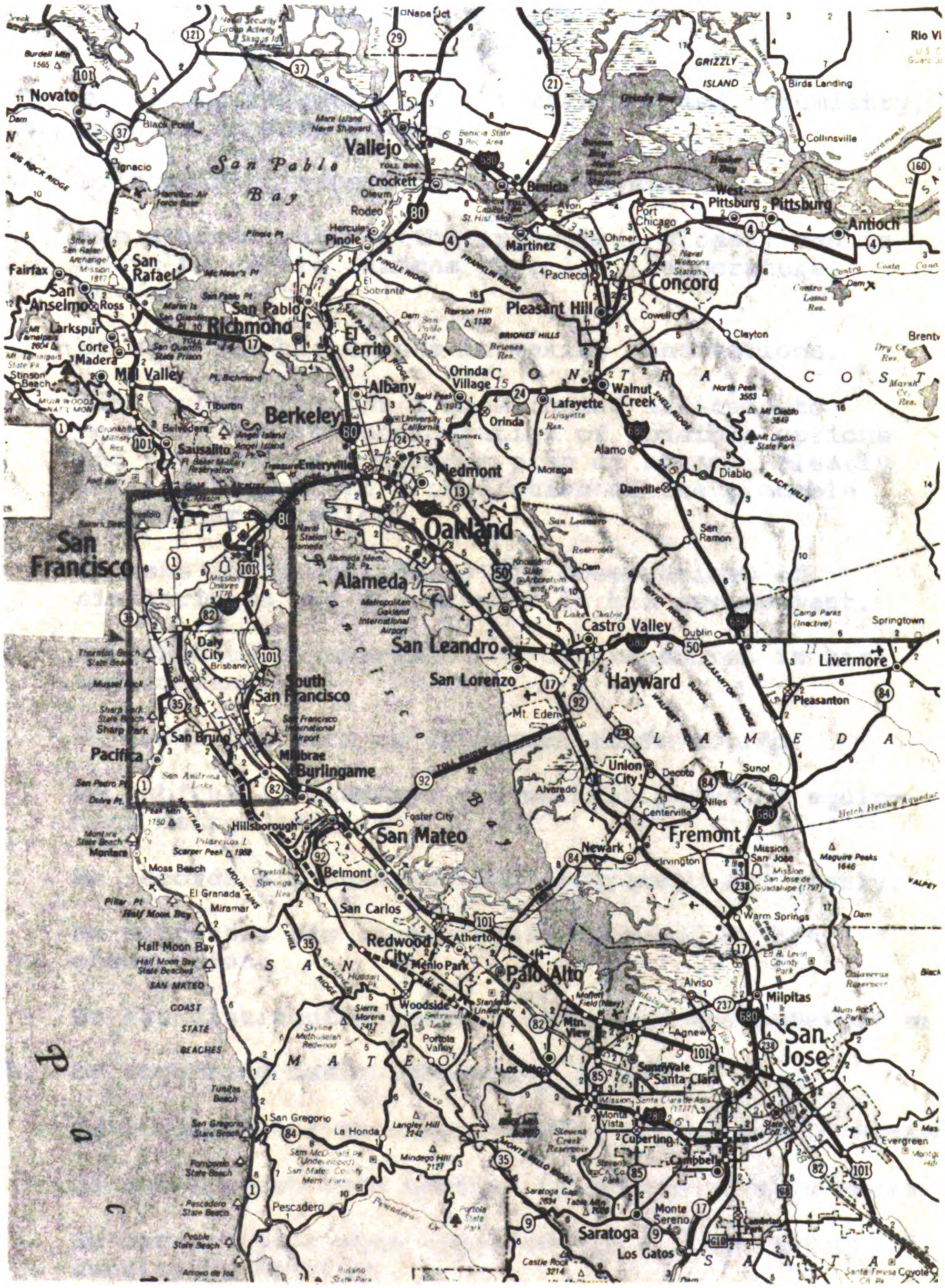
g. The student asks about and shares his observations of similarities and differences in his environment.

h. The student knows what he "doesn't know."

i. The student generates ideas of his own and seeks validity for them.

j. The student seeks validity for the ideas he gets from others and knows "whom he can trust."

MAP OF BAY AREA, CALIFORNIA



BEHAVIORAL OBJECTIVES OF INTRODUCTORY PHYSICAL SCIENCE

1. To be a sound foundation for future physics, chemistry, and perhaps biology courses:

   a. by acquiring experience in observation.

      The student watches the experiment closely and is alert to subtle changes in color, temperature, movement, etc.

      He uses all his senses in making observations.

      The student retains a questioning attitude to permit adequate consideration of possible options and to permit a conscious plan of attack, clearly looking forward to a prediction of the probable outcome or solution.

      He asks about and shares his observations of similarities and differences in his environment.

      He exhibits an awareness of discrepancies in his environment.

      He looks for data or evidence before acting.

      He habitually examines the working parts of equipment being used.

      He records his observations accurately and neatly.

      He expresses his interpretations based on his observation.

      He can distinguish between inference and observation.

   b. by acquiring basic laboratory skills.

      He demonstrates an understanding of the Metric System.

      He can convert from English to Metric or vice versa.

      He can estimate when necessary (e.g., estimation of density by hefting).

He is accurate when necessary (e.g., reading thermometers, scales, and reporting data).

He exhibits an understanding of the mechanism with which he is working.

He exhibits an understanding of density, etc.

He shows a concern about fire hazards and dangerous chemicals.

He exhibits an awareness of the need for cleaning up afterwards and putting everything away.

He sets up his equipment properly.

He works well with his partner (e.g., sharing tasks, ideas, etc.).

c. by acquiring knowledge of how to apply elementary mathematics to experimental results.

He performs necessary basic calculations (e.g., addition, subtraction, multiplication and division).

He exhibits an understanding of how to find area, circumference, distance, density, etc. (knows formulas and how to apply them).

He uses ratios to express relationships (e.g., H to O in H_2O).

He understands graphing (e.g., time, temperature functions).

d. by learning to correlate an abstract idea with a concrete situation.

The student, when faced with a change in color of a chemical, will relate that to a change in state.

When the student sees a new substance formed by a mixture of two chemicals will relate that to the concept of a compound.

e. by acquiring ideas of the orders of magnitude.

The student will use 10^9 instead of writing 1,000,000,000 or 1^{-4} instead of .0001.

The student will understand exponential numbers or powers-of-ten notation; also negative numbers.

f. by developing a feeling for approximation.

The student will practice estimation where feasible.

The student will use significant figures.

g. by learning to judge what is important and what is not.

He volunteers recitation only when he has an organized relevant response.

He considers possible options.

He identifies assumptions made as the basis of his decision-making and then questions their validity and throws out what is not valid.

He discriminates between science and superstition.

He collects data to determine the degree of reliability of common superstitions.

He gives logical arguments for or against government policies for planning research.

He can select appropriate investigative strategies for the solution of a problem.

He discriminates between relevant and irrelevant variables.

He tests inferences to gain additional information.

2. To foster an attitude of inquiry coupled with experimental and mathematical skills.

He asks and challenges teachers, peers, parents, etc.

He is persistent in seeking answers from his own experiments, the experiments of others, books and reference materials, teachers, peers, and his own observations.

He asks different people the same question.

He applies multi resources to one question.

He often takes a second look.

He goes out of his way to find answers.

He can select appropriate investigative strategies for the solution of a problem.

He retains a questioning attitude to permit adequate consideration of all possible options, and to permit a conscious plan of attack, clearly looking forward to a prediction of the probable outcome or solution.

He habitually consults more than one authority in searching for explanations.

3. To furnish sufficient nourishment in the essence, the spirit and the substance of physical science to be a good terminal course for those who will not study physical science later on.

He enjoys science for intellectual stimulus and the pleasure of knowing.

He gravitates toward idea-changing activities.

He can distinguish between causative and contributory data.

He knows about the natural environment.

He knows what he "doesn't know."

He generates ideas of his own and seeks validity for them.

He seeks validity for the ideas he gets from other people and knows "whom he can trust."

HIERARCHY OF BEHAVIORAL OBJECTIVES

Using the categories suggested in Bloom's Taxonomy of Educational Objectives in both the Cognitive and Affective domains, the IPS objectives have been assigned places on the hierarchy.

The first category in the Cognitive Domain, Knowledge, has been omitted because the number of objectives of IPS which fit into this category is too great to include in this brief summary.

For the terminal student, most of the behavioral changes in the cognitive domain will lie in the next category, Comprehension. For the student who will elect more science in high school, it is hoped that many of his behavioral changes will rest in the next three categories, Application, Analysis, and Synthesis. For the student who will probably make science his career, the behavioral changes most likely will be in the last two categories, Synthesis and Evaluation. The creative youngster's responses will more than likely be found under Critical Thinking or divergent thinking.

It is interesting to note that IPS appears to offer a wide range of possible behavioral changes not only in the Cognitive Domain, but also in the Affective Domain. It is more difficult to identify and evaluate changes in the latter, but the orientation of the IPS program allows both the terminal and ongoing science student ample opportunity to grow.

No hierarchy has been established for the Psychomotor Domain, but here again, as one examines the list of objectives, one notes that many of the skills obtainable are reinforcement of previously learned skills as well as serving to undergird the student who is taking the more advanced science courses in high school.

Cognitive Domain

Comprehension

The student can identify and state a problem.

The student can find area, distance, circumference, density, etc.

He exhibits an understanding of the mechanism with which he is working.

He uses graphing (e.g., time, temperature functions) to record data.

He uses ratios to express relationships.

He demonstrates an understanding of the Metric System.

He demonstrates an understanding of density.

He knows about the natural environment.

Application

He knows formulas and can apply them to his data.

When the student sees a new substance formed by a mixture of two chemicals, he will relate that to his concept of a compound.

The student, when faced with the change in color of a substance, will relate that to a change in state.

Analysis

The student will identify unstated assumptions involved in a conclusion or course of action.

The student will identify possible cause-and-effect relationships when interpreting a given phenomenon.

The student will identify the principles that apply to a given situation.

The student will draw generalizations from a body of data.

He can identify the factor most likely to have caused a given change in a system.

He can identify uncontrolled factors in an experimental situation.

Synthesis

The student can make a tentative generalization after examining several independent observations.

Given a set of data, the student will suggest mathematical formulas or verbal generalizations to summarize the relationships shown.

When confronted with a familiar situation, the student will devise an experiment to test a hypothesis.

Critical Thinking - Evaluation

When confronted with an unfamiliar situation, the student will devise an experiment to test a hypothesis.

He generates ideas of his own and seeks validity for them.

He can select appropriate investigative strategies for the solution of a problem.

Upon learning the results of a study, the student states additional possibilities to investigate.

The student offers realistic alternatives to a presented method of doing something.

The student displays a variety of reactions or insights.

He participates in research on his own initiative.

He can judge the appropriateness of a given prediction, conclusion, or course of action.

The student demonstrates that he can judge the relevancy of his data to the immediate problem.

He recognizes when necessary and sufficient data are available to support a conclusion.

He can judge the precision of a suggested answer in light of the precision of the data.

The student can judge whether a quantitative answer lies outside the limits of experimental error.

He can evaluate the relevancy of a hypothesis to a given set of data.

He identifies procedural or logical errors in a given situation.

Affective Domain

Receiving and Attending to Stimuli

At this level the concern is that the learner be sensitized to the existence of certain phenomena and stimuli; that is, that he be willing to receive or attend to them.

He exhibits an awareness of discrepancies in his environment.

The student will collect data and order the collection in some way.

He enjoys science for the intellectual stimulus and the pleasure of knowing.

He exhibits an awareness of the need for cleaning up afterwards and putting everything away.

He shows a concern about fire hazards, dangerous chemicals, etc.

He works well with his partner, sharing tasks, ideas, etc.

He uses all his senses in making observations.

The student watches the experiment closely and is alert to subtle changes in color, temperature, movement, etc.

The student appreciates the interaction between science and technology.

The student shows respect for the ideas of scientists.

Responding to Stimuli

At this level the student is sufficiently motivated so that he is not just willing to attend to phenomena, but actively to attend. As a first stage in a "learning by inquiry" process the student is committing himself in some small measure to the phenomena involved, though it is a very low level of commitment.

He seeks validity for the ideas he gets from other people and knows "whom he can trust" (i.e., which authorities to listen to and how much to listen).

He asks about and shares his observations of similarities and differences in his environment.

The student limits his conclusions to present data but verbally recognizes the possibility of error. He is willing to re-test in the face of seemingly conclusive data.

He gravitates toward idea-changing activities or evidences ability to live with change.

He can distinguish between causative and contributory data.

He can discriminate between science and superstition.

He collects data to determine the degree of reliability of common superstitions.

He gives logical arguments for or against government policies for planning research.

He considers possible options.

He often takes a second look.

He habitually examines the working parts of the equipment he is using.

He habitually consults more than one authority in searching for explanations.

He goes out of his way to find answers.

He can distinguish between inference and observation.

He expresses his interpretations based on his observations.

He looks for data or evidence before acting.

Given a situation, the student can list at least five observations and formulate a possible logical reason for what he observes.

He volunteers recitation only when he has an organized relevant response.

Valuing

At this level the student demonstrates an awareness that a thing, phenomenon, or behavior has worth. Behavior categorized at this level is sufficiently consistent and stable to have taken on the characteristics of a belief or an attitude.

The student retains a questioning attitude to permit adequate consideration of possible options and to permit a conscious plan of attack, clearly looking forward to a prediction of the probable outcome or solution.

Given an experimental situation with many variables, the learner will discriminate between the variables that are relevant and those that are not relevant to the problem. He can list all the relevant variables.

He applies multi resources to one question.

He asks and challenges teachers, peers, parents, etc.

He tests inferences to gain additional information.

He identifies assumptions made as the basis for his decision-making and then questions their validity; throwing out what is not valid.

Answers to his questions cause him to speculate and create new questions. He is not easily satisfied with the answers.

He asks different people the same question.

Organization of a Value System

As the learner successively internalizes values, he encounters situations for which more than one value is relevant. Thus necessity arises for the organization of the values into a system, the determination of interrelationships among them, and the establishment of the dominant and persuasive ones.

The student is willing to perform time-consuming procedures without attempting questionable short-cuts.

He is persistent in seeking answers from his own experiments, the experiments of others, books and reference materials, teachers, peers and his own observations.

The student asks questions which are (1) testable; (2) not testable; and (3) knows the difference.

Undertakes scientific reading, experimentation, or other activities on his own initiative for his own pleasure.

Is willing to consider new evidence and change an opinion or conclusion because of this evidence.

Is intellectually honest and does not lose objectivity when there is an element of personal pride, bias, prejudice, or ambition.

Will plan procedures to solve simple problems and defend his ideas.

<u>Psychomotor Domain</u>

(No hierarchy)

He can estimate when necessary (e.g., estimation of density by hefting).

He can convert from English to Metric or vice versa.

He sets up his equipment properly.

He is accurate when necessary (e.g., reading thermometers, scales, or reporting data).

He records his observations accurately and neatly.

The student uses negative numbers.

He performs necessary basic calculations (e.g., addition, subtraction, multiplication and division).

The student will use significant figures.

The student will use power-of-ten notation.

FOREWORD TO HOW CAN TAX DOLLAR$ MAKE GOOD ADOLES¢ENTS?

by Max Rafferty

A study of California's junior high school programs was considered to be an appropriate use of USEA Title V money because:

1. Over half of California's seventh and eighth grade students are in junior high schools possessing grades seven, eight and nine.

2. The junior high school is considered to be a vital link in the total educational chain, particularly in urban communities.

3. All educators (junior high school principals especially) are continually seeking ways in which to improve the quality of the product.

4. Many districts are asking about the practicability of establishing new three-year junior high schools, in communities of various sizes (urban and rural).

As Superintendent of Public Instruction, I want to augment the efforts of the California Association of Secondary School Administrators Junior High School Committee and do everything possible to help them discover better ways of educating these youth, and provide for all youth those experiences on which they can build:

1. Constructive attitudes toward self, family and the larger community.

2. Character endowed with a love of community and respect for the rights of others.

3. Learning or study skills that will guarantee maximum individual potential.

It is my wish that the task force that undertook this study continue the endeavor whatever the outcome of subsequent requests for federal financing because I know the need is great, the opportunities unlimited and the goal in sight.

(Signed) Max Rafferty

Superintendent of Public
Instruction and Director
of Education

COPY OF LETTER GRANTING PERMISSION TO USE FRAMEWORK

State of California
Department of Education
Sacramento, California

July 8, 1968

Miss Margaret A. James
W-36 Owen Hall
East Lansing, Michigan 48823

Dear Miss James:

This will acknowledge your letter of June 26 requesting permission to quote from the preliminary draft of Science Framework for California Public Schools for purposes of your dissertation. You have our permission to use it as indicated in your letter. Inasmuch as the framework is undergoing what we hope is a final revision, the committee is not anxious to have it widely disseminated in its present form. We are pleased to have your favorable reaction to it and hope that it will be of some help to you.

It is quite obvious that your summer is a busy one. The best of luck in your endeavor.

Yours sincerely,

(Signed) L. Frank Mann

Consultant in Secondary
Education

BAY AREA, CALIFORNIA, SCHOOLS OFFERING IPS DURING 1967-68 SCHOOL YEAR

Fresno Junior and Senior High Schools

Pleasant Hill High School in Contra Costa County

John H. Still High School in Sacramento

Monterey-Pacific Grove High School

Carmel Junior High School

Foothill Intermediate School in Walnut Creek

Price School in San Jose

Vallejo Junior High School

Rincon Valley Junior High School

Kenilworth Junior High and Petaluma Junior High in Petaluma

Sunset High School in Hayward

FEEDBACK FROM PILOT TEACHERS*

1. The students like having the laboratory experiments in the textbook (no separate laboratory manual). This way, the laboratory experiments follow naturally and do not seem to be separate from the text.

2. The course starts with an experiment (distilling wood), thus insuring immediate interest.

3. The "story line" running through the material is a good idea, the investigations being part of the theme.

4. The students learned to do personal investigation and experimentation.

5. The students are highly motivated because they are personally involved.

6. There is a keen sense of competition in the laboratory.

7. They learn to organize and present their data in a concise form.

8. They gain analytical sophistication.

9. The teacher's role is re-defined.

10. It calls for restraint on the part of the teacher--not to bring in extraneous concepts.

11. Some criticism of mathematics and problem-solving.

IPS AND THE FASTER STUDENT

1. It challenges him because the program allows for expanding the problems either through additional experiments or through discussion of HDL problems.

2. Experimenting and the sharing of results can lead to real humility and the recognition of the skills of others.

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*Robert W. Beaird, "The Introductory Physical Science Course in Junior High," <u>School Science and Math</u>, LXVII (October, 1967), 624-630.

3. It gives them a good basis for later courses in BSCS, CHEM Study and PSSC.

4. It motivated some students to decide to go into science-related fields.

IPS AND THE AVERAGE STUDENT

1. The teacher must insist on analysis afterwards; this is very important.

2. The teacher can handle students with varying backgrounds easily.

3. The students get depth in one area; no smattering of knowledge.

4. The average student can do a good job of experimenting and also contributes data at each post-lab discussion.

5. He is often superior in lab skills and frequently teams up with a faster student to the benefit of both.

6. The average student may be motivated to elect more science courses in senior high school.

IPS AND THE TERMINAL STUDENT

1. He experiences success in his endeavors.

2. The compilation of data makes him think his work has a purpose:

    a. He learns more by using the results of many experiments.

    b. He learns accuracy and how to keep records.

3. He enjoys being involved in an activity; he likes to manipulate things.

4. IPS brings up more questions than it answers.

5. He gains purposeful practice of basic mathematical skills.

RESULTS OF TESTING

1. The eighth grade does as well as the ninth.
2. The preparation of the teacher is related to the performance of the student.
3. The student who intends to take more science does better than one who doesn't.
4. The purpose of the tests is to assess the students' attainment of the objectives. (Note: This is highly questionable as was argued in Chapter II.)