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Title: THE COMPARATIVE EFFECTS OF THREE SEVENTH-GRADE SCIENCE PROGRAMS WITH DIFFERENT LABORATORY MATERIALS

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Fred Wayne Fox

Purpose

The problem of this experimental study was to measure the effects of the 1967-68 in-service program for the science teachers of grades seven and eight in the Catholic schools of the Archdiocese of San Francisco. The first purpose of the study was to compare the performances of students enrolled in the new curriculum introduced through the in-service program with the performances of students enrolled in the 1966-67 science program of the Archdiocese of San Francisco. The second purpose was to compare the performances of students benefiting from the in-service program with the performances of students in comparable distant schools where the teachers without the help of monthly in-service meetings used the same new textbook.

Study Materials

The Portland Science Test was the primary instrument for measuring the performances of the students. Half of the questions on this test require the use of the processes of science; the other half seek the recall of the products of science.

Questionnaires, discussions, and interviews were used to evaluate various aspects of the pilot edition of the new textbook Patterns and Processes of Science, Laboratory Text No. 1, the laboratory materials distributed through the in-service program, and the circumstances of teaching in these parochial schools.

Population

More than 14,000 students received benefits from the in-service program through their 188 teachers in 146 schools. Approximately 100 of these teachers completed each of the three major questionnaires.

The experimental group consisted of 499 seventh grade students in seven schools of the Archdiocese of San Francisco. The first control group consisted of 475 seventh grade students in the same seven selected schools during the previous year. Their traditional general science course included few experiments. The second control group consisted of 351 seventh grade students in six distant parochial schools which were paired with selected schools of the Archdiocese of San Francisco. These students used Patterns and Processes of Science although their teachers lacked the help of an in-service program for obtaining and understanding the required laboratory materials.

Results

The questionnaires and the interviews indicated that the teachers attempted to present a modern laboratory-centered program despite the crowded classrooms and shortages of time, textbooks, and laboratory materials. The performances of their students on both parts of the Portland Science Test were significantly inferior to the performances of the students in the previous year. There was no significant difference in the performances between students using the new text with in-service materials and those using the new text in distant schools.

Conclusions

Patterns and Processes of Science is a radically new general science course because it emphasizes quantitative processes. The teachers believed that this emphasis was the chief cause of the decline in performances on the Portland Science Test.

The in-service program created the circumstances in which

188 teachers could present a modern science program. These teachers equaled the standards of those few capable and enthusiastic teachers who chose the same new textbook for use in distant schools.

The Comparative Effects of Three Seventh-Grade Science Programs with Different Laboratory Materials

by

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INTRODUCTION

New Science Programs in the Catholic Schools

On October 4, 1957, scientists of the Soviet Union successfully launched the first man-made satellite into outer space. The American people responded by demanding improvement in our whole system of science education. Within a few years, many new science programs were developed. Recently these new programs have been adopted by many public schools and private schools.

In 1966 Neuwien (74, p. 16) observed that the statistics compiled by the National Science Foundation seem to indicate that the new methods of teaching science are being used more widely in Catholic than in other schools. The journals of Catholic education have strongly advocated the new science programs and the new methods of teaching. For example, Conley (29, p. 4) wrote in the Catholic School Journal of December, 1965:

> Science is a process, a method of discovery and interpretation, which must be taught from the earliest grades onward and upward . . . Only the teacher who understands science can teach science.

Catholic Science Textbooks

The recent adoption of new science programs in Catholic schools reveals new attitudes among these educators. A few years ago, the science textbooks used in grades seven and eight were usually written exclusively for parochial schools. Many sisters had presumed that textbooks used in the American public schools contained a philosophy, a methodology, and an emphasis which were hostile to the doctrines of the Roman Catholic Church.

In 1962 La Noue surveyed the so-called Catholic textbooks in the secular areas. La Noue (60, p. 255-256) noted that Pope Pius XI's encyclical The Christian Education of Youth requires that all textbooks must be regulated by the Christian spirit. This survey uncovered many intrusions of the Catholic world view in science and even in mathematics.

In 1958 Father Fichter presented a report of a year-long study made by a team of sociologists in a Midwestern urban grade school in a typical Catholic parish. Father Fichter (36, p. 299) observed:

> Except for the arithmetic texts, all of the others are deliberately written from the "Catholic point of view," and this means that the over-arching and unifying standard of education is religion.

In 1964 Smith (95, p. 80), director of the Philosophy of Science Institute at St. John's University, Jamaica, New York, wrote:

> In practice, science contains a philosophical

> component, and to that extent it is just as tangential to religion as was Aristotle's philosophy when it threatened theology in the thirteenth century. This philosophical factor, at least implicit in our actual textbooks of science, creates the need in Catholic education for special science textbooks.

Smith and Sister Mary Nicholas (35, p. 4) in the Teacher's Guide for the textbook Science and Life explained:

> There should be an ordering of science to the understanding of religious truths. . . . A series of books for the Christian elementary school will . . . make sure that any philosophy which naturally finds its way into elementary school science will be what reality calls for.

Nevertheless, in 1967 Donceel (32, p. 580) observed that traditional Catholic philosophy is "on the way out." Father Hague (45, p. 277) explained that the new generation of Catholics is oriented more toward the "scientific-democratic than toward the dogmatic-authoritarian." In recent years the number of science textbooks designed for use in Catholic schools has been declining rapidly. The 1966 Bibliography of Science Courses of Study and Textbooks Grades 1-9 published by the National Science Teachers Association (73, p. 17, 23) includes only one series of textbooks for Catholic schools: Science and Life by Sister Mary Nicholas Farley and Vincent Edward Smith.

Smith's article in a 1964 issue of America magazine was answered by many letters to the editor. Barleon (9, p. 208) wrote: "I do not view modern natural science as impregnated with hidden anti-Catholic philosophy." Sister Rita Jean (90, p. 270) saw no need for demanding that present-day scientists should conform to the language of scholastic philosophy. Sister Virginia Maureen (108, p. 270) wrote: "To insist on 'Catholic' science textbooks would be to spoon-feed students and insult teachers." Harrigan (47), a salesman for the company which publishes Smith's series of textbooks, admitted that Smith's philosophical position had aroused much protest and had discouraged the sale of the series.

Within the last few years, articles in Catholic magazines have unanimously encouraged the introduction of the philosophy of science education found in the new science programs which are also used in the public schools. For example, Keeslar (56, p. 45) wrote in his article Process, the Elementary Science Teacher's Prime Target:

> We'd be teaching them to appreciate the effectiveness of . . . the scientific methods of inquiry in seeking answers to everyday problems. . . . In a real sense, we'd be preparing them to become independent, life-long students of the world they live in.

Similarly Clark (27, p. 32) in a recent issue of the Catholic School Journal explained:

> There is strong emphasis on the basic objective of modern science teaching - developing in students the mental attitudes and skills which will help them make discoveries on their own.

The Second Vatican Council (1962-65) began for modern Catholics an age of openness to communication and new ideas. The demand for Catholic science textbooks has been rapidly declining because most Catholic teachers no longer fear using science books written by non-Catholics. Few American Catholics today believe that science needs a special religious interpretation. The new emerging attitude among parochial school teachers is an eagerness to present the best possible science programs, without regard for scholastic philosophy.

Science in Catholic Schools

During the last few years Catholics have sincerely been attempting to re-examine the philosophy and the effectiveness of the American parochial school system. The major surveys which have been published within the last two years show that the most neglected subject taught in these schools has been science. Some Catholic educators are now insisting that this situation must be corrected promptly.

The need for improving science education was indicated by the April, 1967, issue of the magazine U. S. Catholic (49, p. 18) which presented an exclusive report on a nationwide survey of Catholic schools. The superintendents were asked to list the subjects taught at the elementary level which are in need of improvement. From a sample of fifty selected systems, forty-two superintendents stated that science needed improvement. While they were almost unanimous in mentioning the need of improving science education, only thirty-one of the fifty gave the second ranking subject of need (physical education). These superintendents were also asked to list the subjects in which Catholic Schools excell in teaching. Only five systems claimed excellence in the teaching of science. The subject of reading is in an inverse relationship to science because forty-two of the systems claimed excellence in reading.

In 1966 Neuwien (74, p. 77) edited Catholic Schools in Action: The Notre Dame Study of Catholic Elementary and Secondary Schools in the United States. He noted that the achievement of twelfth graders in forty-one Catholic high schools was certainly lower in science than in any other achievement area. The other areas considered in this study were language arts, social studies, and mathematics. Neuwien (74, p. 271) also observed that 94% of the parents identified as "highly important" the goal of teaching children to read and write clearly and well. Slightly more than 70% of these parents rated the schools as highly successful in meeting this goal. On the other hand, 86% gave high importance to teaching arithmetic and science. But only 54% believe that there is high success in this area.

The Notre Dame Study (74, 85-87) also shows that the staff of secondary schools has considerably more training than the elementary staff. Because the teachers rarely remain in one school for many years, it seems obvious that teachers with good preparation in science are soon transferred to the secondary schools. In general there are few teachers in the Catholic elementary schools who have strong preparations in science. Because Catholic junior high schools are extremely rare, these elementary schools include grades seven and eight.

Sister Mary Ambrosia (2, p. 24-26), Secretary of the Curriculum Advisory Committee on Science, National Catholic Education Association, recently reported:

> Our survey reveals that secondary science courses in Catholic schools are: a) predominantly traditional or modified traditional; b) college oriented; c) text centered. . . .
>
> By way of summary of the preceding data we recommend:
>
> 1. Administrators need to give the secondary science teachers the time and the opportunity to study the modern courses in science. In-service institutes and workshops need to be promoted. . . .
> 2. When a teacher is actually teaching the laboratory-centered course, he must be given adequate preparation time for successful teaching.
> 3. Teachers and students must have access to a laboratory and to apparatus. . . .
> 4. Administrators and science teachers need to give some serious consideration to the possibility of offering a second unit of credit in biology, chemistry, or physics.
> 5. The science curriculum at the elementary and junior high levels needs to be upgraded and strengthened. Science teachers in grades 1-12 need to establish lines of communication. This recommendation is obviously the most far-reaching of the five.

Today most large public school systems have junior high schools with specialized science teachers. On the other hand, most Catholic parochial elementary schools have a single class for each grade (one through eight). Traditionally these classes have been self-contained; the nun who is teaching the class must be an expert in about ten different subjects. Recently Novak commented (76, p. 276):

> Nuns of today carry staggering work loads; many sisters face thirty-five hours of teaching a week, plus a turn at cooking supper at home, plus prayers and housecleaning, and after-school and weekend catechetical assignments. Sister is not allowed to stop for a nap, or to take recreation except at specified times, in specified ways. She rarely has a chance to be alone.

Stotler (97, p. 13), Supervisor of Science for the Portland Public Schools, has described the need for science experts to teach in grades seven and eight. Recently there has been a gradual trend in Catholic parochial schools toward departmentalization which allows specialization. Sister Mary Eugene (34, p. 78) in 1967 reported:

> Departmentalization may be viewed as a plan for grouping pupils so that a teacher may specialize in the teaching of two or three subjects. A study made in 1962 indicated that some departmentalization existed in 36% of the schools surveyed. Recent statistics show that there is a trend toward more and greater departmentalization as the schools make the transition to the "new" foreign language, and "new" mathematics, and the "new" science.

Sister Mary Eugene also explained that the new science programs require science specialists in specially equipped rooms.

Guerin for many years has been the National Curriculum Consultant on Catholic Schools for the D. C. Heath and Company. Guerin (44) observed that Catholic schools in the United States are following the trends in science curriculum development. But they are usually far behind the progress in the public school districts. Very few Catholic school teachers are involved in the development of the many science projects which are dominated by public school teachers. There is no group of Catholic educators developing a truly modern science program for grades seven and eight.

The surveys published within the last two years have revealed the need for improving the standards of science education in especially grades seven and eight of the Catholic schools in the United States. The recognition of this need has urged Catholic educators toward improving the preparation of the science teachers. Publications have emphasized the value of in-service programs for the improvement of standards. The next section will describe some of the efforts toward developing such needed programs for the science teachers.

Science In-Service Programs

The new science programs differ from the traditional science courses both in content and methodology. If a teacher does not understand the new concepts of "the process approach," "the investigative laboratory," and "the quantitative approach," she may quickly become disappointed with the new science materials. The authors of the new science programs strongly recommend that teachers should enroll in an in-service program before they attempt to present any of the new science materials. Usually the adoption of the new science programs depends upon the development of appropriate in-service programs.

In 1966 many Catholic educators were advocating the development of science in-service programs. Conley (30, p. 4) wrote in the Catholic School Journal:

> The teacher must attend institutes, summer workshops and systematic programs of in-service training and keep up his regular reading about developments as a starting point for effective science teaching.

Sinevich (93, p. 62) explained in The Catholic Educator: "There should be enough in-service programs for enrichment purposes or upgrading."

Clift and Keys (28, p. 125-126) in What is Happening to Catholic Education? also in 1966 noted three great changes which seem to require the introduction of in-service programs. These changes have occurred in the areas of (1) learning theory, (2) federal legislation, and (3) the accumulation of knowledge.

Clift and Keys (28, p. 126) have listed the major tenets of modern learning theory:

a) Learning results in a change in behavior. . .

b) Persons learn best in a problem-solving situation. . .

c) Behavior, for the most part, is goal-oriented. . .

d) Learning is more apt to take place after feelings have been clarified and needs met than by providing information. . .

e) The learner must experience success and some satisfaction in an activity. . .

Clift and Keys (28, p. 127) have explained the new opportunities for obtaining financial support.

> An interesting feature of recent legislation is the concern for parochial and private education. With assistance being given to individuals rather than institutions, unprecedented possibilities present themselves to parochial and private schools. Early acts provided NDEA funds which enabled schools to upgrade their mathematics, science, and foreign language programs through better equipment for laboratories, improved curricula, and new equipment such as audiovisual materials for teaching. In some states, consultant services of departments of public instruction are being made available to parochial schools.

Finally Clift and Keys (28, p. 128) demand more in-service programs because of the rapid accumulation of knowledge.

> The knowledge explosion has created curriculum problems never before experienced by man. It is estimated that man's knowledge doubles every decade, that more new knowledge has been developed during the past two decades than during the entire period from the dawn of civilization to the turn of the twentieth century, and that 90 percent of all the scientists that have ever lived throughout civilization are alive

> today. . . . Better means for utilizing, classifying, and communicating our knowledge, in all phases of the curriculum, is a problem that school personnel ought to be studying through in-service education programs.

Many other articles in Catholic publications have recently advocated in-service programs. These statements of Catholic educators have followed the leadership of the many American science teachers who have promoted the development of in-service programs through their recent articles and books. The next section will refer to a few of these statements recently found in the literature which is not designed exclusively for teachers in the parochial schools.

The Need for In-Service Programs

In recent years many American educators have stressed the need for in-service programs in order to introduce the new science programs. Bruner (19, p. 89) placed in-service institutes among the measures "that must be taken to improve the quality of teachers." Kageyama (55, p. 2) observed:

> Giving children direct experience with materials and allowing them to do individual experiments makes different demands upon the teacher than a traditional science program.

Fingal (64, p. 16) said:

> Teachers cannot get involved by simply reading the manual. They should experience the same kinds of things they will be asking of their students. Teachers have to be given an opportunity to

> manipulate materials, raise questions, communicate with colleagues in the total program.

Nichols (75, p. 91-92) explained that in-service workshops have helped teachers to become excellent in presenting the new science programs.

Aylesworth (7, p. 15) has noted that teachers can easily discourage students from the use of critical thinking. Kessen (57, p. 100-101) explained that the inadequate preparation of teachers in science has been the most important factor in retarding the development of effective science education. Brandwein (14, p. 4) has accused the liberal colleges of generally failing to prepare science teachers. This failure requires the greater use of in-service programs. Glass (39, p. 23) has observed: "The science teacher must be prepared to engage himself in a never-ending continuation of his education."

In 1963 Obourn (77, p. 75) commented: "In-service education of one kind or another for teachers of science has been practiced for some time by colleges, universities, and school systems." During the last decade grants from the National Science Foundation have supported a large number of in-service programs designed to help teachers who were introducing new science programs into their schools. Many parochial school teachers, especially teachers of grades ten, eleven, and twelve, have participated in these in-service programs. The science teachers of grades seven and eight in the Catholic schools have often lacked the prerequisites for acceptance into the programs sponsored by the National Science Foundation.

Science In-Service Programs in Catholic Schools

Science education in the Catholic schools of the United States is weakest at grades seven and eight. While junior high school students are able to enjoy rather challenging experiments, their teachers in the Catholic schools frequently have little preparation in college science courses. These teachers are tempted to minimize science education because of the relative difficulty of the science materials for the junior high schools.

In recent years Catholic school systems have provided some in-service programs for the science teachers of grades seven and eight. These in-service programs fall into three categories according to type of instructor presenting the in-service meetings. The first type is the representative of the publisher, usually the author of the textbook. The second type is a generous volunteer, usually a high school teacher. The third type is a professional college science teacher, usually receiving a salary for these services from a highly formal program.

The publishers of textbooks have representatives to explain the merits of their books to prospective purchasers. In recent years many publishers will also provide in-service programs to help teachers who are introducing the new textbook. Usually such in-service workshops are one-day meetings of about six hours. For example, on August 28, 1967, the authors of Patterns and Processes of Science, Laboratory Text No. 1 gave a one-day workshop to the junior high school science teachers from the parochial schools of the San Francisco Bay Area. The same workshop was presented on October 7, 1966, at Cardinal O'Hara High School for teachers of the Archdiocese of Philadelphia. During the academic year of 1968-69 five one-day workshops by consultants from publishing companies are planned for the science teachers in the Archdiocese of Detroit. Such workshops are of very limited value because they consist of a few speeches given to large audiences.

Science supervisors in some Catholic school systems have attempted to organize in-service programs conducted by high school teachers who will volunteer to help elementary school teachers. Although many Catholic high schools have highly qualified science teachers, the elementary schools usually are without science specialists. In recent years many science teachers of Catholic high schools have participated in institutes sponsored by the National Science Foundation. Frequently these well-trained teachers wish to give help to less fortunate members of their religious community. For example, Sister Mary Clarice provided an in-service program for science teachers of grades seven and eight in San Francisco during the school year of 1963-64. Her program collapsed in San Francisco when she was transferred to Los Angeles. But in Southern California she organized several high school teachers to present similar in-service workshops. However, she was unable to maintain these workshops during the year 1967-68 because the volunteer high school teachers complained against excessive work and poor results.

Usually the in-service programs provided by volunteer high school teachers are very unstable both in terms of the duration of the programs and the quality of the workshops. Because the science teachers in Catholic high schools are generally burdened with excessive numbers of students and relatively small budgets, they have little time or energy for helping elementary teachers. Often the high school teachers do not meet the needs of the elementary teachers simply because there is not enough time for communication. The elementary teachers may become discouraged because the in-service classes may consist merely of lectures to large groups. Moreover, these teachers rarely have the materials to perform experiments when they return to their elementary schools.

Probably the most successful in-service programs for science teachers of grades seven and eight have been those which were sponsored by grants from the National Science Foundation. The Guide to Programs (71, p. 43) of the National Science Foundation provides the following description of in-service institutes:

> The National Science Foundation awards grants that provide supplemental science or mathematics instruction for secondary school teachers through institutes that meet after school hours or on Saturdays.
>
> A typical in-service institute meets once a week for periods of 2 to 4 hours for a full academic year. These institutes enable teachers to obtain additional knowledge of subject matter and/or to become acquainted with important new textual and laboratory materials developed by a number of course content study groups.
>
> Organizations eligible to apply for grants to support In-Service Institutes for Secondary School Teachers are universities and colleges that grant at least a baccalaureate-level degree and other nonprofit organizations. . . .
>
> To be eligible to attend an In-Service Institute for Secondary School Teachers an individual:
>
> 1. Must be a supervisor or teacher of science or mathematics in grades 7-12;
> 2. Must live within commuting distance of the institute he desires to attend.
>
> In addition, individual institutes establish specific academic prerequisites for admission; their brochures should be consulted for details.

An example of an In-Service Institute for Secondary School Teachers is the Fundamentals of Geology Institute of the University of Notre Dame, Indiana. The Director of this Institute is Father Michael J. Murphy, C. S. C. During the school year of 1969-70 the In-Service Institute will be taught in Chicago. The teachers attending these classes will receive free tuition, travel, and books. The brochure for this Institute explains that the University of Notre Dame will not discriminate on the grounds of race, creed, color, or national origin of any applicant or participant. Nevertheless, the University of Notre Dame will probably attract applicants primarily from Catholic schools.

A disadvantage of this In-Service Institute is the fact that the content of the course is not directed toward immediate presentation to students in grades seven to twelve. The In-Service Institute is part of a three year program leading to the degree of Master of Arts in Teaching Geology. Moreover, there is no attempt to supply the teachers with materials for teaching geology through a laboratory program.

The National Science Foundation also supports the Cooperative College-School Science Program which seeks directly to improve the teaching of science within a selected school system. The National Science Foundation (72, p. 2) provides the following explanation:

> Projects supported by the CCSS Program are as diverse as the problems requiring cooperative efforts between college and school. The common ingredient in them is a cooperative attack by a college or university and a school or group of schools to effect improvements in science and mathematics programs of those schools. The projects thus involve a double commitment. The schools commit themselves to the reforms in their science or mathematics programs which have been developed as a result of the collaboration; the co-operating higher educational institution assumes a responsibility to assist the schools.

An interesting example of a Cooperative College-School Science Program received the following brief description in the 1968 Directory of the National Science Foundation (72, p. 11):

> ROOSEVELT UNIVERSITY, Chicago 60605; Introductory Physical Science; summer: 2 weeks, August 19-30, 1968; 20 Saturday morning meetings during academic year 1968-69; 60 junior high school teachers who will teach IPS in the Chicago schools next year. These teachers will receive training and assistance with the new IPS materials. Dr. Robert W. Estine, Department of Physics.

In the proposal for this program Estine (33, p. 2, 9) wrote:

> At the suggestion of the Archdiocese of Chicago School Board, Roosevelt University is proposing to offer a program during 1968-69 in the recently developed junior high school science course Introductory Physical Science (IPS). . . . The selection of participants and the arrangement of visits to IPS classes, as well as the analysis of the total project will be carried on with the close cooperation of Sister Mary Ivo, BVM, Science Coordinator and Consultant for the Archdiocese of Chicago School Board.

The Cooperative College-School Science Program is extremely effective in bringing improved teaching into the classrooms. Unfortunately the Archdiocese of Chicago is unique among Catholic school systems in developing such a program. Nevertheless, many individuals who teach seventh- or eighth-grade science classes have been participants in the in-service institutes for secondary school teachers provided by many colleges and universities through grants from the National Science Foundation.

Perhaps the chief disadvantage of the in-service programs sponsored by the National Science Foundation is the limited number of teachers who may participate. In 1965 the Archdiocese of Detroit attempted to help all of the science teachers of the parochial schools through six television programs. Curriculum consultants from the Archdiocesan office wrote and presented the half hour weekly telecasts. The University of Detroit TV studio was used for the broadcast. The Archdiocese bought time for the local channel WTVS, an educational channel for the Detroit Public Schools. Probably there was little demand for continuing this series because the Archdiocese of Detroit offered the television programs for only one year.

The preceding description of science in-service programs in Catholic schools has been a brief summary which stressed the variety of programs. The next sections will discuss in detail the history, goals, and structure of the 1967-68 science in-service program of the Archdiocese of San Francisco.

The Science In-Service Program of San Francisco

The San Francisco Bay Area is famous for research and development in the sciences. The parents of many students in the Catholic schools of the Archdiocese of San Francisco are professional scientists. These parents have often suggested more adequate science education for the students in grades seven and eight.

Recently there have been sincere attempts to improve the quality of teaching science in these parochial elementary schools of grades one through eight. (There are no distinct Catholic junior high schools in Northern California.)

In the Archdiocese of San Francisco, Sister Mary Clarice pioneered an in-service program for science teachers of grades seven and eight. Sister M. Clarice (26) has described its history:

> When I returned from Oak Ridge in the Fall of 1960 where I was trained to stimulate an interest in science and science teaching, I found for the most part that there was little or no science teaching being done. I hope I do not exaggerate. My plan was definitely an intermediate one. . . . In my mind that was a single step in the process of the development of a true science program that would be the result of a more scholarly approach.

During the summer of 1960, Sister had spent thirteen weeks at the Oak Ridge Institute of Nuclear Studies where she was given $1200 worth of scientific equipment. During the years 1961 and 1962 she used this equipment in sporadic workshops; these two-hour sessions were presented in Arizona, California, and Oregon to stimulate interest in science education. Although she aroused the interest of many teachers, most of the parochial schools in this area continued to neglect the teaching of science. Usually these schools had relatively old science textbooks which remained on the shelf and unused throughout the entire school year. A typical example of such a textbook was <u>Science and Living in Today's World</u> by Sister Mary

Raphael, S. S. J. and Sister Monica Marie, S. S. J., who explain in their introduction that this book will give the Christian philosophy of science. This seventh-grade text was published in 1955 by the Catholic Textbook Division of Doubleday and Company.

During the academic year of 1963-64, Sister Mary Clarice presented an in-service program for science teachers of grades seven and eight. Approximately ninety teachers came on Saturday mornings once each month to Immaculate Conception Academy in San Francisco. During each three-hour workshop, half of the time was spent in listening to lectures on science; the other half was used in doing laboratory work or in studying motion pictures. Sister Mary Clarice gave the teachers a sixteen-page Tentative Outlines Grade 7 - Science and also Tentative Outlines Grade 8 - Science in fourteen pages. In general, these outlines follow the sequence of typical junior high school science textbooks of that time. Sister intended that these outlines would guide only those who attended the monthly workshops.

In September, 1964, Sister Mary Clarice became Curriculum Coordinator for the Department of Education in the Archdiocese of Los Angeles. When she left the San Francisco Bay Area, her in-service program ceased. Nevertheless, the Department of Education for the Archdiocese of San Francisco continued to distribute her outlines to the science teachers of grades seven and eight. These replaced any recommended textbook. The turnover of teachers in the parochial schools is at a rate of about thirty percent each year. Soon the new teachers in these parochial schools of the San Francisco Bay Area began to abandon the teaching of science.

At the beginning of the academic year 1966-67, Sister Mary Claude, an elementary school supervisor in the Department of Education in the Archdiocese of San Francisco, attempted to improve science education in grades seven and eight. She organized a committee of twenty-two nuns who were interested in selecting an appropriate textbook for these grades. Although this committee listened to the explanations of salesmen for many hours, these nuns were unable to agree on the selection of any one book. Their votes were rather evenly distributed over four different texts. Moreover, they failed to define the goals of science education or the criteria for selecting a textbook.

In December, 1966, Sister Mary Claude organized a new committee which consisted of four experienced high school teachers. On March 22, 1967, this new committee made the series of recommendations which guided the formation of the 1967-68 science in-service program of the Archdiocese of San Francisco. The goals and structure of this program will be described in the next section.

Goals of the San Francisco Program

In April of 1967 the Department of Education of the Archdiocese of San Francisco accepted the recommendations of the committee of four experienced high school science teachers. These master teachers were placed in charge of developing the in-service program which they had recommended. They clearly recognized their task in the words expressed by Conley (30, p. 4) when he wrote in the Catholic School Journal:

> The task before us in vitalizing science instruction is threefold: (a) rethinking of the objectives and the curriculum, (b) continuing education of science teachers, and (c) providing modern equipment.

The goals of the in-service program were defined in a similar threefold manner. First of all, the objectives of the new curriculum stress the learning of the process of science through discovery. Secondly, the science teachers must be specialists who will appreciate the appropriate role of the teacher in the environment of the laboratory. Finally, the in-service program must provide these teachers with sufficient equipment and materials that they may be able to present a laboratory-centered course.

On April 28, 1967, the following statement was mailed from the Department of Education of the Archdiocese of San Francisco to all pastors and principals of elementary schools in this area:

After year-long deliberation and consultation with classroom teachers, textbook authors and publishers, and other specialists, the Department of Education has adopted plans for a new science program for grades 7 and 8 to begin in all schools in September, 1967. This memorandum includes only preliminary information. . . .

MAIN FEATURES OF NEW PROGRAM

(1) Laboratory experience will constitute the substance of the course. Plans for space and equipment requirements are noted below.
(2) Time allotments for science in grades 7 and 8 will remain 100 minutes per week, preferably in two 50-minute periods weekly.
(3) Grades 7 and 8 will take the same course and use the same textbook and equipment during the first year of the program.
(4) Science specialists must be designated in each school to be primarily or exclusively responsible for the program in both grades. Double schools may have to designate two specialists.
(5) An in-service program for these specialists will be an essential feature of the plan.

Patterns and Processes of Science, Book I by Brock, Paulsen, and Weisbruch, published by D. C. Heath and Company, is a paperbound laboratory text, which contains material for a two-year course, based on the time allotment of 100 minutes per week. Cost will be approximately $2.25 per book. Note that one set of books will serve both grade levels. Order forms will be sent by D. C. Heath directly to each principal, who will then place her order directly with the publisher.

Equipment and materials required for the course are now being inventoried. In the near future, minimum equipment requirements, costs, and instructions for ordering will be sent to all schools. We do not expect the per pupil cost for equipment to exceed the normal cost of a new cloth-bound textbook. (It has been suggested that the financing of laboratory equipment would be a very attractive project for parents' groups.)

> Space requirements for the program will not be extensive or complex. Guidelines for the arrangement of classroom, cafeteria, or other space for laboratory purposes will be provided. The Department expects to be able to provide a resource person to visit schools on request during the summer to advise principals on the best utilization of space for the laboratory needs.
>
> The science specialists designated by the principals will be responsible for all science instruction in grades 7 and 8 and will be expected to attend a special in-service program now being planned. Details will be sent as soon as available. We expect to offer a two-day program in September, followed by regular sessions every three or four weeks throughout the year.

The two-day program was later scheduled for August 28 and 29 at Presentation High School in San Francisco. One hundred and ninety-seven teachers attended this opening meeting of the in-service program. These teachers came from 146 parochial schools which have more than 14,000 students in grades seven and eight. Each teacher received a copy of the Tentative Time Schedule which is Appendix V of this study. This schedule gives the appropriate dates for presenting the materials of the laboratory text. At the monthly meetings of the in-service program the master teachers explained the materials scheduled for the month. The master teachers spent less than half of the three-hour monthly meetings in giving explanations and answering questions. The teachers used at least half of the time at each meeting in performing the scheduled experiments.

The Distribution of Laboratory Materials

The most central function of the monthly workshop meetings for the science teachers of grades seven and eight in the parochial schools of the San Francisco Bay Area was the distribution of laboratory materials. At each meeting each teacher received a box of equipment and materials for the experiments of the month. The teachers then learned how to use these items through performing the experiments. The master teachers focused their efforts upon presenting these experiments and answering the questions of the teachers.

Most of the parochial schools of the San Francisco Bay Area previously did not attempt laboratory work simply because these schools lacked equipment and materials. In 1966 Father Greeley (42, p. 221, 227) reported on the extent of this problem in the Catholic schools of the United States:

> The most common criticisms of the schools have to do with their physical facilities. . . . It appears that the major problems the schools face are increasing the number of facilities available and at the same time improving quality of instruction.

Because the obtaining and use of laboratory materials are of central importance in the developing of new science programs in grades seven and eight of the parochial schools, this study will compare three science programs with different laboratory materials.

The first program is the older traditional course which is substantially without laboratory materials. The second program is the 1967-68 science in-service program of the Archdiocese of San Francisco. This program supplies laboratory materials to the teachers through the in-service meetings. The third science program is one which uses the same new textbook which is used in the Archdiocese of San Francisco. But in the third program the teachers do not have the help of an in-service program and must order their own laboratory materials directly from scientific companies.

Significance of the Study

The 1967-68 science in-service program of the Archdiocese of San Francisco attempted to help the teachers who were assigned to present a modern science curriculum to the students of grades seven and eight. The potential problems of these teachers and students were clearly and sympathetically recognized. In order to meet their needs, many innovations in the organization of an in-service program were introduced. Because of these unique features the effects of the new science curriculum introduced through this in-service program deserve special attention and analysis. The problem of this experimental study is to determine the effects of this in-service institute. One purpose of this study is to compare the performances of students enrolled in the older program of the Archdiocese of San Francisco with the performances of students enrolled in the new program introduced through the in-service institute. A second purpose is to compare students benefiting from this in-service program with students who used the same textbook but whose teachers lacked the help of an in-service program.

Criteria for Establishing an In-Service Program

The 1967-68 science in-service program of the Archdiocese of San Francisco is unique in Catholic education. Among programs sponsored by Catholic organizations, it is probably the only in-service program for science teachers of grades seven and eight which has fulfilled all the criteria provided in 1966 by the book What Is Happening to Catholic Education? In this book Clift and Keys (28, p. 129-133) gave the following twelve criteria for establishing an in-service education program:

1. The basis of any activity in in-service education programs is the improvement of education for children and youth served by the school.

2. In-service education programs may contribute to the growth and betterment of individual teachers.

3. The in-service program is made up of problems with significance for teachers.

4. The organization of the program should be such that there is provision for study and work by groups and by individual members, whichever the situation demands.

5. Goals and procedures of in-service programs must be formulated by persons affected.

6. There should be built into the organizational plan many opportunities for interaction by the people involved.

7. A climate of permissiveness, support, and mutual respect is essential for creative solutions to professional and personal problems.

8. Resource materials and consultants must be made available to persons working in an in-service education program.

9. Means must be provided for carrying through to action the results of the work of groups.

10. Provision for evaluation of all aspects of the program. There are two facts concerning evaluation that cannot be overlooked. The first is that evaluation is a continuous process, and secondly that it is most effective when it is done by the persons directly involved.

11. Develop within the organization sufficient flexibility to enable a number of different kinds of groups to function simultaneously.

12. The work of individuals and groups of persons must be coordinated and related internally and externally with activities of the school, community, and professional organizations.

The master teachers of the 1967-68 science in-service program of the Archdiocese of San Francisco attempted to fulfill each of the twelve criteria provided above. The way in which each criterion was fulfilled according to the plans of these master teachers will be given in the following twelve statements:

1. All activities of the in-service were designed to

assist the teachers in presenting Patterns and Processes of Science to the students.

2. The individual teachers not only learned much about science but also became familiar with a new method of education, the discovery approach.

3. The problems solved by the in-service program were of immediate and great significance to the teachers because they used these solutions in presenting the course to their students.

4. The organization of the program provided the teachers with the opportunity to discuss their problems with a small group of four or five other teachers who were working at the same laboratory table. Each teacher had the opportunity to do the experiments individually and to question the master teacher or his assistants.

5. On the first day of the in-service program, the teachers were given encouragement to state desirable goals and procedures. Questionnaires, interviews, and discussions throughout the year constantly helped to keep the goals and procedures formulated by the persons affected.

6. There were built into the organizational plan many opportunities for interaction by the people involved. Many teachers stated that the most valuable aspect of the in-service program was the opportunity to discuss their problems of teaching science with other teachers.

7. A climate of permissiveness, support, and mutual respect was established at all meetings. The staff of the in-service program clearly saw their role in terms of assisting other professional teachers. The suggestions and observations of the elementary teachers were constantly sought and appreciated.

8. Resource materials and consultants were available to persons working in the in-service program. The staff of the in-service program supplied the laboratory equipment and materials for the schools. The

master teachers were eager to help teachers with individual problems. The master teachers themselves received help from the authors of the text, the publishers of the text, and Catholic School Purchasing Division of the Archdiocese of San Francisco.

9. The work of all groups was carried through to action. The meetings of the master teachers with themselves and with their assistants were preparations for presenting the workshops. The in-service workshop meetings prepared the teachers to present the course to their students.

10. Evaluation of all aspects of the program was a continuous process under the direction of one researcher who was also a master teacher of the in-service program. This researcher helped initiate the program from its beginning. At approximately the same time when the program was publically announced, he was testing a control group for comparisons. Throughout the program he provided questionnaires, tests, and interviews.

11. The organization of the in-service program allowed several different kinds of groups to function simultaneously. Each of the four sections under its own master teacher operated distinctly and independently according to the directions of the master teacher. Nevertheless, the master teachers themselves met as a group. The group which purchased and distributed the laboratory materials had many members who were not otherwise directly involved in the in-service meetings.

12. The work of individuals and groups of persons were coordinated and related internally and externally with activities of the school, community, and professional organizations primarily through the cooperation of the Departments of Education of the Archdiocese of San Francisco and the Diocese of Oakland. Official directions were sent from these Departments to the principals of the schools and to the science teachers. The master teachers met monthly with representatives of the Departments.

> The Departments referred representatives of the community and professional organizations to the staff of the in-service program.

Unique Features of the San Francisco Program

The 1967-68 in-service program for science teachers of grades seven and eight in the Archdiocese of San Francisco has six unique features which distinguish it from other in-service programs provided for junior high school science teachers of the parochial schools. The first unique feature is the order from the Department of Education of the Archdiocese of San Francisco by which the principals were required to designate a science specialist who would attend the meetings of the in-service program. Other in-service programs are open to volunteers who wish to participate. Moreover, the San Francisco program includes an unusually large number of participants because it requires the participation of every seventh- or eighth-grade science teacher in the entire school system.

The second unique feature of the San Francisco program is the centralized purchasing and distribution of laboratory equipment and materials. Other in-service programs leave the purchasing of materials in the hands of the individual teacher or school. But the Archdiocese of San Francisco required each school to purchase a "kit" of equipment and materials for all of the experiments of the year.

The third unique feature is the work of the staff in modifying the pilot edition of the text. Many experiments were changed. The staff sent its suggestions to the authors of the text to contribute to the revision of the pilot edition before the publication of the first regular edition. Therefore, there was an active participation in the development of a new experimental science program. Other in-service programs in parochial schools simply introduce a new science program. A few Catholic schools have participated in pilot programs for new science texts. But these individual schools have not been participating in an in-service institute sponsored by a Catholic school system.

The fourth unique feature of the San Francisco program is the relationship between the staff of the in-service program and the cooperating college. When the National Science Foundation supports in-service programs with grants, members of the faculty of a college or university are responsible for directing and presenting the program. On the other hand, the College of Notre Dame, Belmont, merely accepted the staff of the San Francisco in-service program as professionally competent. The staff of the in-service program consists of experienced high school teachers who have at least the degree Master of Science. The College of Notre Dame recognized the researcher of this dissertation as the instructor of Science in Junior High School. The College itself participated in the in-service program only by collecting the registration fee and recording the grades.

A fifth unique feature is the development of a special testing program for the in-service participants. At each of the monthly workshop meetings a test for the students was distributed to all of the teachers. One of the major purposes of these tests was to guide the teachers toward emphasizing the most important aspects of the course. Local norms were established for these tests to suggest standards of achievement. Other in-service programs in Catholic schools lack such immediate local testing programs.

Finally the sixth unique feature which distinguishes the in-service program of 1967-68 in the Archdiocese of San Francisco from other in-service programs for science teachers of grades seven and eight in parochial schools is the quantity and quality of evaluation of this program. The majority of teachers in the San Francisco program completed three written questionnaires. These questionnaires were done at the beginning, middle, and end of the academic year. The comparative effects of the program were studied by using the Portland Science Test. The seventh-grade students in seven selected schools of the Archdiocese of San Francisco were compared by administering this Test in May of 1967 and in May of 1968. The same Test was also administered in six distant parochial schools in May of 1968 to isolate the effect of the in-service meetings from the introduction of the new textbook. Moreover, many teachers were interviewed privately; group discussions on evaluation were monthly.

Anthony E. Seidl, Assistant Professor of Education at the University of San Francisco, is the Project Director of Seminars on Catholic Schools for Long Range Planning. The Ford Foundation is supporting this project. On April 16, 1968, Anthony Seidl explained to the researcher that the great problem of Catholic education is the almost total lack of self-evaluation and self-criticism. Although he had visited countless Catholic schools across the nation, he found that Catholic educators were making serious evaluations of their schools only during the process of accreditation. In general, Catholic school systems lack the administrative staff required for producing questionnaires or statistical studies. Although Archdiocesan tests and achievement-placement tests are commonly given, the results of these tests are rarely used for re-examining curriculum offerings.

The Archdioceses of Chicago and Detroit have exceptionally excellent Science Coordinators. Nevertheless, they have depended primarily upon a few interviews in order to evaluate any new science program. On April 17, 1968, Sister Mary Ivo of the Archdiocese of Chicago explained to the researcher that she must rely on the judgments of the teachers who have used new programs. Sister Mary

Ambrosia (3) of the Archdiocese of Detroit wrote:

> Our seventh and eighth grade students take the test to accompany the texts in use in each school. We have not structured an evaluation instrument specifically for our schools. Student enthusiasm and personal satisfaction to teachers and parents indicate that learning is taking place in science classes.

The abstracts of recent dissertations do not include any studies on science education in grades seven or eight of parochial schools. Brother Anthony Wallace (114) of the National Catholic Educational Association was unable to discover any studies on in-service programs for science teachers of grades seven or eight or any other research on science education in grade seven of the parochial schools. Hence this evaluation of the effects from the in-service program in the Archdiocese of San Francisco may be unique.

In 1967 Father O'Neill (80, p. 183) described the lack of research in Catholic schools:

> American Catholic education should assume a new role in educational research and experimentation. The strongest - and almost the only - plea for this development has come, interestingly enough, from an educator outside the Catholic establishment, Myron Lieberman. In an address to the superintendents' division of the 1960 NCEA convention, Lieberman contended that Catholic education 1) was not even beginning to hold its own in educational research or experimentation, and 2) was in some ways more free to do such work than public education was. . . . Lieberman based his first contention upon information supplied by the Cooperative Research Program of the United States Office of Education and the Ford Foundation's Fund for the Advancement of Education, and

> upon the dearth of parochial school teachers involved in new curriculum projects and the almost total absence of Catholic researchers noted in leading textbooks.
>
> For over two years, I have attempted to continue Lieberman's "curbstone research" on the contribution of Catholic institutions and educators to research and experimentation, and I feel perfectly safe in stating that the picture is very nearly as dark as Lieberman painted it six years ago. Only a handful of Catholic educators enter the pages of scholarly journals and books in education: most of these writers were trained at non-Catholic universities, such as Harvard, Chicago, Wisconsin, Columbia, and Berkeley, and some of them - Fr. Fichter and Fr. Greeley, for instance - are "borrowed" from other disciplines. Few educational research studies of note came from Catholic institutions; the fare too often consisted of poorly done survey research that had little general interest even within Catholic circles. Catholic educational publications are almost totally devoid of anything that could be classified as genuine research.

This experimental study will attempt to contribute genuine research to science education in the Catholic schools.

Materials of This Study

The problem of this experimental study is to determine the effects of the in-service program for the science teachers of grades seven and eight in the Archdiocese of San Francisco. This in-service program introduced a modern science curriculum which emphasized the process approach, the investigative laboratory, and the quantitative approach. The effects of this in-service program on the teachers will be measured through questionnaires and interviews. The effects of this in-service program on the students will be measured especially by the Portland Science Test.

Questionnaires and Interviews for the Teachers

The teachers participating in the in-service program completed three questionnaires. The first questionnaire at the beginning of the year required a listing of courses taken in science, mathematics, and education. It also required an evaluation of the philosophy expressed by the authors of Patterns and Processes of Science at the in-service meetings in August, 1967. The second questionnaire was prepared by D. C. Heath and Company for a national survey of comments from users of Patterns and Processes of Science. This questionnaire was distributed to the teachers in February of 1968. The third and final questionnaire at the end of the school year asked for an open-ended, long essay-type of evaluation. Through these questionnaires the teachers were able to show their attitudes toward science, the in-service program, and the role of the teacher in the classroom.

Many of the teachers participating in the in-service program were interviewed. Often strong attitudes were expressed in interviews while the same attitudes were omitted or relatively hidden if they were expressed only on a written questionnaire.

Tests for the Students

The Portland Science Test was the instrument used to compare samples of students from different groups. The authors of this test have attempted to produce an instrument which places a minimum reliance on reading skill. This claim was considered locally by calculating the coefficient of correlation between the scores on the Burnett Advanced Reading Test and the scores on the Portland Science Test. A poor correlation would demonstrate that the Portland Science Test is independent of reading skills.

The Portland Science Test can be appropriately administered to students in grades four through twelve. This instrument evaluates knowledge of the ways in which scientists learn (processes) as well as what scientists have learned (products). Because the text used in the in-service program, Patterns and Processes of Science, Laboratory Text Number One, is designed for use in the seventh grade, the Portland Science Test in this study was administered only to seventh-grade students. The situation of teaching this same laboratory text to both seventh- and eighth-grade students was temporary; only during the year 1967-68 were both grades using the same materials and the same sections of the text. Nevertheless, a comparison was made between the performances of students in the two different grades by an analysis of specially prepared examinations which were distributed through the in-service program. Item analysis of these examinations can show any significant differences between students of the different grades.

Because the in-service program required the appointment of science specialists, the performance of newly appointed science specialists were compared to that of teachers who simply continued to teach science at the same school. This comparison was made through the scores of the students on the Portland Science Test.

The Portland Science Test was also used to compare the performances of students benefiting from the in-service program with performances of students using the same laboratory text but without teachers involved in an in-service program for that text. A special questionnaire was prepared for pairing schools within the Archdiocese of San Francisco with some beyond this area. Schools were matched if they both were using the same text for about one hundred minutes per week, were parochial schools of the same social and economic level, and had teachers with similar preparations and teaching experience.

The Advanced Science Test of the Stanford Achievement Test was used in only one school. This selected school of the Archdiocese of San Francisco had neglected science education during the academic year of 1966-67. The test was administered to contrast the effects of no science program with the effects of the new science program introduced through the in-service institute. This test was administered to students in both the seventh grade and the eighth grade.

Problem of This Study

The problem of this experimental study is to determine the effects of the 1967-68 in-service program for the science teachers of grades seven and eight in the Archdiocese of San Francisco. The goals and structure of the in-service program itself have already been evaluated above through using criteria provided by Clift and Keys. The problem of this study is to determine the effects of the in-service program on the teachers who participated in the monthly meetings and on the students who used the laboratory materials distributed through the in-service program. The teachers have described the effects of the in-service program through questionnaires and interviews. Multiple choice tests were used to measure the performances of students who had used the laboratory materials of the in-service program.

The 1967-68 in-service program introduced the use of Patterns and Processes of Science, Laboratory Text No. 1 which emphasizes the processes of science. During the previous year the older science program of the Archdiocese of San Francisco had stressed the products of science. The first purpose of this experimental study was to compare the performances of students enrolled in the older program with those of students enrolled in the new program introduced through the in-service institute. The performances of these students were measured by the Portland Science Test. Half of the questions of this test requires the use of the processes of science; the other half demands recall of the products of science.

The second purpose of this study was to isolate the effect of the in-service program from the effects of the new textbook. Students in the Archdiocese of San Francisco had the benefit of teachers prepared by monthly in-service meetings and the advantage of receiving laboratory materials distributed through the in-service program. The Portland Science Test was used to compare these students with parochial school students in comparable distant schools where the teachers had no monthly in-service meetings and no help in obtaining the required laboratory materials.

Hypotheses to be Tested

Four major null hypotheses were tested for significance at the 0.01 and 0.05 levels of confidence. Each of these four major hypotheses has two minor hypotheses: one considers scores on the questions concerning the processes of science; the other considers scores on the questions concerning the products of science. The major null hypotheses deal with total scores on the Portland Science Test.

In order to shorten the wording of the null hypotheses, the following definitions will be used. "Old program" is here defined as the use of Tentative Outlines Grade 7 - Science written by Sister Mary Clarice in 1962; these outlines were used during the year 1966-67 in the parochial schools of the Archdiocese of San Francisco. "New text" is here defined as Patterns and Processes of Science, Laboratory Text Number One by J. A. M. Brock, Donald W. Paulsen, and Fred T. Weisbruch. The pilot edition was published by D. C. Heath and Company for use during the year 1967-68. "In-service materials" is here defined as the equipment and materials obtained or produced by the staff of the in-service program in the Archdiocese of San Francisco during the year 1967-68 and distributed to the teachers through the monthly in-service workshop meetings. "Performances" in all of the following null hypotheses is qualified by the phrase "as measured by the Portland Science Test."

The major null hypotheses are numbered "1, 2, 3, 4." The minor null hypotheses have the letters "a, b." This study will test the following hypotheses:

1. There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials.

    a. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials.

    b. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials.

2. There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

a. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

b. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

3. There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

a. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

b. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

4. There is no significant difference in the performances between students using the new text with

in-service materials and those using the new text without these materials.

a. There is no significant difference in the performances to use the processes of science between students using the new text with in-service materials and those using the new text without these materials.

b. There is no significant difference in the performances to learn the products of science between students using the new text with in-service materials and those using the new text without these materials.

Assumptions

This study is based on the following assumptions:

1. The sample of students tested represent the population of the parochial elementary schools in the San Francisco Bay Area or similar areas.

2. The students in the control group and those in the experimental group are similar samples from the same population.

3. The teachers can express their abilities, attitudes, and needs through questionnaires, interviews, and essays.

4. The Portland Science Test is a valid and reliable testing instrument for measuring students' abilities to use the processes of science and to learn the products of science.

5. The staff of the in-service program can obtain appropriate materials for the experiments and can prepare the teachers to use these materials in the classrooms.

6. The "Hawthorne effect" may be operative through the in-service program for teachers because they will

be using the experimental materials for the first time. In order to counterbalance against this effect, the schools which are included in the testing program but which are not in the in-service program, were selected on the basis of ambitious interest in teaching science.

Limitations

There are four important limitations to this study:

1. The study will consider primarily the present science needs of students in the seventh grade of the Catholic elementary schools of the San Francisco Bay Area.

2. Students will be tested during the school years of 1966-67 and 1967-68.

3. The study will seek to evaluate the effects of the in-service program of the Archdiocese of San Francisco during the year 1967-68.

4. Patterns and Processes of Science, Laboratory Text Number One was adopted at the beginning of the program.

Experimental Design of the Study

The total sample consisted of approximately 500 students per year in selected elementary schools in the San Francisco Bay Area and approximately 350 students in the year 1967-68 in schools outside the San Francisco Bay Area. The selected schools of the San Francisco Archdiocese administered the Portland Science Test in May of 1967 and May of 1968 to the students of the seventh grade. A group of schools similar to those of the San Francisco Bay Area administered the test only in May of 1968.

This study has the true experimental design of the "Posttest-Only Control Group." In 1963 Campbell and Stanley (22, p. 195) explained:

> While the pretest is a concept deeply embedded in the thinking of research workers in education and psychology, it is not actually essential to true experimental designs. For psychological reasons it is difficult to give up "knowing for sure" that the experimental and control groups were "equal" before the differential experimental treatment. Nonetheless, the most adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence stated by the tests of significance, randomization can suffice without the pretest. . . . In educational research, particularly in the primary grades, we must frequently experiment with methods for the initial introduction of entirely new subject matter, for which pretests in the ordinary sense are impossible, just as pretests on believed guilt or innocence would be inappropriate in a study of the effects of lawyers' briefs upon a jury. . . . Its form is as follows:

$$\begin{array}{lll} R & X & O_1 \\ R & & O_2 \end{array}$$

"R" is the randomized group; "X" is the experimental variable; "O" is the observation of the posttest. This form is based on the law of the single variable. Each of the following three variables will be considered:

1. The textbook used: either Tentative Outlines Grade 7 - Science or Patterns and Processes of Science, Laboratory Text Number One.

2. The laboratory materials used to accompany Patterns and Processes of Science, Laboratory Text Number One: either materials provided through the in-service program of 1967-68 in the Archdiocese of San Francisco or materials obtained through various commercial sources without the help of the in-service program.

3. The assignment of science teachers during the years 1966-67 and 1967-68; either the same teacher at the same school during both years or a new "science specialist" assigned at a school during the second year.

The experimental design of the "Posttest-Only Control Group" requires randomization of the groups. In this study randomization is presumed because of the large numbers in each group and the relatively large number of schools involved in the testing. The significance of the difference between the means of two groups will be determined by the application of the *t*-test.

Information gathered from the teachers through questionnaires and interviews will be summarized in tables which will show the percentages of groups of teachers holding various opinions. The analyses of these tables will be rather obvious and will not require the application of statistical tests. Nevertheless, the statements of the teachers will be extremely important in evaluating the effects of the in-service program.

REVIEW OF THE LITERATURE

Introduction

The new science programs have been introduced into American schools in recent years primarily because of philosophical arguments. The authorities in science education have explained that students will appreciate science only if they engage in the processes of science through a laboratory-centered course. Students must be active in the process of inquiry and the use of quantitative reasoning.

Many new science programs have been introduced into the senior high schools. Recent experimental studies have been testing the effects of these programs. New elementary science programs were developed more slowly. Finally new science programs for the junior high schools are usually in the stage of pilot programs. Much research will be needed to determine the effects of these new programs especially at the seventh grade, which is the grade most neglected by the authors of new science programs.

This Review of the Literature will begin by observing some of the arguments proposed by the authorities in science education for the quantitative approach to science. Their arguments arise from the conviction that the nature of science demands the use of mathematics. Secondly, there will be a consideration of the arguments in favor of the process of inquiry. Some studies, especially into motivation of the students, confirm the advantages of this approach. A third consideration will be on the topic of laboratory-centered programs. At this time, studies on the effects of such programs in the junior high schools seem inconclusive. Finally there will be a discussion of problems involved in supplying laboratory materials. Surveys have indicated the needs of teachers with limited funds and preparation.

The 1967-68 science in-service program of the Archdiocese of San Francisco introduced the pilot edition of a new science program for the seventh grade. This new textbook requires the quantitative approach to science and the process of inquiry. In order to help the teachers to present a truly laboratory-centered course, the in-service program provided the required laboratory materials. The various aspects of this in-service program require a consideration of these four topics: (1) The Quantitative Approach, (2) The Process of Inquiry, (3) Laboratory-Centered Programs, and (4) Providing Laboratory Materials.

This experimental study seeks to determine the effects of the 1967-68 science in-service program of the Archdiocese of San Francisco. In the first chapter the goals and structure of this in-service program were briefly evaluated by the criteria of Clift and Keys. This study seeks to measure the effects of the program on the teachers and their students. Through questionnaires and interviews they have expressed their understandings and attitudes toward the various aspects of the in-service program. The performances of students on tests have been used to compare the effects of the in-service program with two other science programs.

The Quantitative Approach

Walker (113, p. iv) in his book The Nature of Scientific Thought has explained that mathematics is necessary in order to understand modern science. Similarly Jones (54, p. 2), the Director of the Minnesota Mathematics and Science Teaching Project, asserted that the boundaries between science and mathematics are not always well defined. Thier (101, p. 66) observed that the method of science involves working with tools of measurement and performing quantitative experiments. Decker (31, p. 44) acted as chairman of the National Science Teachers Association Curriculum Committee, which stated the following position:

> It is unrealistic to think that the true character of science can be portrayed without mathematical reasoning. . . . Efforts in science curriculum development should be accompanied by corresponding developments in mathematics, and the two must be closely correlated at all levels.

Aylesworth (7, p. 32) concluded that most of the authorities in science education feel that science in the classroom should be as quantitative as possible. Swartz (100, p. 4-5) in presenting the philosophy of the Elementary School Science by a Quantitative

Approach has reasoned that in every grade the science program should be tied to the mathematical studies. Moreover, Thurber (102, p. 500) commented: "Pupils need a science program that is based upon mathematical concepts from the beginning."

Rising (89, p. 29) has condemned the "old fashioned natural history elementary programs" which ignored mathematics. Brother Weisbruch (115, p. 35) of the Society of Mary in 1963 wrote in the Catholic School Journal:

> A purely descriptive elementary general science course possibly may have some value as a beginning program in science. It has little value on the junior high school level and, I strongly suspect, becomes a waste of time at the ninth-grade level. It is time that we take a new hard look at the elementary and junior high school level of science in our Catholic schools and ask some searching questions about the educative value of the so-called K-12 program.

The Catholic School Journal published Brother Weisbruch's article with the title: Science in the Ninth Grade: Content vs. Method. In July of 1964 this same article was accepted as the official position of the Curriculum Advisory Committee on Science, Secondary School Department, National Catholic Educational Association. Brother Weisbruch (116, p. 19-23) through his article advocated the new quantitative approach to science which is contained in the series of textbooks for junior high school Patterns and Processes of Science. Brother Weisbruch is the principal author of the third book in this series, the book for the ninth grade.

The 1967-68 science in-service program of the Archdiocese of San Francisco adopted the textbook designed for the seventh grade: Patterns and Processes of Science, Laboratory Text No. 1. J. A. M. Brock and Donald W. Paulsen are the co-authors of this text. They have emphasized the quantitative approach throughout the text. On the other hand, the seventh-grade science teachers of the Archdiocese of San Francisco during the academic year of 1966-67 were teaching a descriptive general science course.

The Process of Inquiry

Van Deventer (106, p. 5) from his survey of the new science programs has concluded:

> All of the modern curriculum studies list as an objective the teaching of science as inquiry. Open-ended laboratory is a part of inquiry but by no means all of it. Science is not a set of facts to be learned, nor even a list of problems to be solved. It is rather an attitude of learning through inquiring. Sometimes problem formulating is more important for the process of inquiry than problem solving.

Hurd (51, p. 9-10) has argued that the investigative strategies in science should minimize authoritarian teaching and encourage independent learning. Similarly Richardson (86, p. 259) has explained that the first obligation of the science teacher is to help the student to recognize experience as the ultimate source of authority. Therefore, the science teacher must help the students to do the processes of science.

Hale (46, p. 3) wrote: "The process aspect of the scientific enterprise is . . . the meaning of science." Glass (39, p. 21) concluded: "Science must be recognized as a process." Carleton (25, p. 26) emphasized the processes of science among the goals of science education. Moreover, Tyler (104, p. 13) in 1966 explained that students must engage in the processes of science in order to understand the investigative nature of science.

Brakken (13, p. 21) from his survey of the supporters of the process approach observed:

> Exponents of the process approach feel that unless a pupil has some facility in the basic skills, assimilation of scientific information is impossible.

Kurtz (58, p. 32) has described the success of the process approach in stimulating his students. Similarly Alexenberg (1, p. 179) observed that children respond well when they have the opportunity to make their own discoveries.

Livermore (61, p. 273) has listed the processes developed by the American Association for the Advancement of Science in Science - A Process Approach, a new program for kindergarten through sixth grade:

> In the primary grades, eight processes have been identified: (1) observing, (2) classifying, (3) measuring, (4) communicating, (5) inferring, (6) predicting, (7) recognizing space/time relations, (8) recognizing number relations. At the level of

> grades four and five integrated processes are used. The integrated processes are: (1) formulating hypotheses, (2) making operational definitions, (3) controlling and manipulating variables, (4) experimenting, (5) interpreting data, (6) formulating models.

Brock and Paulsen (18, p. iv) have listed the processes which are the goals of Patterns and Processes of Science, a new program for students in junior high school:

A. Analyzing problems
B. Interpreting graphs and tables
C. Analyzing data
D. Seeking relationships
E. Drawing conclusions
F. Hypothesizing
G. Synthesizing models
H. Designing experiments

Studies by Maw and Maw (68, p. 201) show that motivation has a basic role in learning. Waetjen (112, p. 24) explained that motivation will be high when the learner "engages in exploratory behavior." Piaget (83, p. 185) said: "Learning is possible only when there is active assimilation." In order to involve the students in active participation, the current literature stresses the need for teaching the processes of science. Smith (94, p. 212) noted that the term "process" describes "science as a mode of inquiry, as method(s), as a self-correcting procedure for the seeking of knowledge, and as a critical, continuing probing for the truth."

During a period of five years Suchman at the University of Illinois studied fifth and sixth grade students. Finally Suchman (99,

p. 81) observed:

> Our main conclusion from the test results and from our experience with Inquiry Training in many classrooms is that the technique in its present form has a marked effect on the motivation, autonomy and question-asking fluency of children. They clearly enjoy having their quest for assimilation. Because they are not generally accustomed to having and exercising this freedom under ordinary circumstances in most classrooms, they have some initial difficulty making full use of it in the beginning of the training period. But, as the results clearly show, after twenty-four weeks their fluency and autonomy are far in advance of children who have not had Inquiry Training.

Also in 1962 Atkin and Karplus (5, p. 47) concluded:

> The educational problem . . . is to teach the children to carry out their creative thinking with some intellectual discipline.

In 1964 Renner (85, p. 413) encouraged the teaching of the processes of science when he explained:

> Science is concerned with two parts, i.e., processes and products. The processes are observation, classification, hypothesizing, and verifying. The products of science are its facts and general laws.

The Portland Science Test is a recently developed instrument which distinguishes between the student's ability to use the processes of science and his knowledge of the products of science. In 1964 and 1965 Hutchinson used this test in his experimental study. Hutchinson (52, p. 108) explained:

> This study was designed to measure the effects, if any, of an automated science curriculum on the

> science learning of eighth grade students. This curriculum involved the use of Keysort cards as a flexible teacher's handbook and included in the directions for use a teaching method which required the direct involvement of students in the scientific behaviors of investigation.

The Portland Science Test is being used for the second time in an experimental study. But the researcher of this dissertation is using the test to measure the effects of an unusual in-service program on seventh grade students. The two studies are similar because both seek to evaluate the effects of introducing a new method of teaching science. In both cases the new methods emphasize the using of the processes of science.

Because half of the questions of the Portland Science Test considers the processes of science while the other half is on the products of science, this unique test attempts to contrast the performances of students who have taken a new science course with the performances of others who had a traditional general science course. Most general science tests simply favor the recall of the products of science. Tests which consider only the processes of science seem limited to those tests which are designed to accompany a specific new general science program.

Obradovic, Project Director of the Far West Laboratory for Educational Research and Development, in June of 1968 completed a study on the evaluation of the implementation of new science curricula. She did not attempt to use tests in order to contrast the performances of students. Her study is limited to questionnaires which have revealed many important problems in the implementation of the new curricula. For example, Obradovic (78, p. 10) discovered that teachers of Introductory Physical Science (a new program for grade eight or nine) strongly believe that most teachers need special instruction to teach this curriculum.

Laboratory-Centered Programs

Credit for introducing the modern approach to experiments probably belongs to the Physical Science Study Committee. This committee (82, p. iv) in the preface to the laboratory guide for PSSC Physics explained that the students will use the laboratory to investigate physical phenomena rather than to verify known conclusions. In 1960 PSSC Physics made the experiences of the laboratory to be the primary source of learning.

In 1963 the Chemical Education Material Study presented its new science course in a final edition. McClellan (65, p. 2) observed that the students in the CHEM Study course will often be sent into the laboratory to investigate properties of nature before they are treated in class. In the following year the authors of the Biological Sciences Curriculum Study (11, p. 25-26) advocated the same investigative function of laboratory work.

Nevertheless, authorities in science education for many years have been encouraging this use of the laboratory. For example, in 1955 Carleton (24, p. 174) insisted that the heart of science teaching must be investigative laboratory work. Textbooks, demonstrations, field trips, and all other aids must be only secondary. Similarly in 1957 Richardson (86, p. 70) demanded that the laboratory must have the central position in teaching science. In the following year Brandwein, Watson, and Blackwood (15, p. 117) described the process of seeking to solve a problem through observation and experimentation. The solutions to such problems lead to new concepts and to the statement of new problems. The most useful way of developing concepts is through experimentation by which the student himself goes through the process of forming the concepts.

Zacharias (121, p. 16) has observed that changes in the educational system usually require a generation or two. The last grades in the educational system which are receiving new science curricula are those of the junior high school. In 1962 Obourn (77, p. 75) wrote: "No other level of the curriculum in science is in such a state of flux and uncertainty as the junior high school." In the same year Decker (31, p. 43) recognized that there is no clear image of the ideal science curriculum for the junior high schools. Also in 1962 Rutledge (91, p. 269) explained:

Caught between the changes in the high-school programs and the growing elementary science programs, junior-high school science is in sore need of revision.

In 1965 Glass (40, p. 82) complained:

> Very little is currently being done, however, to improve the teaching of science in the junior high school, generally acknowledged to be the weakest link in the chain of science education.

In 1966 Montag (69, p. 211) observed that the aims and purposes used in support of P. S. S. C., CHEM Study and B. S. C. S. are not found in any of the textbooks in general science. In 1967 Brock and Paulsen (16, p. 1) observed:

> Countless numbers of junior high science teachers have searched for the last several years for adequate instructional materials but to no avail.

In 1968 Hungerford (50, p. 35) concluded:

> It seems to this writer that science education in the junior high school reflects a tremendous amount of indecision on the part of science educators.

Nevertheless, the Report of the International Clearinghouse on Science and Mathematics Curricular Developments shows steady progress in new programs for the junior high schools. The 1967 Report, compiled under the direction of J. David Lockard, was the fifth in a series of these annual studies. This Report lists three excellent new programs for grade eight or nine: (1) Earth Science Curriculum Project, (2) Introductory Physical Science, and (3) Secondary School Science Project. The Report seems to indicate that the seventh grade is the most neglected of all grades because relatively few projects have produced materials for this level.

In 1966 the Elementary-School Science Project at the University of Illinois published six textbooks on astronomy for grades five through nine. No behavioral objectives were identified; the series is probably orientated toward the products of science.

The Elementary Science Study has purchasable materials for eight experiments which are appropriate for seventh-grade students. This Study is not producing a course of study but only a variety of experiments.

The Flint Hills Elementary Science Program Development Project and the Pennsylvania Earth and Space Science Improvement Program have produced only resource materials for the teachers.

The NSTA-NASA Aerospace Science Education Project, the School Science Curriculum Project, the Michigan Science Curriculum Committee Junior High School Project, and the Intermediate Science Curriculum Study have not yet produced purchasable materials. Lockard (62, p. 262, 280) has indicated that these last two projects will soon provide excellent materials requiring the processes of science.

The Inquiry Development Programs of J. Richard Suchman are not quantitative and do not provide a course with sequence. The required materials are too expensive for the schools of the Archdiocese of San Francisco.

In general, the other textbooks which are now available for science in the seventh grade, aim at the accumulation of information and do not well integrate the laboratory with the text. The committee of four master teachers in the Archdiocese of San Francisco decided that the best available textbook for seventh-grade students in the parochial schools of the San Francisco Bay Area is Patterns and Processes of Science, Laboratory Text No. 1. Paulsen (81, p. 1-4), coauthor of this textbook, has explained that it was developed by junior high school teachers who were dissatisfied with the available science programs for the seventh grade. Guerin (43, p. 4-5) observed that this text is appropriate for inexperienced junior high school students. Brock and Paulsen (17, p. 257), the authors, have provided the detailed directions which are needed by beginners in the laboratory. Woodburn and Obourn (120, p. 367-368) agree that students in the junior high school need detailed laboratory exercises to develop basic skills.

Measuring the Effects of Laboratory Work

Carleton (23, p. 160) noted that students taking general science taught in a perfunctory way, with little or no laboratory work, elect fewer science courses later. Anderson (4, p. 17) has explained that the traditional general science courses which emphasize memorization of facts are not interesting to children. On the other hand, Heiss (48, p. 164) observed that experimenting is naturally interesting and appealing to young people. Thurber and Collette (102, p. 106) concluded:

> In general, adolescents enjoy the opportunities to manipulate materials, the comparative freedom of action, and the satisfaction of tangible achievements.

In 1918 Wiley reported on his experimental study of methods in teaching high school chemistry. He compared pupils who were taught by the following three methods: the textbook recitation method, the lecture method, and the laboratory method. Wiley (117, p. 197-198) concluded that there was little difference between the three methods in the general acquisition of knowledge. The textbook method was superior for immediate learning. The laboratory method seemed slightly superior for permanent learning.

In 1931 Tyler (105, p. 28-29) observed that the literature for the years 1928 to 1931 gave conflicting evaluations of the effectiveness of individual laboratory method contrasted with the presentation of demonstrations.

In 1956 Boeck (12, p. 92-97) discovered no significant difference between three groups in terms of factual information attained. However, a combination of reading and demonstration produced the best effects in terms of interests and attitudes. Demonstrations alone followed in efficiency; pure reading was the least efficient method.

In 1963 Butts (21, p. 135-143) did demonstrations of science without providing explanations. He observed that the children made no significant improvement in any concept except action-reaction. He concluded that the teacher must provide directions for the discovery of relationships. Atkin and Karplus (5, p. 45-51) came to the same conclusion.

In 1964 Atkin (6, p. 1-8) reviewed the literature between June, 1961, and June, 1964, on junior high school science. He observed that the inductive discovery methods of science instruction did not produce learning more effectively than the traditional deductive verification methods.

In 1963 Toohey (103, p. 101) wrote:

> The laboratory method of teaching is significantly superior to the lecture method of teaching both earth science and general science courses of study, because students retain significantly more science matter when taught by the laboratory method. The critical element in teaching for retention of science subject matter appears to be related to the method of teaching and not to the particular course of study.

Toohey's study of ninth grade students confirmed the results of a similar study on eleventh grade students by Lucow. In 1953 Lucow (63) in his dissertation observed that non-accelerated pupils of high school chemistry had superior learning when the laboratory-centered approach replaced the textbook-centered approach.

Nevertheless, Strehle (98) in 1964 could not find a statistically significant difference with seventh grade students. He concluded that the use of laboratory methods in an elective exploratory science course failed to produce a higher mastery of scientific concepts than did enriched lecture demonstration when this mastery is measured by achievement on a standardized test.

Gomez (41) in 1965 came to the opposite conclusion when he studied 814 students of junior high schools. He observed that the demonstration method was superior to the laboratory method.

In 1965 Fryback (37, p. 69-70) found that fifth grade students had significant advantages in achievement when they did the experiments.

In 1966 Johns (53, p. 78-79) made the following conclusions from his study of eighth grade students:

> Since the traditional group did significantly better than the experimental group on only three of the five units of study, it would indicate that great amounts of teacher involvement, coupled with directed exercises, structured laboratory periods, and free access to books does not lead to significantly better performance in certain areas of science than is attained by students who are free to work independently if given structured, progressive problem-solving activities. The word "progressive" as used here implies sequential rather than an innovation. It also indicates that even though a teacher may have an inadequate science background it is possible to obtain desirable educational results through the use of structured problem-solving exercises.
>
> The results of administering the subject-matter tests a third time to test for retention of subject-

> matter seem to indicate that once the student has arrived at certain conclusions to the problems encountered in the laboratory he is much more disposed toward internalizing the problem's solution once it has been made available to him.

Because the conclusions on the value of investigative laboratory work by junior high school students are weak, contradictory, or simply inconclusive, obviously more research is needed.

Providing Laboratory Materials

Mann (67, p. 58) has contrasted science education at the beginning of this century in the American public high schools with that in the schools of France and Germany. The American teachers were using inexpensive materials in the laboratory while in Europe the use of laboratories was just beginning. Even in recent years many educators recognize the necessity of teaching science with inexpensive materials.

Recently Vrana (111, p. 67) in his article on laboratory work in grades seven and eight pointed out that the laboratory materials must be inexpensive. Richardson (86, p. 266) has encouraged teachers to build or improvise apparatus. Morlan (70, p. 1) has provided many useful suggestions for the preparation of inexpensive materials. Woodburn (119, p. 1) insists that the good science teacher will be inventive in providing laboratory materials.

Swartz (100, p. 6-7) gave the following summary:

> The experience of the high schools and colleges has been that expensive equipment designed exclusively as a teaching tool is usually not very effective. The tendency of the manufacturer is to make such devices overly elaborate, often with an unnecessary emphasis on precision. The reaction against this, started by the PSSC physics program, has influenced teaching equipment at all levels.

The Physical Science Study Committee (82, p. iv) explained:

> Complicated apparatus is apt to obscure the basic simplicity of the subject under investigation, while simple apparatus makes it easy both to see the principles of physics and to appreciate how these principles influence the design of measuring instruments. In addition, because the apparatus is made of common materials, it can be duplicated and used at home. Thus the laboratory helps to prevent a split between the student's world and that of science.

Many teachers of grades seven or eight do not have sufficient time to prepare or even to collect laboratory materials. Piltz and Gruver (84, p. 5) have observed:

> The hours a busy science teacher with no laboratory aides may be compelled to spend in preparation for class laboratory work may virtually double his workload. Equipment may have to be brought from several storage areas and made ready for use, and much tedious weighing or measuring of chemicals into precise amounts may have to be done. The use of kits, carefully selected for specific experiments and demonstrations, may save hours of precious time which would otherwise have been spent in routine preparation of this kind and thus may result in better planned laboratory and demonstration programs.

In 1963 Piltz and Gruver (84, p. 23-24) listed 49 companies which were manufacturing laboratory kits for science classes. In 1964

Olsen (79, p. 342) predicted that packaged science materials will continue to make progress and will be more widely used.

Sternig (96, p. 26) made a survey of 52 elementary school systems in 36 states. He asked the question: "What additional facilities and equipment would you like to have?" One of the great needs was "science kits of equipment keyed to curriculum." Although there is a great abundance of kits, apparently it is difficult to find any geared to the instructional program.

Ruchlis (84, p. 8) observed that elementary teachers need science kits in order to present the subject correctly.

> After questioning hundreds of elementary teachers during the research preceding the development of this kit, it was found that most teachers are faced with a common problem, fear - fear of the seemingly complex subject and the unfamiliar materials and techniques used in the direct problem-solving approach. Because of lack of formal training in subject matters, teachers feel inadequate using only the text and the all-too-meager personal knowledge they bring to the situation. Kits have been specifically designed to provide both the direction and method that will enable teachers to direct science learning that emphasizes and adheres to the scientific process in every problem-solving activity.

The 1967-68 science in-service program of the Archdiocese of San Francisco distributed to the teachers, kits of materials for all of the required experiments. These kits contained relatively inexpensive materials for the students in grades seven and eight. This study will include a survey of the teachers' opinions of these kits.

Almost all of these teachers had only the facilities of an ordinary classroom for performing experiments. In 1965 Bailey (8) discovered that the inappropriateness of classrooms caused the greatest number of problems for beginning teachers. This study will also consider the teachers' statements on their facilities for teaching.

Summary

Mallinson and Buck (66, p. 20-22) have observed that more research is being done in science teaching than in any other elementary school subject except reading. But the new science programs have recently introduced many innovations which now require studies. This search of the literature has revealed generalizations about four major aspects of the new programs. Although the authorities in science education have general agreement on the ideals of curriculum, many of these philosophical concepts are only in the early stages of appearing in the new programs.

The first major section of this review considered the quantitative approach to science. Patterns and Processes of Science, Laboratory Text No. 1 is the first new general science program for the seventh grade which emphasizes the use of mathematics. The literature contains strong arguments which support such a program. This study is the first attempt to evaluate through tests the effects of this new program.

The second section reviews the literature on the process of inquiry. Recent authorities strongly advocate the inquiry approach to science through doing the processes of science. Patterns and Processes of Science, Laboratory Text No. 1 is the first available textbook for the seventh grade which consistently seeks to present the processes of science. Suchman has tested fifth and sixth grade students who have had Inquiry Training. He discovered a significant increase in motivation. Hutchinson has tested eighth graders who were involved in using the processes of science. His study did not produce conclusive results. Several surveys have indicated that the process approach can greatly stimulate the interest of children.

The third section of this review is devoted to the new laboratory-centered programs. A survey of the new courses indicates that the authors of new programs have tended to neglect the development of materials for grade seven. Probably the best available program for the seventh grade is Patterns and Processes of Science, Laboratory Text No. 1, which provides investigative work in the laboratory.

The effects of laboratory work have been measured by many studies. In general, these studies indicate that laboratory work encourages greater motivation. There are conflicting reports on the effects of laboratory work on various tests of achievement. More experimental studies are needed to test the effects of the new programs which emphasize the investigative function of the laboratory.

The fourth and final section of this review deals with the provision of laboratory materials. Surveys have indicated that teachers in junior high schools need inexpensive science kits. The kits provided by the 1967-68 in-service program of the Archdiocese of San Francisco will be evaluated in this study through questionnaires completed by the teachers.

THE STUDY

Introduction

The problem of this study is to determine the effects of the 1967-68 in-service program for science teachers of grades seven and eight in the Archdiocese of San Francisco. The program's effects on the teachers were measured primarily through questionnaires and interviews. The program's effects on the students were measured chiefly by tests. This study has used the scores on tests in the true experimental design of the "Posttest-Only Control Group." The performances of students benefiting from the in-service program have been compared with the performances of students in two control groups. One control group consisted of students using a traditional general science course; the other was constituted by students using the same modern textbook but without the help of an in-service institute for their teachers.

The first chapter has described the unique features of the in-service program and of this study. The second chapter has considered what is already known about various aspects of new science programs which are similar to the 1967-68 science in-service program of the Archdiocese of San Francisco. The contents of this chapter will describe details of the design of the study and the materials used with that design.

The first section of this chapter defines the population of students in the parochial schools of this study. From this population, samples have been selected on the basis of several criteria. The performances of students in the selected schools of the sample will be compared to the performances of students in similar schools. The criteria for pairing schools will be presented. The collection and treatment of the data from testing these samples will be explained.

The second major section of this chapter discusses the Portland Science Test, which is the primary instrument for measuring the performances of the students in this study. The goals and design criteria of this test are explained. The appropriateness of using this test in the study is demonstrated by an analysis of the following statistics: (1) the significance of the differences between the means of any two of the selected schools, (2) the coefficients of correlation between the Portland Science Test and a reading test, and (3) the coefficients of correlation between the "process" questions of the test and the "product" questions of the same test.

The third and final major section of this chapter provides details concerning the questionnaires and interviews of the teachers. The population of teachers participating in the in-service program is discussed. Their statements will be the primary means of evaluating the textbook, the organization of the in-service program, and the laboratory materials distributed through this program.

Procedures Used in the Study

The ultimate goal of the 1967-68 science in-service program of the Archdiocese of San Francisco is to provide better science education for the students in these parochial schools. This experimental study will evaluate the effects of this in-service program through tests administered to samples of these students. The performances of these students will be compared with those of students of the previous year and those of students using the same textbook but without the benefit of an in-service program for their teachers.

Nature of the Population

During the academic year of 1967-68, 188 teachers participated in the San Francisco in-service program. Approximately one hundred of these teachers completed each of the three major questionnaires of this study. This sample of the teachers seems large enough to express the consensus of the entire group.

The teachers carried the effects of the in-service program to more than 7,000 seventh grade students and more than 7,000 eighth grade students in 146 schools. These schools have all of the economic and social variations of the parochial schools in the San Francisco Bay Area. Approximately 500 seventh grade students attending seven schools comprised the sample which represented all students using the laboratory materials distributed through the in-service program. Another 500 seventh grade students in the same seven schools constituted the sample which described the students of the previous year. Finally 351 students in six distant parochial schools became the sample for students using the same modern textbook but without the benefit of an in-service program for their teachers. The total population of students in this last category is approximately 600; these students attend eleven Catholic schools in six different states.

Selection of the Samples

The students of seven schools in the Archdiocese of San Francisco were selected as the representative sample of the entire population of students receiving benefits from the 1967-68 science in-service program. An intensive study of the performances of these students will allow an evaluation of the effects of the in-service program on the entire population of students in the parochial schools of the San Francisco Bay Area. There were three criteria used in selecting these seven schools within the Archdiocese of San Francisco. First of all, they must represent the various socio-economic strata found in the parochial schools of the San Francisco Bay Area. Secondly, the teachers must represent the variations in years of teaching experience and in preparations for science teaching. Finally during the year 1966-67 the teachers must have sincerely attempted to follow the

Tentative Outlines Grade 7 - Science.

This last criterion was necessary for two reasons. First of all, most of the parochial schools of the Archdiocese of San Francisco were almost entirely neglecting science in grades seven and eight during the year 1966-67. If these schools were used to compare the 1966-67 program with the 1967-68 program, the Hawthorne effect might limit the value of the comparison. The Hawthorne effect observes that higher achievement occurs when the participants believe that they are contributing to an experimental new program. To counterbalance against this effect, the seven schools were selected on the basis of ambitious interest in teaching science during the year before the in-service program. Moreover, the second reason for requiring the use of Tentative Outlines Grade 7 - Science during the year 1966-67 is to provide a sharp contrast between the older program stressing the products of science and the new program emphasizing the process of science.

The teachers of seventh-grade science in these seven schools exemplify the continuum of experience and preparation for teaching science. At one extreme, a young sister has the minimum number of science courses to receive the bachelor's degree. At the other extreme, a relatively elderly layman has taught thirty years and has a major in science.

The seven schools also provide a spectrum of socio-economic conditions. The following summary is partly based on the statistical study of Catholic parishes by E. J. Schallert, S. J. (92, p. 49, 64, 95, 98, 117, 122) of the Department of Sociology, the University of San Francisco:

School A is upper middle class in a university town.

School B is upper middle class, suburban.

School C is middle class, suburban.

School D is middle class in a small town.

School E is upper class, urban.

School F is lower middle class, urban.

School G is lower middle class, bilingual in the inner city.

The average class size in these schools for the seventh grade is forty-three pupils. The local public school districts of the San Francisco Bay Area have approximately thirty students in each classroom.

On March 7, 1967, all seventh-grade students in the parochial schools of the Archdiocese of San Francisco took the Advanced Level Survey Test in the Burnett Reading Series, Form A. This test is intended for use in grades seven, eight, and nine. The author of this test, Richard W. Burnett (20, p. 9), explains that the total score is the sum of the raw scores from the "Word Meaning (Vocabulary)" section and the "Comprehension" section of the test. The maximum possible total score is 140. Table 1 gives a summary of the average total scores from the students in the seven selected schools of the

Table 1. Summary of the Scores on the Advanced Reading Test.

School	Mean	Standard Deviation	Number of Students
A	112.0	11.0	31
B	111.6	12.9	87
C	109.0	11.5	79
D	108.0	12.8	35
E	107.9	13.2	48
F	106.6	13.1	85
G	99.8	14.5	110
ABCDEFG	106.9	13.6	475

Table 2. Critical Ratios between Any Two of the Seven Selected Schools on the Advanced Reading Test.

Scores from Students in School		A	B	C	D	E	F
	B	0.167					
	C	1.27	1.38				
	D	1.35	1.41	0.397			
	E	1.50	1.58	0.482	0.0348		
	F	2.21	2.51	1.46	0.695	0.721	
	G	5.07	6.02	4.87	3.19	3.46	3.42

Archdiocese of San Francisco.

The significance of the difference between the mean of one group and that of another can be determined by use of the critical ratio which approximates "Student's" t statistic. Henry E. Garrett (38, p. 213-217) has explained the critical ratio and its appropriate use. Statistical significance at the one percent level means that the observed difference would occur only one time in one hundred if the true difference were zero. The critical ratio must equal or exceed 2.58 to give a significant difference at the one percent level. At the five percent level of confidence, the difference between the means is significant when the critical ratio equals or exceeds 1.96. Table 2 reports the critical ratios between the means of performances of students on the Advanced Level Survey Test in the Burnett Reading Series. This table provides the critical ratios between any two of the seven selected schools in the Archdiocese of San Francisco.

From the scores on the Advanced Level Survey Test in the Burnett Reading Series, the critical ratios show six significant differences at the one percent level and eight significant differences at the five percent level. All of the six significant differences at the one percent level involve School G in comparisons with the other six schools. The two differences which are significant only at the five percent level contrast School F with the two schools having the highest scores (Schools A and B).

The students at School F and especially School G have inferior reading abilities. The dichotomy between these two schools and the other schools follows the parallel dichotomy in socio-economic levels. Children in the parishes where the people are older, wealthier, more professional and better educated, have higher scores on the reading test. The same trends are found in the public schools when the socio-economic levels of the school districts are compared to the scores on reading tests released by the Assembly Education Committee of the state of California. The achievements of students in different schools can usually be predicted roughly by simply noting the socio-economic levels of the communities.

Father Schallert (92, p. 1) observed that at least five years are required before there will be any significant differences in the socio-economic levels of the parishes in San Francisco. Therefore, the performances of seventh-grade students on a reading test taken in 1967 will not significantly differ from the performances of seventh-grade students of the same school on the same test taken in 1968. The teachers have not attempted any change in their methods of teaching reading during these two years.

On the other hand, this study will evaluate the effect of attempting new methods in science education. The performances of students on the Portland Science Test taken in May of 1967 will be compared with the performances of students taking the same test in May of

1968. If the science course had remained the same, there would be no significant difference between the performances of seventh graders in 1967 and the performances of seventh graders in 1968 in the same school. This comparison will reveal the impact of the new textbook with the in-service program.

In order to isolate the effect of the in-service program, the seven selected schools of the Archdiocese of San Francisco will be compared to similar schools which lack the help of an in-service program. Six schools participating in the in-service program have been paired with six distant schools. No school was located which could be paired with School F. The pairing of schools was based on the following three criteria:

1. Both schools during the year 1967-68 have been using Patterns and Processes of Science, Laboratory Text No. 1 for approximately one hundred minutes per week.

2. The seventh-grade science teachers in both schools have similar backgrounds in years of teaching experience and in courses taken in mathematics and science.

3. Both are parochial schools of the same socio-economic description.

The six distant schools were located in Kansas City, Missouri, Corvallis, Oregon, Pacific Grove, California, Sacramento, California, Newtown Square, Pennsylvania, and Morton, Pennsylvania.

Collection and Treatment of Data

In the seven selected schools of the Archdiocese of San Francisco, the Portland Science Test was administered to the seventh grade students in May of 1968. Their teachers had participated in the in-service meetings throughout the academic year of 1967-68. The performances of these students constitute the experimental group of this study.

The first control group consists of the performances of the seventh grade students of the year 1966-67 in the same seven selected schools of the Archdiocese of San Francisco. These students took the Portland Science Test in May of 1967 at the end of the school year in which the teachers had followed the Tentative Outlines Grade 7 - Science. These outlines stress the products of science while the laboratory text of the in-service program, Patterns and Processes of Science, emphasizes the processes of science. Because the science program of 1966-67 had a goal which differs from that of the 1967-68 program, the Portland Science Test with its "process" questions and "product" questions seemed appropriate for measuring any possible change in the performances of the students. The same edition of the test was administered both years because there was a different group of seventh grade students each year and because the lapse of one year eliminated the likelihood that the older students might remember or communicate information to the younger students.

The t statistic was calculated to reveal any possible significant difference between the mean of each experimental group and the mean of its corresponding control group. For each pair of means the t statistic revealed any significant differences at both the one percent and five percent level of confidence. In all cases the t statistic was calculated between the two means (1) from total scores on the Portland Science Test, (2) from the "process" questions of the same test, and (3) from the "product" questions of the same test.

The first comparison was between the control group of 1966-67 and the experimental group of 1967-68. Although each of the seven schools received individual consideration, special attention was given to the circumstance of changing teachers. The three schools where the teacher remained the same during both years constituted a subgroup. Performances of students in these three schools indicated the effect of two different science programs in the Archdiocese of San Francisco. The four schools where the teacher was changed formed a second subgroup. The performances of students in these four schools revealed the combined effect of introducing not only a new science curriculum but also new science specialists.

A second control group consisted of approximately 350 seventh grade students in six schools which are distant from the San Francisco Bay Area. Each of these six schools has been matched with one of the seven selected schools of the Archdiocese of San Francisco. Each pair of schools has the same general socio-economic situation. Each pair of teachers has similar backgrounds in years of teaching experience and in courses taken in science and mathematics. In all of these schools the students have used Patterns and Processes of Science, Laboratory Text No. 1 for one hundred minutes per week, during the year 1967-68. The teachers in the schools at a distance from the San Francisco Bay Area did not have the benefit of any in-service program which might help them to present the new curriculum during the year.

The scores of students on the Portland Science Test and also on the Advanced Level Survey Test in the Burnett Reading Series were recorded on punch cards of the International Business Machines Corporation. These cards were used in the operation of the IBM 1130 Computer System (Fortran). The investigator was assisted by Michael A. Kelly at the Computer Center of the University of San Francisco. This computer performed the calculations of the product moment correlation coefficients, the means, the standard deviations, and the t statistics. In calculating the t statistics, the investigator was able to assume homogeneity of variance which means that the sources of variance within each of the samples are essentially the same and that the variances in the corresponding populations are equal. Winer (118, p. 31-32) provided the computational formula for the t statistic used in this study.

The Portland Science Test

Hale (46, p. 6) recently noted: "There is a serious lack of standard tests for junior high school science." Dissatisfaction with existing science evaluation instruments caused the organization of a committee of Portland teachers and supervisors in the fall of 1959. They met in the Curriculum Center of the Public Schools, Portland, Oregon. This committee worked for four years before they could produce the first edition of the *Portland Science Test*. This 1963-64 edition was administered to all ninth graders in the city of Portland, Oregon, in November of 1963. During the year 1963-64 the committee dedicated its efforts to producing more items and to revising the 1963-64 edition of the *Portland Science Test* in terms of the item analysis of the fall testing. The first revised form of the test was administered in November of 1964. The committee has continued to revise and to improve editions of this test for many years.

Goals

During the first year of activity the committee of Portland teachers and supervisors established the following goals which are listed by Hutchinson (52, p. 75):

1. Produce an instrument which places a minimum

> reliance on reading skill.
>
> The testing instruments examined required a reading skill to such an extent that the tests were, in fact, evaluating reading ability of the examinee. Evaluation of science skill was valid only for those with high reading ability.
>
> 2. Produce an instrument which evaluates knowledge of the ways in which scientists learn (processes) as well as what scientists have learned (products).
>
>   The science tests examined by the committee were found to require excessive recall of information with little attention given to the ways in which the information was learned. . . .
>
> 3. Produce an instrument consistent with the Portland science program.
>
>   The major emphasis in the evolution of the present Portland science program has been placed on the investigative patterns of learning. It was the feeling of the committee members that an evaluation instrument should be established which would reveal whether or not these patterns were in fact being encouraged in classroom practice. It was the hope that high student scores would indicate that teachers were providing opportunities for active student participation in investigative processes.
>
> 4. Produce an instrument which could be appropriately administered to students in grades four through twelve.

These four goals coincide with the objectives of a science evaluation instrument needed by the in-service program of the Archdiocese of San Francisco. First of all, the students of the parochial schools in the San Francisco Bay Area require a science test with minimum reliance on reading skill because of the great diversity of reading skills in these schools. An analysis of scores on the Advanced Level Survey Test in the Burnett Reading Series reveals many significant differences between the performances of students in different schools. These scores by seventh-grade students have been discussed above.

Secondly the in-service program needs an evaluation instrument which distinguishes between the processes and the products of science. During the year 1966-67 the teachers in these parochial schools were using Tentative Outlines Grade 7 - Science. These outlines emphasized the memorization of the products of science. Then in 1967-68 the students in the parochial schools of the San Francisco Bay Area began using Patterns and Processes of Science, Laboratory Text No. 1, which stresses the processes of science. If the in-service program is successful, the teachers will change their philosophy of science education. An evaluation instrument is needed which can reveal a change in performances from knowledge of the products of science to use of the processes of science.

The third goal of the Portland Science Test is to show whether or not the students have been actively participating in investigative processes. A truly laboratory-centered program could provide students with the opportunity to engage in the investigative processes. The in-service program of the Archdiocese of San Francisco has focused prime attention upon producing a laboratory-centered course not only by distributing all needed laboratory materials to the schools but also by preparing the teachers to understand the experiments. The in-service program requires an evaluation instrument which can demonstrate a greatly increased emphasis upon laboratory investigations. During the year 1966-67 the students in the parochial schools of the San Francisco Bay Area did relatively few experiments.

Finally the Portland Science Test is designed for students in grades four through twelve. Because grade seven is approximately in the middle of this range, the test is ideally suited for this level. The in-service program requires a test for students of grade seven because Patterns and Processes of Science, Laboratory Text No. 1 is also designed especially for seventh-grade students. Probably this Laboratory Text will be used in the parochial schools of the San Francisco Bay Area not only during the year 1967-68 but also for many subsequent years.

Design Criteria

To avoid reliance on reading skill, the Portland Science Test consists of pictures and a series of questions about the pictures. Hutchinson (52, p. 79) lists the criteria for selecting the pictures and sketches.

> . . . The pictures and sketches should
>
> 1. set the problem in the student's mind.
>
> 2. provide the visual percepts of the problem.

3. stimulate thought in the problem area.

4. serve as a reference for stimulation in probable solution.

Hutchinson (52, p. 79-80) also gives the ten basic concepts which the committee identified for limiting the subject matter of the test.

1. Space is vast.

2. The universe is composed of matter and energy which is probably the same everywhere.

3. All things are relative to the point of observation - time, space, matter, and energy.

4. Motion in the universe seems continuous, orderly, and controlled.

5. The physical laws of the universe affect all natural phenomena, including its largest and smallest portions.

6. Living matter is an organization of molecules complex enough to effect reproduction.

7. Living things adapt to the environment.

8. There is great variety in living and non-living things.

9. Living things are interdependent.

10. Sunlight is the original source of energy which maintains life on earth.

Because the subject matter of the Portland Science Test considers only these basic concepts found in almost all courses of general science for the junior high schools, this test is appropriate for comparing two different seventh-grade science programs. These same ten big ideas are contained in both the Tentative Outlines Grade 7 - Science and in Patterns and Processes of Science, Laboratory Text No. 1. Therefore this test can be used to contrast the 1966-67 program with the 1967-68 program for seventh-grade science in the parochial schools of the San Francisco Bay Area.

Hutchinson (52, p. 80) observed that the committee of Portland teachers and supervisors made the following important definitions:

> Process items were defined as those items which are designed to require the student to think, i.e., to link together a sequence of two or more mental responses in order to select the best of the possible answers set forth in the test item. Product items were defined as those items designed so that the desired response can be made by simple recall, i.e., one mental response.
>
> It was immediately recognized that the process items could be of several varieties. The limiting criteria which were originally identified by the committee included the following process skills:
>
> 1. Problem recognition - present a challenging situation and ask the student to select the response which most clearly states the problem.
>
> 2. Hypothesis choosing - pose a problem and ask the student to choose the most likely hypothetical solution.
>
> 3. Experiment choosing - present an hypothesis and ask the student to select the experiment that would provide the most productive data.

Use by Seventh Grade Students in San Francisco

The reliability and validity of the Portland Science Test have been clearly established by studies on ninth-grade students in the Portland Public Schools. Nevertheless, some educators may question the use of this same test by seventh-grade students in the parochial schools of the San Francisco Bay Area. The following questions may be reasonably asked:

1. Does the Portland Science Test measure significant differences between the performances of students attending parochial schools at the extremes of the socio-economic levels?

2. Does the Portland Science Test place a minimum reliance on reading skill for the seventh-grade students in the parochial schools of the Archdiocese of San Francisco?

3. Does the Portland Science Test measure the two distinct aspects of science (processes and products) when it is taken by seventh-grade students in the parochial schools of the Archdiocese of San Francisco?

All of these questions are answered affirmatively by the scores of seventh-grade students in seven of the parochial schools in the Archdiocese of San Francisco. In May of 1967, 475 students of the schools selected as the representative sample took the 1966-67 edition of the Portland Science Test (Form A). This multiple choice test has thirty questions on the use of the processes of science and thirty questions on knowledge of the products of science. The maximum possible total score is sixty. Table 3 provides the raw data from testing in these seven schools. In this table "S. D. " is the abbreviation for standard deviation; "N" is the number of students. When these scores are compared with the maximum possible scores, the Portland Science Test appears neither too difficult nor too easy for these seventh graders. The standard deviations are similar to those of the schools studied in Portland, Oregon.

Table 3. Summary of the Raw Data for the Control Group of 1966-67 on the Portland Science Test

		Process		Product		Total	
School	N	Mean	S. D.	Mean	S. D.	Mean	S. D.
A	31	17.4	3.4	17.6	2.8	35.0	5.4
B	87	16.2	3.8	17.8	3.6	34.1	6.9
E	48	16.6	3.4	17.4	2.9	34.1	5.5
D	35	16.0	4.0	16.9	3.7	32.9	7.1
C	79	15.6	4.2	16.1	4.0	31.8	7.5
F	85	14.9	3.8	14.7	3.6	29.6	6.8
G	110	13.8	3.7	15.0	4.3	28.8	7.2
Total	475	15.4	3.9	16.2	3.9	31.7	7.2

Table 4 reports the critical ratios calculated between the means of the performances of students on the Portland Science Test. This table gives the critical ratios between any two of the seven selected schools. The first section of the table presents the critical ratios for the total scores; the second section contains the critical

Table 4. Critical Ratios between Any Two of the Seven Selected Schools on the Portland Science Test.

Critical Ratios for Total Scores on the Portland Science Test.

School	A	B	E	D	C	F
B	0.750					
E	0.686	0.000				
D	1.36	0.850	0.805			
C	2.49	2.05	1.89	0.749		
F	4.43	4.31	3.90	2.34	1.96	
G	5.20	5.27	4.73	2.97	2.75	0.792

Critical Ratios for the Process Questions.

School	A	E	B	D	C	F
E	1.03					
B	1.63	0.625				
D	1.52	0.716	0.253			
C	2.33	1.460	0.963	0.485		
F	3.90	2.630	2.240	1.380	1.114	
G	5.09	4.590	4.450	2.880	2.880	2.020

Critical Ratios for the Product Questions.

School	B	A	E	D	C	G
A	0.316					
E	0.707	0.308				
D	1.243	0.875	0.667			
C	2.860	2.230	2.130	1.040		
G	4.970	4.030	4.120	2.540	1.810	
F	5.620	4.560	4.730	2.980	2.350	0.529

ratios for the "process" questions of the same test; the third section has the critical ratios for the "product" questions of the same test.

The critical ratios for total scores on the Portland Science Test show eight significant differences at the one percent level. Five of these eight significant differences compare School G with other schools. The other three significant differences at the one percent level make comparisons between School F and other schools. Schools F and G do not differ significantly at either the one or five percent level.

Already it was noted that the students of Schools F and G have significantly inferior reading abilities when they are contrasted with the other selected schools of the Archdiocese of San Francisco. The dichotomy between these two schools and the other schools follows the parallel dichotomy in socio-economic levels. The Advanced Level Survey Test in the Burnett Reading Series disclosed six significant differences at the one percent level and eight significant differences at the five percent level.

The total scores on the Portland Science Test uncovered eight significant differences at the one percent level and twelve significant differences at the five percent level. The "process" questions of this test revealed seven significant differences at the one percent level and ten significant differences at the five percent level. The "product" questions of this test provided eight significant differences at the one percent level and twelve significant differences at the five percent level. Because the total scores on the Portland Science Test or either part of the same test show more significant differences than the Advanced Level Survey Test in the Burnett Reading Series, the Portland Science Test appears as the more sensitive instrument for measuring differences between the performances of students at different schools. Nor can this superiority be denied by claiming that there is greater diversity in the quality of science education than in the quality of teaching reading. The seven schools selected in the Archdiocese of San Francisco were chosen because the teachers in these schools were sincerely attempting to present good science programs.

All of the significant differences at the one percent level from total scores on the Portland Science Test describe the inferiority of Schools F and G when compared to the other schools. Again all of the significant differences at the one percent level from the "process" questions of this test show the inferiority of performances at Schools F and G when compared to those at other schools. Seven of the eight significant differences at the one percent level from the "product" questions of the test also point out the inferiority of the two schools of the lower socio-economic station when compared to schools located in wealthier areas. Therefore the Portland Science Test does confirm the anticipated pattern of performances which sociologists predict from considering the extremes of the socio-economic levels.

When the coefficient of correlation is calculated to show the relationship between the performances of students on the Advanced Level Survey Test in the Burnett Reading Series and the performances of the same students on the Portland Science Test, this science test seems to place a minimum reliance on reading skill. John W. Best (10, p. 230-231, 239-240) has explained:

> Correlation is the relationship between two or more paired variables, that is, two or more sets of data. . . . The degree of relationship can be represented numerically by the coefficient of correlation. A perfect positive coefficient of correlation is +1.00. . . .
>
> Frequently textbook authors present a general criterion for the evaluation of the significance of coefficients.

Coefficient (r)	Relationship
00 to .20	negligible
.20 to .40	low or slight
.40 to .60	moderate
.60 to .80	substantial or marked
.80 to 1.00	high to very high

> The foregoing is a crude analysis and may be somewhat misleading. The significance of a coefficient of correlation depends upon the nature of the factors related, the number of cases involved, the range of score data, and the purposes of the application of the measure.

Hutchinson (52, p. 75) observed that the coefficient of correlation between a reading test and a general science test usually shows high relationship. If the correlation is only substantial, then the science test has little reliance upon reading ability. When the correlation is only moderate, the science test has a minimum dependence upon reading skill.

Table 5 reports the coefficients of correlation between the Advanced Level Survey Test in the Burnett Reading Series and (1) the "process" questions of the Portland Science Test, (2) the "product" questions of the Portland Science Test, and (3) the total scores on the Portland Science Test. Because there is only a moderate correlation between the Advanced Level Survey Test in the Burnett Reading Series and either the "process" questions or the "product" questions of the Portland Science Test, this science test displays a minimum dependence upon reading skill. Seventh-grade students in the Archdiocese of San Francisco may use the Portland Science Test to measure their performances in science despite their variety of reading skills.

Finally the performances of the 475 seventh grade students of the seven selected schools indicate that the "process" questions of the Portland Science Test are truly measuring an aspect of science which is distinct from that measured by the "product" questions. Table 6 gives the coefficients of correlation between the "process" questions and the "product" questions. There is a slightly stronger correlation between the scores on the Advanced Level Survey Test in

Table 5. Coefficients of Correlation between the Advanced Reading Test and the Portland Science Test.

School	(1) Process	(2) Product	(3) Total
A	0.463	0.627	0.609
B	0.642	0.524	0.641
C	0.518	0.545	0.583
D	0.439	0.424	0.470
E	0.497	0.646	0.649
F	0.669	0.520	0.662
G	0.519	0.591	0.639
Total	0.584	0.572	0.639

Table 6. Coefficients of Correlation between the Process Questions and the Product Questions of the Portland Science Test.

School	r	School	r
A	0.553	E	0.521
B	0.662	F	0.623
C	0.658	G	0.566
D	0.685	Total	0.635

the Burnett Reading Series and the total scores on the Portland Science Test than the correlation between performances on the "process" questions and those on the "product" questions. Therefore, the "process" questions seem to be measuring a behavior which is quite distinct from that measured by the "product" questions. Process and product appear more distinct than reading skill and performance on the science test.

Questionnaires and Interviews

D. C. Heath and Company is the publisher of the textbook used by the 1967-68 science in-service program of the Archdiocese of San Francisco. Louis F. Vogel (109), Head of the High School Science Department of this company, has stated that to his knowledge only questionnaires and interviews have been used to evaluate the pilot edition of Patterns and Processes of Science, Laboratory Text No. 1. Vogel (110) has also explained that his company attempted to send a questionnaire to every teacher who is using this new text. He has received few responses.

The investigator in this study of the San Francisco in-service program has distributed questionnaires and has interviewed teachers and students throughout the academic year of 1967-68. The appendices of this study contain four questionnaires which were completed by teachers participating in this in-service program. The investigator was able to obtain much information from the teachers who enrolled in his course "Science in Junior High School." This course (Education X299) was accepted by the College of Notre Dame in Belmont, California. Only participants in the San Francisco in-service program could obtain two semester hours of credit through this course. Those teachers who elected to enroll were required to pay a registration fee and to write an evaluation of the program. The average length of these essays was nine pages. In writing these evaluations the teachers were not restricted to any list of topics but were free to express whatever they wished to write. These papers were open-ended questionnaires.

During the academic year of 1967-68 the teachers attended each month a meeting of three hours. These in-service meetings were held in four elementary schools in four different cities of the San Francisco Bay Area. The time required to drive an automobile between any two of these schools is at least 45 minutes. The following table describes the teachers who participated in the in-service program.

Table 7. Summary of Teachers Participating in the In-Service Program

	Places of In-Service Meetings				
Teachers	San Francisco	Burlingame	San Jose	Oakland	Totals
Sisters	64	18	30	43	155
Laymen	4	1	3	3	11
Laywomen	3	5	7	7	22
Enrolled for Credit	45	14	23	26	108
Not for Credit	26	10	17	27	80
Totals	71	24	40	53	188

The Text

Francis R. Verre (107), Project Director of _Patterns and Processes of Science_, observed that the final revision of _Laboratory Text No. 1_ should be completed by July of 1968. A regular edition of this text should be available for sale before the Spring of 1969. During the academic year of 1967-68 the science in-service program of the Archdiocese of San Francisco used a pilot edition of this text. Information from the questionnaires and interviews was used in the process of revising the pilot edition. The investigator contributed new experiments and substitutions of materials which were used by the participants of the in-service program.

The selection of this text was based on the following four criteria:

1. The new text must present the process approach to science through investigative laboratory work.

2. The new text must be intended for students in the seventh grade and be available for purchase during the year 1967-68.

3. The new text must contain sufficient directions to guide both inexperienced students and poorly prepared teachers.

4. The new text must emphasize measurement and the quantitative approach to science.

The Review of Literature in this study has demonstrated that Patterns and Processes of Science, Laboratory Text No. 1 uniquely fulfills these four criteria.

One of the most difficult tasks of the in-service program was to persuade the teachers to present a quantitative approach to their students. Although Patterns and Processes of Science, Laboratory Text No. 1 certainly presents the quantitative approach through measurements in the laboratory, a teacher could fail to emphasize the usefulness and importance of measurement. A teacher could turn the course into a purely descriptive consideration of science by ignoring calculations with the measurements and by drilling the students on the definitions of words in the vocabulary lists.

The investigator attempted to lay stress on the importance of the quantitative approach by providing a series of tests. At each of the monthly meetings the teachers received copies of these tests and sheets providing the correct answers. The primary goal of these tests was to encourage the teachers to emphasize the arithmetical calculations which should accompany the measurements done in some of the experiments. The tests provided by Patterns and Processes of Science have questions which rarely require the use of calculations. Furthermore, the parochial school teachers of the Archdiocese of San Francisco are accustomed to giving more tests than the number provided by this laboratory text.

As soon as sufficient data could be gathered, an analysis of each test was given to each teacher. Usually the analysis for each test was based on a sample of approximately 500 seventh grade students and approximately 500 eighth grade students. Both an analysis of scores and an item analysis were done for each test. Because both kinds of analyses were done for both the seventh grade and the eighth grade, the performances of students in the two grades could be compared. Only during the academic year of 1967-68 would students in both the seventh grade and the eighth grade use the same science curriculum. In the following year of 1968-69 only the seventh grade students would repeat the same curriculum. Therefore, the circumstances of the year 1967-68 provided a unique opportunity to evaluate the relative merits of Patterns and Processes of Science, Laboratory Text No. 1 at two different grade levels.

The tests distributed through the in-service program were used in almost every school participating in the program. The teachers showed great interest in the norms established by these tests and enjoyed contributing to this research. The analysis of each test allowed a continual evaluation of the students' progress and weaknesses. The Archdiocese of San Francisco had never before attempted to evaluate a course through a series of tests provided throughout the school year.

The Laboratory Materials

Questionnaires and interviews were the means used to evaluate the quantity and quality of laboratory materials. Most of the schools which had teachers participating in the in-service program received their laboratory materials through the centralized purchasing and distribution of the in-service staff. The principals of these schools had agreed to order the laboratory materials through the in-service program in June of 1967.

In August of 1967 twelve additional schools had principals who expressed interest in ordering the needed laboratory materials through the in-service program. Because the staff of the in-service program had already placed all of the major orders for equipment and materials with large science companies, these principals were referred to a scientific company. The Sales Manager for this company prepared a special kit for these schools.

The following table describes the schools which sent teachers to participate in the San Francisco in-service program.

Table 8. Summary of the Schools Involved in the In-Service Program

Schools Receiving Laboratory Materials from:	Places of In-Service Meetings				
	San Francisco	Burlingame	San Jose	Oakland	Totals
In-Service Program	51	22	26	35	134
The Scientific Co.	1	0	4	7	12
Totals	52	22	30	42	146

The primary purpose of every monthly meeting of the in-service program was to prepare the teachers to do the experiments scheduled during the month. The teachers received laboratory materials at the meetings and performed the experiments. The staff of the in-service program believes that this system should be continued. When the kit from the scientific company is compared to items supplied through the in-service program, the following six major advantages of the in-service system appear:

1. Professional science teachers designed the in-service kit to accompany Patterns and Processes of Science, Laboratory Text No. 1. The Sales Manager for the scientific company prepared a kit to accompany this text or "any comparable science text."

2. The in-service program through large orders

placed by bids to various companies provides a savings of 33% on the comparable items of the kit of the scientific company.

3. The in-service kit includes all necessary items. The other kit lacks many items; it lacks all samples of minerals and animals.

4. The in-service kit omits all unnecessary items and excessive quantities of required materials.

5. The in-service staff has been able to discover sources of inexpensive items and to receive donations of free materials.

6. The in-service staff has been able to produce some inexpensive items and apparatus.

In general, the companies which sell scientific supplies prefer the handling of relatively expensive items. But science in the junior high schools usually requires only inexpensive items. Because of large overhead costs the scientific companies tend to regard the small orders of inexpensive items as nuisances. If these companies attempt to fill such orders, their prices are many times greater than the prices found for the same items in retail grocery or hardward stores.

But the science teachers in the junior high schools rarely have enough time to collect supplies from many sources. Moreover, they cannot afford the prices of the scientific companies. The way out of the dilemma is through the centralized purchasing and distribution of the in-service program.

Summary

The problem of this study is to evaluate the effects of the 1967-68 science in-service program of the Archdiocese of San Francisco. The effects of this program will be compared with the effects of the program in the previous year and the program in comparable schools with the same text but without an in-service program. The population of the more than 14,000 students benefiting from the in-service program was defined. The criteria for selecting samples for testing were explained.

The Portland Science Test has been used with great success in the Public Schools of Portland, Oregon. Because the goals of the Portland program in science education are the same as those found in the in-service program of the Archdiocese of San Francisco, the same test is theoretically appropriate. Moreover, analysis of the performances of 475 seventh-grade students of the Archdiocese of San Francisco show that the Portland Science Test is a practical instrument for measuring the students' abilities to use the processes of science and to recall the products of science.

An important source of information for evaluating the in-service program comes from the questionnaires and interviews of the teachers. Their statements will greatly influence the revision of the pilot edition of the textbook. Their opinions will also govern the development of the quantity and the quality of laboratory materials distributed through the in-service program.

ANALYSIS OF THE DATA

Introduction

This experimental study seeks to determine the effects of the 1967-68 in-service program for science teachers of the Catholic schools in the San Francisco Bay Area. From the Fall of 1966 until June of 1968 the researcher has gathered information through correspondence, interviews, discussions, and questionnaires. The primary source of statistical data is from the scores of seventh grade students on the Portland Science Test. This test was administered in selected schools of the Archdiocese of San Francisco both in May of 1967 and in May of 1968 to compare the science programs of the two different years. The same test was administered to comparable schools at a distance from San Francisco in May of 1968 in order to isolate the effect of the in-service program from the use of the new laboratory text.

The data of this study will now be presented in eight major sections: (1) The Performances of Students on the Portland Science Test, (2) Comments of Teachers and Students on the Portland Science Test, (3) The Preparation of Science Teachers, (4) The Philosophy of the Course, (5) The In-Service Program, (6) The Quantitative Approach, (7) The Laboratory Text, and (8) Practical Problems of Teaching. The first major section contains data from tests. The other sections present data from interviews, discussions and questionnaires. In each section an interpretation of the data will follow immediately after the presentation of the data.

The Performances of Students on the Portland Science Test

The first purpose of this experimental study is to compare students enrolled in the older program of the Archdiocese of San Francisco with students enrolled in the new program using Patterns and Processes of Science. The program of 1966-67 emphasized the products of science while the new program of 1967-68 stressed the processes of science. Seven schools of the Archdiocese of San Francisco were selected for this comparison. One of the major criteria for this selection was the fact that the teachers in these schools during the academic year of 1966-67 were sincerely attempting to teach the Tentative Outlines Grade 7 - Science.

Schools Neglecting Science in 1966-67

During the year of 1966-67 the majority of schools in the Archdiocese of San Francisco were almost totally neglecting science education in grades seven and eight. Therefore if the same science test was administered to seventh graders of the year 1966-67 and to seventh graders of the year 1967-68 in the typical schools of the

Archdiocese of San Francisco, a comparison of the scores achieved in the two different years would reflect the difference between receiving no science course during the year 1966-67 and having the new science program during the year 1967-68. Any educator would anticipate that a group of students receiving a science program would have scores significantly higher than a comparable group of students deprived of any science course.

In order to consider the contrast between receiving no science course and having the science program of 1967-68, one school was selected because of its comprehensive testing program in recent years. In January of 1967 at this school 46 seventh graders and 50 eighth graders took the advanced science test, form X, of the Stanford Achievement Test. In January of 1968 48 seventh graders and 46 eighth graders in the same school took form Y of the same test. Established norms were used to convert the raw scores into equivalent scores for the two forms of the test. The following table provides the critical ratios between any two of the four classes which were tested:

Table 9. Critical Ratios from the Stanford Achievement Test, Advanced Science Test

	1967-68 8th grade	1967-68 7th grade	1966-67 8th grade
1967-68 7th grade	4.11		
1966-67 8th grade	4.94	0.077	
1966-67 7th grade	7.42	4.87	4.61

The critical ratio must equal or exceed 2.58 to give a significant difference at the one percent level. Here the critical ratios show that the 1967-68 eighth graders were significantly superior to the other groups (the 1967-68 seventh graders, the 1966-67 eighth graders, and the 1966-67 seventh graders). On the other hand, the 1966-67 seventh graders are significantly inferior to the other three groups. There is no significant difference between the 1967-68 seventh graders and the 1966-67 eighth graders although there is a slight difference in the means, favoring the 1967-68 seventh graders. The laboratory-centered, process-oriented program of 1967-68 encouraged the students in both the seventh grade and the eighth grade to excel in achievement over the performances of the corresponding classes of the previous year. Certainly the 1967-68 science program had a dramatic effect on improving the standards of science education in this school of the Archdiocese of San Francisco.

The investigator believes that almost every question on the advanced science test of the Stanford Achievement Test should be classified as a question on the products of science. The 1967-68 science program in the Archdiocese of San Francisco stressed only the processes of science. Half of the questions of the Portland Science Test require using the processes of science while the other half are on the products of science. The advanced science test of the Stanford Achievement Test requires 25 minutes; the Portland Science Test needs 40 minutes.

Comparing Two Programs Used in San Francisco

Both in May of 1967 and in May of 1968 the Portland Science Test was administered to the seventh grade students in seven schools of the Archdiocese of San Francisco. These seven schools represent the spectrum of the socio-economic strata and the variety of teachers. At all of these schools the teachers were presenting a traditional general science course during the year 1966-67 and the new Patterns and Processes of Science during the year 1967-68.

For each school the difference between the two means (the mean of the scores from May 1967 and the mean of the scores from May 1968) was tested to consider any possible significance. Table 10 gives the t statistics which were calculated to test the hypothesis concerning the significance of the difference between each mean of 1967 and the corresponding mean of 1968. The table gives the means for the "process" questions, "product" questions, and total scores on the Portland Science Test. Column "N" provides the number of students in the group at each of the seven schools.

The means on this table reveal that in every instance the score achieved in 1968 was lower than the score of 1967. In five of the seven schools there is a significant difference between the means on the "process" questions. In four of the seven schools there is a

Table 10. Results of Tests for Significance of Mean Differences in San Francisco Schools Using the Portland Science Test in 1967 and in 1968.

School	Test	N 1967	Mean 1967	N 1968	Mean 1968	t Statistic
A	Process	31	17.419	38	15.078	3.2199**
A	Product	31	17.612	38	16.157	1.8036*
A	Total	31	35.032	38	31.236	2.8790**
B	Process	87	16.241	90	13.555	4.3911**
B	Product	87	17.873	90	14.022	6.4718**
B	Total	87	34.114	90	27.577	5.9247**
C	Process	79	15.632	82	14.243	2.1095**
C	Product	79	16.189	82	16.048	0.2003
C	Total	79	31.822	82	30.292	1.2153
D	Process	35	16.000	35	14.914	1.2396
D	Product	35	16.914	35	15.514	1.4591
D	Total	35	32.914	35	30.428	1.5010
E	Process	49	16.693	49	14.061	3.4862**
E	Product	49	17.469	49	15.959	2.2305**
E	Total	49	34.163	49	30.020	3.2526**
F	Process	84	14.916	85	13.823	1.9493*
F	Product	84	14.773	85	14.752	0.0376
F	Total	84	29.690	85	28.576	1.1270
G	Process	110	13.818	120	13.466	0.7304
G	Product	110	15.036	120	14.008	1.9773**
G	Total	110	28.854	120	27.475	1.5546
all	Process	475	15.450	499	13.953	6.0469**
all	Product	475	16.258	499	14.933	5.1495**
all	Total	475	31.709	499	28.887	6.1882**

* Significant at the 5% level of confidence.

**Significant at both the 5% and the 1% level.

significant difference between the means on the "product" questions. In three of the seven schools there is a significant difference between the means on the total scores. When the scores of the 475 students of 1967 are compared to the scores of the 499 students of 1968, there are significant differences at the one percent level of confidence for "process," "product," and total. Therefore the following three null hypotheses are rejected:

1. There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials.

2. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials.

3. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials.

In schools A, B, and C the same teacher taught the traditional general science course during the year 1966-67 and Patterns and Processes of Science during the year 1967-68. In all of these schools there was a significant decline in the scores on the "process" questions. In two of the three schools there was also a significant lowering of the scores on the "product" questions and the totals. Therefore the following three null hypotheses are rejected:

1. There is no significant difference in the performances between students enrolled in the old program

and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

2. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

3. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

In schools D, E, F, and G one teacher presented the traditional general science course during the academic year of 1966-67, and another teacher introduced the new program of Patterns and Processes of Science during the year of 1967-68. In half of these four schools there was a significant lowering of scores on the "process" questions and on the "product" questions. Therefore the following two null hypotheses can be reasonably rejected:

1. There is no significant difference in the performances to use the processes of science between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

2. There is no significant difference in the performances to learn the products of science between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

Although the total scores in all four schools were lower in May of 1968 than the total scores of May, 1967, nevertheless, in only one school was this difference significant. The evidence is rather weak for the rejection of the following hypothesis:

> There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

In the three schools (A, B, and C) where the science teacher was the same person for both years, there was strong evidence that the new program reduced performances on the Portland Science Test. On the other hand, in the four schools (D, E, F, and G) where a new teacher introduced Patterns and Processes of Science in the year 1967-68, the evidence is much weaker that this new program lowered the scores on the Portland Science Test. The investigator believes that this difference is due primarily to the improved abilities of the new teachers who were assigned to be the "science specialists" for 1967-68. The demand by the Department of Education of the Archdiocese of San Francisco for departmentalization and specialization was somewhat effective in providing science teachers with better preparations.

The Effect of the In-Service Program

To isolate the effect of the in-service program, six of the selected schools in the Archdiocese of San Francisco were compared to similar schools which lack the help of an in-service program. The pairing of schools was based on the following criteria:

1. Both schools during the year 1967-68 have been using Patterns and Processes of Science, Laboratory Text No. 1 for approximately one hundred minutes per week.

2. The seventh-grade science teachers in both schools have similar backgrounds in years of teaching experience and in courses taken in mathematics and science.

3. Both are parochial schools of the same socio-economic description.

These six pairs of schools have the following general socio-economic description:

A and H - upper middle class, university town,

B and I - upper middle class, suburban,

C and J - middle class, suburban,

D and K - middle class, small town,

E and L - upper class, urban,

G and M - lower middle class, inner city, bilingual.

For each pair of schools (one in the Archdiocese of San Francisco and the other at a distance from the San Francisco Bay Area) the difference between the two means of the scores from using the

Portland Science Test in May of 1968 was tested to discover any possible significance. Table 11 gives the t statistics which were calculated to test the hypothesis about the significance of the difference between each mean of a San Francisco school and the corresponding mean of a distant school. The table gives the means for the "process" questions, "product" questions, and total scores on the Portland Science Test. Column "N" gives the number of students in the group at each of the twelve schools.

When the 499 students tested in the Archdiocese of San Francisco in May of 1968 are compared with the 351 students in the six distant schools, there are significant differences favoring the distant students. Nevertheless, when schools are compared only with their matched partner, there are significant differences found in only two such pairs. The other four pairs have no significant differences.

The investigator observed that in the two pairs where significant differences were found, both of the distant schools were in the Archdiocese of Philadelphia, Pennsylvania. Further research uncovered the fact that the students in these schools had received a much more intensive training in science during grades one through six than students in the other schools. Therefore, a fourth criterion for the pairing of schools should be that the students had received similar courses in science from grade one through grade six.

After eliminating the two schools of the Archdiocese of

Table 11. Results of Tests for the Significance of the Mean Differences in the Paired Schools Using the Portland Science Test in 1968.

	San Francisco			Distant			t
Test	School	N	Mean	School	N	Mean	Statistic
Process	A	38	15.078	H	17	16.352	1.3746
Product	A	38	16.157	H	17	16.235	0.0684
Total	A	38	31.236	H	17	32.588	0.7700
Process	B	90	13.555	I	124	16.951	6.0918**
Product	B	90	14.022	I	124	17.500	6.6333**
Total	B	90	27.577	I	124	34.451	7.0006**
Process	C	82	14.243	J	100	15.710	2.5335**
Product	C	82	16.048	J	100	17.380	2.1589**
Total	C	82	30.292	J	100	33.090	2.5502**
Process	D	35	14.914	K	31	15.290	0.4517
Product	D	35	15.514	K	31	15.870	0.3376
Total	D	35	30.428	K	31	31.161	0.4357
Process	E	49	14.061	L	45	14.755	0.8415
Product	E	49	15.959	L	45	16.022	0.0855
Total	E	49	30.020	L	45	30.777	0.5428
Process	G	120	13.466	M	34	13.441	0.0355
Product	G	120	14.008	M	34	13.323	0.9477
Total	G	120	27.475	M	34	26.764	0.5549
Process	all	499	13.953	all	351	15.800	6.9115**
Product	all	499	14.933	all	351	16.666	6.2655**
Total	all	499	28.887	all	351	32.467	7.3121**

* Significant at the 5% level of confidence.

**Significant at both the 5% and the 1% level.

Philadelphia, the following three null hypotheses must be accepted:

1. There is no significant difference in the performances between students using the new text with in-service materials and those using the new text without these materials.

2. There is no significant difference in the performances to use the processes of science between students using the new text with in-service materials and those using the new text without these materials.

3. There is no significant difference in the performances to learn the products of science between students using the new text with in-service materials and those using the new text without these materials.

Therefore the in-service program was able to help the teachers of the Archdiocese of San Francisco to provide a course which seems equivalent to that presented by teachers in distant schools without any in-service program. The six teachers in these distant schools are enthusiastic and capable instructors who had selected Patterns and Processes of Science because they believed that it was the best available text. On the other hand, the committee of master teachers had imposed Patterns and Processes of Science on the teachers in the Archdiocese of San Francisco. Apparently the in-service program had the effect of overcoming the initial lack of confidence in the new text. (The initial attitudes of the teachers toward the text will be described on page 137.)

Comments of Teachers and Students on the Portland Science Test

In May of 1967 the Portland Science Test was administered to the seventh grade students in seven schools of the Archdiocese of San Francisco. Through interviews and discussions with both teachers and students, the investigator observed that this test was well received with many compliments. Both teachers and students regarded the test as reasonably coinciding with the material presented in a traditional general science course.

In May of 1968 the Portland Science Test was administered to the seventh grade students in the same seven schools of the Archdiocese of San Francisco and in six parochial schools at a distance from the San Francisco Bay Area. These students were completing a year of using Patterns and Processes of Science, Laboratory Text No. 1. Through interviews, discussions, written statements and a questionnaire, the investigator discovered that there were many complaints against this test. Both teachers and students regarded the test as inappropriate for measuring the comprehension of materials contained in Patterns and Processes of Science. Table 12 shows that the students in one school did not believe that this test reasonably coincided with the materials of their science course.

Table 12. Summary of Students' Attitudes toward the Portland Science Test in May of 1968

Questions and Answers	N	% of 45	% of Those Answering This Question
Did you find the test difficult?			
"yes"	21	46.7	56.8
"yes and no"	5	11.1	13.5
"no"	11	24.4	29.7
no reply	8	17.8	—
Did you think this test tested your knowledge of science as learned this year?			
"yes"	7	15.6	20.0
"yes and no"	7	15.6	20.0
"no"	21	46.6	60.0
no reply	10	22.2	—

Comparing Two Programs Used in San Francisco

The 1967-68 science in-service program of the Archdiocese of San Francisco caused the serious teaching of science to students in the seventh and the eighth grade. In the previous year the majority of the parochial schools of the San Francisco Bay Area had been neglecting science education almost entirely. In general the teachers were very appreciative of the help provided through the in-service meetings.

Nevertheless, there were at least twelve schools where the teachers were presenting an excellent science course during the academic year of 1966-67. Seven of these schools were selected for administering the Portland Science Test both in May of 1967 and in May of 1968. The criteria for selecting these seven schools are found on page 76. Some schools were omitted from the testing program because they repeated the general description of one of the seven selected schools.

The seven selected schools demonstrated a significant decline in the performances of the students because of the introduction of the new science program. The teachers in these schools offered three reasons for the poorer achievement in 1968. First of all, they argued that the Portland Science Test contained many questions which favored the older general science course. Secondly, these teachers were much stronger than the average teacher who participated in the in-service program in their complaints against the lack of laboratory equipment and other practical problems. Apparently they were satisfied with the practical aspects of the traditional general science course when they were attempting to teach science to an average of 43 students in each classroom. The third and final explanation offered for the lower scores was the decline in enthusiasm for science. Some of the teachers observed that the traditional general science courses present interesting information while Patterns and Processes of Science tends to bore the bright students and to overwhelm the slow students.

The first explanation seems valid. Comparable schools at a distance from the San Francisco Bay Area had students with similar scores on the Portland Science Test when they attempted to use Patterns and Processes of Science. This new course is such a radical departure from the topics of other modern general science courses that the students of this new course are at a disadvantage in competition with other students when they use an available science test. On the other hand, it seems reasonable to presume that students of other modern general science courses would score poorly on a test designed especially to accompany Patterns and Processes of Science.

The teachers observed that the "product" questions of the Portland Science Test discuss the typical topics found in general science courses. The "process" questions of the test require the use of the concepts which underlie the same topics. On the other hand, Patterns and Processes of Science emphasizes the quantitative approach, especially in the processes of measuring, analyzing and seeking relationships. Probably these quantitative skills were not measured by the Portland Science Test. Support for this assertion comes from the fact that when the seventh grade students in a San Francisco school had performances on the "product" questions which were significantly inferior in 1968, they usually also had significantly inferior performances on the "process" questions.

The second explanation seems credible because of the many similar statements obtained through the questionnaires and term papers of evaluation. There were many practical problems in attempting to present the new laboratory-centered course to an average of 43 students in an ordinary classroom with a very limited supply of equipment and materials. If these practical problems cannot be reasonably solved, then the teachers may be forced to abandon Patterns and Processes of Science. Obviously the students will learn more from a well-prepared demonstration than from a chaotic laboratory period.

The third explanation involves the difficulty in motivating students to interest in the contents of Patterns and Processes of Science. Probably this difficulty arises from the fact that in the opinion of the participants in the in-service program, Patterns and Processes of Science, Laboratory Text No. 1 is appropriate only for seventh grade students who have had little or no background for studying science and yet who are capable of understanding the quantitative approach to science. In general the participants in the in-service program tended to follow the suggestions and schedule of the program with slavish dedication. On the other hand, during the previous year some teachers exercised considerable imagination and ingenuity in using the relatively vague directions provided by the Tentative Outlines Grade 7 - Science.

One of the greatest disadvantages of the in-service program was the tendency of the sisters to follow the suggestions of the master teachers with uncritical obedience. If the teachers had better preparations in college science courses, it would be more probable that they could better care for the individual needs of their students. Without such preparations the teachers were excessively dependent upon the directions suggested at the in-service meetings. A science resource center could help alleviate this problem by providing help to individual teachers.

In schools D, E, F, and G one teacher taught the traditional general science course during the academic year of 1966-67, and another teacher introduced the new program of Patterns and Processes of Science during the year of 1967-68. In general, the new science specialists were slightly younger and better qualified. Table 13 shows the preparation and experience of these teachers and allows comparisons to be made.

In the three schools (A, B, and C) where the science teacher was the same person for both years, there was strong evidence that the new program reduced performances on the Portland Science Test. In the four schools (D, E, F, and G) where a new teacher introduced Patterns and Processes of Science in the year 1967-68, the evidence is much weaker. Probably the new science specialists through their superior teaching abilities were able to counterbalance the full effect of the new science program which occurred in the other three schools.

Table 13. Summary of Teachers' Preparation and Experience in the Schools Where Teachers Changed Positions.

		Years of Teaching		Semester Hours of College Credit in		
School	Year	All Subjects	Science	Science	Mathematics	Education
D	1966-67	6	6	66	6	5
D	1967-68	6	6	9	21	21
E	1966-67	7	3	6	0	41
E	1967-68	15	8	40	6	37
F	1966-67	9	3	9	0	36
F	1967-68	5	2	17	12	5
G	1966-67	28	8	13	12	21
G	1967-68	15	8	40	6	37
DEFG	1966-67	50	20	94	18	103
DEFG	1967-68	41	24	106	45	100

The Effect of the In-Service Program

In 1968 when the Portland Science Test was administered to the seventh graders in six schools at a distance from the San Francisco Bay Area, there was an absence of any significant difference between the performances in each of the distant schools and the performances in the properly paired schools of the Archdiocese of San Francisco. (The criteria for pairing schools were described on pages 119 and 120.) In all of these schools the students had used Patterns and Processes of Science during the academic year of 1967-68. The San Francisco students had scores significantly lower than those of students in the previous year. Probably any teacher who uses Patterns and Processes of Science should anticipate that her students will have lower performances on the currently available general science tests.

The teachers in the six distant schools have expressed great enthusiasm for the goals and methods of Patterns and Processes of Science. They have implied that a skilled teacher can motivate her students to enjoy the learning of those processes which are presented in the new text. Table 14 compares the six teachers who received the help of the in-service program (at schools A, B, C, D, E, and G) with the six teachers who did not receive such help (at the distant schools H, I, J, K, L, and M). In making a pairing of teachers,

Table 14. Summary of Preparation and Experience of the Paired Teachers with and without the In-Service Program.

School	In-Service	Years of Teaching		Semester Hours of College Credit in		
		All Subjects	Science	Science	Mathematics	Education
A	yes	13	2	6	0	39
H	no	1	1	24	8	16
B	yes	16	4	10	24	44
I	no	36	9	31	8	34
C	yes	30	30	45	0	20
J	no	15	5	26	6	33
D	yes	6	6	9	21	21
K	no	3	2	101	6	33
E	yes	15	8	40	6	37
L	no	14	12	44	4	35
G	yes	15	8	40	6	37
M	no	2	2	49	12	12
ABCDEG	yes	95	58	150	57	198
HIJKLM	no	71	31	275	44	155

sometimes years of teaching experience in one teacher was compensated by better preparation in science courses in another teacher. The matching of schools gives the pairs A-H, B-I, C-J, D-K, E-L, and G-M.

The Preparation of Science Teachers

The first meeting of the in-service program was held on August 28, 1967. Although a questionnaire was distributed to all participants, 71 teachers (37.8% of the total number of participants) failed to return the completed questionnaire; 117 questionnaires were returned. This questionnaire asked the teachers to give the number of semester credits earned in science courses, mathematics courses, and education courses. Table 15 summarizes their answers. This table reveals that approximately half of the science teachers for grades seven and eight have either the minimum number of credits for a bachelor's degree or less than the minimum number of credits in science courses. These same teachers have had very few courses in mathematics; more than half of them have taken less than four semester credits in mathematics. Moreover, these statistics do not reveal many semester credits in professional education courses. More than one third of these science teachers have had less than ten credits in education.

Although 188 teachers participated in the in-service program, only 108 enrolled for two semester credits through the College of Notre Dame. The usual reason for not enrolling for credit was the lack of time for writing an evaluation of the program at the end of the academic year. When the teachers enrolled for credit, they were asked to indicate the highest degree held or (if no degree) the last college year finished. Table 16 summarizes their answers on this form for registration.

Table 16 indicates that almost three quarters of these teachers have at least the bachelor's degree. Less than five percent have completed less than three years of college. When the average number of science courses completed is compared with the average number of years spent in college, it is obvious that these junior high school science teachers rarely have planned either a major or minor in science. In general they are poorly prepared for teaching science in grades seven and eight.

The questionnaire of August 28, 1967, asked the teachers to list any special needs which they may have. Usually the question was not answered. But twelve teachers said that they needed more background in science. The statement from twelve teachers seems significant because the next largest group of similar answers came from only five teachers who requested smaller numbers at the seminars.

At the end of the academic year 1967-68, 79 teachers wrote lengthy evaluations of the in-service program. Because the teachers

Table 15. Summary of Courses Which Prepare Science Teachers.

Credits in Science	Number of Teachers	% of 117 Questionnaires	% of Those Answering This Question (94)
50 - 100	4	3.4	4.3
16 - 49	9	7.7	9.6
7 - 15	35	29.9	37.2
4 - 6	30	25.6	31.9
below 4	16	13.8	17.0
no reply	23	19.6	--
Credits in Mathematics			% of Those Answering This Question (85)
over 6	17	14.5	20.0
4 - 6	24	20.5	28.2
1 - 3	34	29.0	40.0
0	10	8.6	11.8
no reply	32	27.4	--
Credits in Education			% of Those Answering This Question (86)
over 20	31	26.5	36.0
10 - 20	25	21.4	29.1
below 10	30	25.6	34.9
no reply	31	26.5	--

Table 16. Summary of Degrees or Years of College Completed.

Highest Degree Held	Number of Teachers	% of 108 Enrolled	% of 84 Answering the Question
M. A.	7	6.5	8.3
B. A.	54	50.0	64.3
Last Year Completed			
Senior	3	2.8	3.6
Junior	16	14.8	19.0
Sophomore	3	2.8	3.6
Freshman	1	0.9	1.2
No reply	24	22.2	--

had received almost no directions for preparing these evaluations, their free responses indicate the areas of greatest interest and concern. Of the 79 teachers, 28 teachers (or 35.4% of the total) explicitly referred to their inadequate preparations for teaching science. Moreover, 35 papers (or 44.3%) complained about the inadequacy of the Teachers' Manual. Usually these teachers explained that they needed a manual which would clearly give them full details on the scientific concepts which they should be presenting to their pupils. This request is not entirely reasonable because the solution to their problem seems to require more courses in the fundamentals of science rather than a gigantic teachers' manual.

On February 5, 1968, a brief questionnaire was completed by 48 teachers who comprise one of the four sections of the in-service program. The question was asked: "Do you feel that greater depth in training is necessary for teaching this course?" Of the 48 teachers, 18 (37.5%) answered "yes"; 27 (56.3%) said "no"; 3 (6.2%) gave no reply. Probably more did not answer "yes" because they did not wish to imply that the in-service program was failing them.

The following are quotations from eight of the evaluations contributed at the end of the academic year:

> (1) The teacher is the weak link in the program. . . . Many classroom teachers do not have sufficient background in science to be secure enough to provide a model of competence.

(2) I began this program without adequate background, save the workshops provided.

(3) I have had no training to teach science in itself other than the in-service program being offered to those of us in this area, and I have always maintained I have no aptitude for science. . . . I presumed to volunteer simply because the only other junior high teacher was a sister who absolutely felt she could not handle science and the principal.

(4) I am very much in favor of the inquiry method for both the teacher and student but the teacher must know enough about the principle being discovered to guide the students in their thinking. There is a discrepancy between that which is required in the related disciplines and that which is actually utilized. Virtually all science curricula includes requirements in biology, chemistry, physics and mathematics. Therefore teachers must have guidelines for arriving at the principles being presented.

(5) I'm not sure enough of certain facts.

(6) I spent three hours trying to discover why energy does not occupy space.

(7) The Teachers' Manual is inadequate because it does not point out relationships that may not be obvious to a non-science major.

(8) Having had very little background preparation to teach science, the thought of piloting the Patterns and Processes of Science program at first was overwhelming. I have found that my inadequate background has not presented a stumbling block to teaching the course. . . . Without the in-service workshops it would have been impossible for a non-science teacher to have taught the course.

The last quotation emphasizes that the inadequately prepared teachers were extremely dependent upon the guidance provided through the in-service program. Fortunately through the in-service program the amount of science taught in the parochial schools of the San Francisco Bay Area was greatly increased during the year 1967-68. Previously science had been relatively neglected for the same reasons which were listed by John S. Richardson (87, p. 258-259) when in 1960 he described the general situation in the United States.

> There are several reasons why science in education has traditionally been neglected. These include the conflict in point of view between experimentation and classical authority, inadequate preparation of teachers, and poor communication on the part of scientists who have stressed the technical aspects of their work in a way that has made it appear overwhelming to the uninitiated.

The Philosophy of the Course

The questionnaire of the opening meeting on August 28, 1967, asked the teachers to comment on the philosophy of the course which was presented that day by the authors of the text. Table 17 provides a summary of the answers from the 117 copies which were returned. This table indicates that the majority of the teachers seemed to have many fears concerning the new science program when it was first presented to them. Nevertheless, at the end of the same academic year these same teachers gave almost an unanimous vote of confidence to the philosophy of the course. When they wrote their final evaluations, 58 teachers (73.5%) clearly endorsed the philosophy of the discovery or process approach in a laboratory-centered course.

Table 17. Summary of Comments on the Philosophy of the Course.

Comments: The philosophy -	Number of Teachers	% of 117 Questionnaires	% of Those Answering This Question (69)
is excellent	15	12.8	21.7
has some problems	49	41.9	71.0
is wrong	5	4.3	7.3
no reply	48	41.0	--

Table 18. Summary of Comments on Students' Attitudes Toward Experimenting.

Comments of Teachers: My students in Grade -	Number of Teachers	% of 79 papers	% of Those Discussing This Topic
7 enjoyed experimenting	46	58.3	93.9
7 disliked experimenting	3	3.80	6.1
8 enjoyed experimenting	46	58.3	90.2
8 disliked experimenting	5	6.3	9.8

Only one teacher (1.3%) condemned the philosophy while 24 (25.2%) did not discuss the philosophy in their papers.

The teachers have explained that they changed their attitude because they observed the success of using the new philosophy of science education. Table 18 records the comments of the teachers in their final evaluations when they discussed the attitudes of their students toward experimenting. When 258 students in three different schools were asked: "Do you like the new science program," 229 (88.8%) answered "yes"; 29 (11.2%) replied "no." In another three schools 171 students were asked to write the name of the activity which they enjoyed most in this year's science program. Of these 171 pupils, 133 (77.8%) said that they like doing the experiments. The remaining 38 students (22.2%) gave many other activities.

The following quotations are from seventh or eighth grade students:

> In past grades we never had laboratory equipment.
>
> We just read but now we read it and work it out finding why.
>
> I enjoy lab because you yourself can find out things without someone telling you.
>
> In the experiment I can see what is happening. In a book, I just have to believe what it says.

The following quotations are from three teachers who obviously enjoyed introducing this new science program into their schools:

> (1) Children in the sixth grade learned little from my demonstrations. Science today must involve our children in scientific experimentation and investigation.
>
> (2) Science teachers have the greatest advantage of anyone teaching. They have the opportunity to awaken in young people a desire for the reason "why?".
>
> (3) Students especially like contact with phenomena. Their learning seems to be in proportion to their involvement. Students do not perfer biology. They studied animals in the lower grades and now want physical sciences, especially chemistry.

In contrast to these statements, one teacher in San Francisco argued that she should continue to teach science with the same content and methods which she had used in previous years:

> Teacher demonstrations and class discussion have seemed to create the most enthusiasm in my eighth grade class this year. . . . My students have been exposed to biology and like it. Many of them feel that this course is not really science but only a preparation for further science courses.

Many teachers observed that the in-service program of 1967-68 introduced for the first time a laboratory-centered course in science. For example, two teachers wrote:

> (1) This is the first real attempt to introduce elementary students to a meaningful science program.
>
> (2) This is the first year for a really, honest-to-goodness science program being carried out in a general way.

The philosophy of the new science program requires that the teacher takes the role of being a guide or helper in place of the traditional role of giving information. The following quotations from seven teachers describe the process of introducing a new philosophy:

> (1) I strongly recommend, especially for those with traditional methods, a more comprehensive training in this approach to teaching and in the philosophy of science on which this program is based.
>
> (2) Patterns and Processes of Science wants self-learning by the students. But our children have no experience of learning on their own.
>
> (3) At first students were confused by written directions because of inexperience with the discovery method. Repeated investigations have made students more independent in interpreting directions and in scientific investigation and recording.
>
> (4) The initial experience with a laboratory-centered course that minimizes rote learning requires some adjustment. . . . There is some suspicion that the course is a hoax and that there are facts being withheld by the teacher. Science taught this way is not comfortable and the response to it is mixed.
>
> (5) Seventh graders particularly seem hesitant to launch out from neat patterns of thinking to the type of free lance thinking essential for a scientist.
>
> (6) My seventh graders were not ready for this course intellectually or psychologically. There was a noticeable change in the mental attitude of the seventh graders since the beginning of this scholastic year. Next year should show the benefits of the program.
>
> (7) This elementary program was of greater interest to the children than previous academic classes. . . . I discovered that many of the students had yet to learn how to work and share with one another. At first the new found freedom of activity was almost intoxicating. Many did not know how to conduct themselves. While the situation has still to be improved, I consider the lessons learned in self-control,

> cooperation, and the establishment of independent work habits to be the greatest value gained from the program. The classes I had were not prepared for this type of instruction.

On the other hand, one teacher clearly condemned the new philosophy of the course. She observed:

> Most of my students commented that the science experiments, for the most part, were either boring, too difficult, too obvious to bother about, or nothing more than a lot of skill-learning. I think this is because the teacher has had to stand aside too much. . . . I feel that the teacher should have a more decisive role. The teacher should be able to explain thoroughly what each experiment is trying to teach, why the procedure is as it is, and what new knowledge is to be gained by performing it.

The difficulties experienced by the science teachers in the San Francisco Bay Area are typical of those experienced by any teacher who is introducing the investigative approach. For example, George T. Ladd (59, p. 61-62) recently described the confusion of his ninth grade students attempting to use the new course <u>Investigating the Earth</u>.

> The above-average students had difficulties with the investigative approach. At first they were not able to cope with problem-solving, had little confidence in their observations, and were unable to defend their procedures and conclusions. As time progressed, these students grew in scientific maturity, confidence, and most importantly, enthusiasm. Many of them for the first time were challenged to think, reason, apply, observe, discuss, defend, and above all to question. . . . These students, because of their above-average ability and the structure of the usual traditional science course, had not previously been required to apply

> their knowledge to the solution of problems. They were able to listen intently in class, memorize a given vocabulary and do very well on examinations. Suddenly, in the ESCP approach to earth science, they found that memorization of facts would not supply the answer to a problem.

None of the science teachers who participated in the 1967-68 in-service program said that the science program of the previous year had a superior philosophy. Seventeen teachers (21.5% of those contributing final evaluations) explicitly wrote that this year's program was superior to that of the previous year.

The In-Service Program

In their final evaluations, 41 teachers (52.0% of those writing papers) strongly praised the work of the in-service program. Only two teachers (2.5%) expressed some disappointment with the meetings. Both of these teachers participated in that section of the in-service program which was located in the City of San Francisco. Because this group was too large (71 participants), one of the teachers gave this recommendation for the San Francisco section:

> My recommendations for the following year would be: 1. Have the teachers of this course meet in small clusters in their own local area. 2. Have a few high school science teachers available rather than one in one place.

Twenty-eight of the teachers (36.7%) described the in-service program in terms of necessity. The following six quotations express the typical attitude of the science teachers:

> (1) if this in-service program had not been provided, the science program would have met an immediate death. I do not see how the program can continue if the in-service program is not given next year or if the teachers who have taken the first part of the course are transferred to another diocese.
>
> (2) The in-service system of distributing materials is necessary. Otherwise this program should not be recommended.
>
> (3) If the teachers of the schools in the Archdiocese of San Francisco have achieved any success in teaching Patterns and Processes of Science, the credit is due to those persons who planned the program, supplied the equipment, and conducted the in-service workshops.
>
> (4) The main advantage to this science course was the fact that all the equipment necessary was provided to the schools. . . . No teacher has the time to get the amount of material necessary.
>
> (5) Without the in-service workshops it would have been impossible . . . to have taught the course. . . . It would have taken hours to assemble the needed equipment for each experiment.
>
> (6) The present diocesan program for in-service training is the best such program to be sponsored in recent years. . . . The fact that materials are packaged and labeled, ready for use, is a boon to any teacher, today subject to increased pressures and work loads.

Several teachers expressed great appreciation because the in-service program prepared them to present classes of high quality. Moreover they observed that elementary teachers need such help in other subjects. Three examples of this conviction are the following:

(1) I have found the in-service program most beneficial. Too bad we don't have more of them to give us more information on how we should tackle the other subjects on the curriculum.

(2) Never before have I taken an education course that so prepared a person in the subject being presented.

(3) The discipline of science is a discipline of a person's mind and activities - a way of life - affecting everything he thinks and does. . . . The success of this program has affected all faculty members of my school.

Many teachers in the Archdiocese of San Francisco recognize the value of the inquiry method of teaching. The Department of Education for the Archdiocese has received during the year of 1967-68 many requests for in-service programs which will introduce the inquiry method into many subjects. Moreover, several teachers advocated more in-service meetings because of the value of informal discussions among the teachers. The following are two examples:

(1) The discussion among teachers at the workshops greatly supported the program.

(2) Because I feel that this informal type of sharing is so valuable, I would suggest here that in May we might have an optional meeting of all who have taken part in the program to share the year of experience and to project some suggestions for next year.

The Archdiocesan Monthly Tests

One of the major contributions of the science in-service program was the distribution of a monthly test for the students. In their final evaluations only eight teachers (10.13%) mentioned these tests. Six of these teachers (7.60%) were very happy with the Archdiocesan tests while two teachers (2.53%) made the same complaint. The following four quotations are from sisters who liked the tests:

> (1) I was very pleased with the Diocesan tests which gave me some idea of how much was really going home to them.
>
> (2) The tests secured through the Diocesan Office are excellent learning devices in that they do more than simply ask for the recall of memorized facts.
>
> (3) The tests that are used are very helpful since they give a clear concept of the student's knowledge through application rather than memorization.
>
> (4) The tests offered through the in-service course are far superior to those in the Teacher's Manual and really act as a test of the child's understanding of a particular concept.

The two sisters who disliked the tests wrote:

> (1) The tests of the Archdiocese were mainly calculations and not a valid instrument for measuring the science learned.
>
> (2) The diocesan tests were drill papers on too limited a number of topics.

The researcher is the author of these tests. He strongly emphasized the quantitative aspects of the course because Patterns and Processes of Science is a quantitative approach to science and because there was a danger that some of the teachers might revert to their old methods of teaching science through the memorization of definitions. Eighth grade students consistently did better on these tests because they had learned more mathematics than the seventh graders. Nevertheless, there was no significant difference in achievement when the question on a test required only recall of information.

The Quantitative Approach

In their final evaluations several teachers expressed great satisfaction over the quantitative approach:

> (1) The student must know mathematics if he is to read and understand modern science.
>
> (2) This course has been a great aid to the weaker student in the understanding of measurement in their mathematics program.
>
> (3) One of my students said: "This course has helped my math immensely."

On February 5, 1968, 137 teachers at the in-service workshops were asked this question: "Did you find the mathematics commensurate with the computational skills usually associated with this grade level?" The following table summarizes their answers:

Table 19. Summary of Appropriateness of Required Mathematics

Answers from Teachers:	Seventh Grade	Eighth Grade
"Yes"		
Number of Teachers	32	44
% Answering This Question	32	50.6
"No"		
Number of Teachers	68	43
% Answering This Question	68	49.4

The eighth grade teachers were equally divided into groups giving the answer "yes" and "no." On the other hand, more than two thirds of the seventh grade teachers answered "no." Therefore the questionnaire of February 5, 1968, seems to indicate considerable dissatisfaction with the required computational skills.

Nevertheless, in their final evaluations the teachers did not show any dissatisfaction with the quantitative approach to science. Relatively few of the teachers elected to mention anything referring to mathematics. Only twelve teachers (15.2%) discussed the need for improving the teaching of the required computational skills. When the "yes" and "no" answers on the questionnaire of February 5 are interpreted through the statements written in the papers of the final evaluation, it appears that the teachers are not dissatisfied with the required computational skills although they clearly recognize certain practical problems in teaching these skills. The following four quotations from the teachers explain the typical recommendations made by the teachers in their final evaluations:

> (1) The mathematics program should be coordinated with science.
>
> (2) The mathematics program should include the metric system.
>
> (3) Drill in mathematics and the metric system should be included in the text.
>
> (4) For the seventh-grade level, I found much of the material to be quite advanced for them. Not that they

> couldn't handle it, but that they just weren't prepared for it. Almost all of the students had very little or no math background in the decimals and metric system. There just wasn't enough time to get them prepared so that the actual figuring of density and volumes could be done to their advantage. I did turn immediately to this section in their math texts, but by the time they were adept in this area, the main part of it in science was finished. . . . I'm sure that if we were to go back to that unit in science now, they would be very capable of understanding the work. . . . They found the relationship of their science work in the other subjects. I feel this is very important since it makes all learning seem very organized and integrated, as opposed to something to be "pigeonholed" after science is finished for that hour or day.

In general the teachers have indicated that they will be able to avoid many of the recently experienced difficulties with mathematics when they present this course a second time. However, the text should give them greater assistance in describing the needed computations.

The Laboratory Text

The teachers have made many recommendations for improving the pilot edition of _Patterns and Processes of Science, Laboratory Text No. 1_.

Directions

The teachers have expressed their greatest concern for the improvement of the directions provided by the text. Of the thirty-three teachers who discussed this topic in their final evaluations, 30 teachers (38.0% of those contributing evaluations) described the directions as poor. Only three teachers (3.8%) praised the directions as appropriate for the discovery method. The following table gives the responses of the teachers on the questionnaire of February 5, 1968. The percentages show the fractions of only those who answered the questions.

Table 20. Summary of Opinions of Teachers on the Directions

	Replies			
	"Yes"		"No"	
Questions	N	%	N	%
Are the instructions -				
clear?	40	61.6	25	38.4
adequate?	32	36.8	55	63.2
Were there any difficulties with the problems which had to be answered -				
by seventh grade students?	64	70.3	27	29.7
by eighth grade students?	60	68.2	28	31.8

The answers on this questionnaire seem to indicate that the students are having difficulty because the directions are not adequate. Nevertheless the cause of this problem may be simply the inexperience of these students in individually interpreting directions. One teacher observed: "The most common fault in the lab work is not reading the directions carefully."

The majority of students were satisfied with the directions. When 303 students were asked in four schools the question "Were the directions for each experiment clear," 216 (71.4%) answered "yes" while 87 (28.6%) replied "no."

Format of the Text

On February 5, 1968, 48 teachers who were participants in one section of the in-service program were asked the question: "Are you satisfied with the format of the text as it is?" Sixteen teachers (33.3%) answered "yes"; 21 (43.7%) said "no" while 11 (23.0%) made no reply. Moreover, in their final evaluations, only 16 teachers (20.2% of those writing these papers) chose to discuss the format of the text. Fifteen of these teachers (19.0%) described the format as "dull" or "uninteresting." One teacher (1.2%) expressed satisfaction with the present format. Another teacher reported from her survey: "It interested me that the fact that the book was not attractive with color and pictures and variety of format was not even mentioned by the students."

Probably some teachers want attractive and colorful textbooks because they presume that a beautiful format will motivate the students. The format of the pilot edition of Patterns and Processes of Science, Laboratory Text No. 1 is plain and efficient. The junior high school students in the parochial schools of the San Francisco

Bay Area usually have enough maturity to be indifferent to colorful pictures which are included only for the purpose of motivation.

Supplementary Materials

The Teacher's Manual of Patterns and Processes of Science encourages the teachers to present some lessons through recordings on tapes. Only five teachers (6.3% of those writing papers) mentioned these tapes in their final evaluations. Two of these teachers seemed satisfied with this teaching technique while three teachers seemed dissatisfied. For example, one teacher complained: "The tapes have frequently sentences and thought patterns which are very long and complicated." The following table describes the responses of students in one school.

Table 21. Summary of Students' Opinions of the Tapes

Question: Were the tape recordings -	Answers	7th Graders		8th Graders	
		N	%	N	%
clear?	"yes"	30	81.1	19	63.4
	"no"	7	18.9	11	36.6
interesting?	"yes"	23	62.2	4	13.3
	"no"	14	31.8	26	86.7

The eighth grade students were much more critical of the tape recordings than the seventh grade students. Probably the younger students were more fascinated by the new teaching technique.

The Teacher's Manual also recommends the use of the supplementary sections, the "Literature Search." These searches teach the history of science through requiring the use of the library. Few teachers had time to assign this work to their students. Only three teachers (3.8% of those writing papers) commented on the Literature Search in their final evaluations. These three teachers praised this material for use by the superior students. For example, one teacher wrote: "The Literature Search really challenges the accelerated students."

Vocabulary Builders

When 133 students in two schools were asked "Were the experiments too difficult?" only 12 students (9.0%) said "yes" while 121 (91.0%) replied "no." On the other hand, when 270 students in four schools were asked "Were the Vocabulary Builders too difficult?" 79 students (29.3%) said "yes" while 191 (70.7%) replied "no." Although few students expressed difficulty with the experiments, a relatively large percentage of the students admitted problems with the vocabulary.

In their final evaluations, only two teachers (2.5% of those writing the papers) explicitly praised the Vocabulary Builders of the text. But ten teachers (12.7%) explicitly demanded major changes in the Vocabulary Builders. One teacher observed that science had become the favorite subject for her "non-readers" because they enjoyed doing the experiments.

Two teachers made the following suggestions:

> (1) The vocabulary is aimed at the brighter students. I would like to work on a committee to procure help for the slower science but otherwise average student. . . . Perhaps if the vocabulary pertinent to the experiment could be placed before the experiment as a preparation, it would help. Also within the vocabulary exercises, if a matching exercise with word and outlined drawn illustrations, as is found in so many of the current spelling books, could be included, it would help the verbally slow student's understanding of the meanings of the technical science words.
>
> (2) The Vocabulary Skill Builders are too hard for the average student to do in independent study. Not enough information is given to complete the Vocabulary Understanding satisfactorily.

Two other teachers insisted that the vocabulary of _Patterns and Processes of Science_ is impossibly difficult for culturally deprived bilingual students.

> (1) Here at the Chinese Day School, the slower pupils found the science course very frustrating, and it was extremely difficult to motivate them into trying even the simplest laboratory skills. . . . A child who must use a Chinese dictionary for the easiest of English phrases has no business becoming frustrated in a course beyond his comprehension. . . . There seems to be a more universal understanding of numbers than words, and the non-English speaking students were able to grasp concepts such as volume and density through mathematics.
>
> (2) Most of my students are Spanish speaking and use English only during school hours. . . . Even the

> brightest of our students couldn't seem to grasp or visualize the meaning of such terms as rate, standard, and unit. . . . The course might have tremendous advantages if it were offered to a smaller group through which more time would be allowed to assimilate knowledge. But since this is not foreseeable, I can only hope the course will be reconstructed so as to meet the intellectual needs of every type of student.

Nevertheless, another teacher of bilingual students clearly stated that difficulties in presenting Patterns and Processes of Science arise from lack of ability of the teachers, not from the course itself.

> This new emphasis on process adds a considerable burden to the teacher. It requires considerably more scientific knowledge to start. A great deal more of preparation time must be put in. . . . I teach in an inner city school, and contrary to what some people might think, I feel that this course is neither too difficult nor boring for my students. In fact, they are quite happy with the course.

Appropriate Grade Level for the Text

During the academic year of 1967-68 students in both the seventh and the eighth grade of the parochial schools in the San Francisco Bay Area studied the same material in the pilot edition of Patterns and Processes of Science, Laboratory Text No. 1. In general the teachers described the seventh graders as enthusiastic and appropriately challenged. There is a general consensus that the topics considered were appropriate for seventh grade students who have had little or no background for studying science.

One teacher mentioned in her final evaluation that the sixth experiment was "very appealing" to her seventh graders but bored her eighth graders. Five teachers (6.3% of those writing papers) described the course as too elementary for eighth grade students:

> (1) I feel that many of the concepts in these topics are much below the eighth grade level.
>
> (2) The first 15 experiments were an insult to some students. The work is not up to eighth grade level.
>
> (3) The course, as now designed, is aimed at the junior high student who has had absolutely no background in science. The content of the experiments is so elementary as to seem childish to the superior or high-average student.
>
> (4) Self-discovery methods do not initiate boredom. Getting bogged down in repetitive, irrelevant minutiae, however, signifies certain death. One of my students said: "The book was well written, but not for eighth graders. This book would be better for the sixth grade."

A fifth teacher listed ten of the topics presented in the first part of <u>Patterns and Processes of Science, Laboratory Text No. 1</u>. Then she asked each of the other members of the faculty of her elementary school to indicate if she had taught any of these concepts in her mathematics or science classes. This questionnaire for the faculty demonstrated that six of the concepts had been taught at or below the fifth grade (1. observation and scientific description, 2. measuring and comparing sizes, 3. use of the metric system to measure, 4. timing and rate of speed, 5. distinguishing sense perceptions, and 6. calculating volume by multiplying length times width times height). Only four of the concepts were new (1. using a graduated cylinder, 2. using a balance, 3. locating an object with reference to a fixed location, and 4. measuring volume by displacement). She concluded that too many of the behaviors required by Patterns and Processes of Science had already been mastered. Therefore the course seems boring and unchallenging.

On the other hand, three teachers (3.8% of those writing papers) protested that the concepts were too difficult:

> (1) The material is definitely a challenge even for the superior student.
>
> (2) This science program as it is set up seems to be geared to the higher ability students. Only the high ability students show any understanding of what has occured in the laboratory.
>
> (3) The text is not geared toward the slow reader or the below average reader.

One teacher was delighted with the challenging concepts demanded by the text. She explained that the use of Patterns and Processes of Science had produced excellent projects for the science fair. Two of her students won first prizes at the county science fair by developing concepts learned in the course.

While one group of teachers described the text as too challenging, an approximately equal number of teachers regarded the text as too elementary. Only one teacher expressed the frustrations of both opinions simultaneously. She wrote:

> Slower students find the terminology and explanations difficult to understand while superior students with strong scientific backgrounds become bored and uninterested.

Probably many teachers were discouraged by the confusion of the slow students and the boredom of the bright students because they were presenting for the first time the discovery approach in a laboratory-centered course. Such a program accentuates the differences among students because there is much greater emphasis upon self-learning. When the teacher used traditional methods, she usually herded the class as if it were a uniform group. But the role of the teacher in the new science course demands that she help individual students to do the processes of science in their unique ways. Therefore one teacher insisted that a well-prepared teacher could use the text in presenting an excellent course:

> From my experience in teaching the course, I find that both aspects of the problem, that is, a revamping of subject and materials, and consideration of individual differences among age groups, have been offered a workable solution. . . .
>
> This program is one which requires that the teacher be trained. It would be extremely difficult, if not impossible for the majority of teachers to teach the course without help. As far as possible, I would suggest keeping science teachers where they are at least a year or two to get this course off the ground and to insure continuity for maximum efficiency in the teaching of science.

Most of the teachers seem quite satisfied with the new text and in agreement with the following quotation from the term paper of one excellent teacher:

> Patterns and Processes of Science recognizes the lack of adequate science education in the elementary school, since it presumes that much of what could have been assimilated by children on a level lower than that of the junior high school has not been presented to them. It is on this point that the text is most realistic, and I am most grateful.

Lack of Religious Concepts

Only one teacher explicitly complained that Patterns and Processes of Science did not mention religion:

> One of the main objectives of a science course in the Catholic school should be to provide our children with understandings that aim to increase their love of God through a knowledge of creation, as well as to achieve social development through Christian social principles. Even in the literature studies an appreciation of God's providence and the development of God-given talents through careful study of these great leaders lacks any Christian reference. I believe that if the authors want to place their book on a level with other texts which incorporate this feature, they will have to study this phase of Patterns and Processes of Science unless they have better reasons for omitting it.

Another teacher expressed some fear that science may be opposed to the religious attitude:

> Because we are so much more in control of our environment than our forefathers, it becomes easier to deny our dependence on our Creator.

Two other teachers mentioned in their final evaluations that scientific knowledge is inferior to theology:

> (1) Science deals only with natural phenomena. Religion is the broadest and most complete understanding of the universe.
>
> (2) Pope Pius XII . . . urged all his children to take advantage of science's benefits to mankind. He bids us to know the world in which we live so that we may come through it to God. He tells us that the study of science should lead to the study of philosophy, and thence to theology.

Nevertheless, two sisters clearly expressed satisfaction in their papers with the omission of religion from this science course.

> (1) I don't think we should have special textbooks for the Science program in Catholic schools. Catholics are now an accepted part of the mainstream of American society. Since we have shed our ghetto mentality, we don't have to emphasize our Catholicity to the same extent as formerly. In the past several years we have gotten away from "Catholic" math, English and history textbooks.
>
> (2) Science has been characterized by some as being amoral. What greater morality is there than that which resides in truth? Inquiry is the means of arriving at truth.

The researcher interviewed singly six nuns to ascertain their attitudes on Catholic science textbooks. In each case these sisters strongly protested against such "preaching." One of these nuns simply noted that Catholic approval of a science textbook means "nothing." Although it is possible to find a few sisters who want a Catholic science textbook, the researcher has observed that this traditional attitude has almost disappeared.

Practical Problems of Teaching

In their final evaluations, the teachers had four major complaints about the circumstances of their teaching during this year. First of all, the time allotted for science is insufficient. Secondly, it is impractical to have the students sharing texts; in the future each student must have his own consumable laboratory manual. Third is the complaint against the large number of students in each classroom. Finally the quantity of laboratory equipment and materials is insufficient. In the final evaluation, no teacher explicitly stated an opinion opposed to these four complaints. For example, no teacher said that the time allotment was satisfactory. Table 22 summarizes the numbers of teachers making the four major complaints which involve problems of the allotment of time, the number of textbooks, the size of the classes, and the quantity of laboratory equipment.

Time Allotment

The most commonly expressed complaint concerned the time allotment for science in the Archdiocese of San Francisco. The parochial elementary schools of this area have required only 100 minutes per week for science. At the beginning of the academic year 1967-68 the staff of the science in-service program distributed to the teachers a time schedule for the entire year. This time

Table 22. Summary of the Major Complaints of the Teachers.

Complaints of the Teachers: Insufficient is the -	Number of Teachers	% of Those Writing Papers
1. allotment of time	34	43.1
2. number of textbooks	28	35.5
3. limit of class size	23	29.1
4. quantity of laboratory equipment	20	25.3

Table 23. Summary of Teachers' Evaluation of Time Allotment.

Were the students able to complete the experiments within the laboratory period?	Number of Teachers	% of 137 Questionnaires	% of Those Answering This Question (123)
"yes"	44	32.1	. 35.8
"no"	79	57.6	64.2
no reply	14	10.3	--

schedule (Appendix V) gave an outline of the experiments and topics which would be discussed at each of the monthly workshop meetings. But few teachers during the year were able to maintain the pace expected by the time schedule.

The following quotation from one teacher expresses the opinion of very many teachers:

> The biggest handicap is time. It seems strange to me that the Catholic school system's time allotment for spelling in the seventh and eighth grade is 20 minutes a day, which is the same time alloted for science. At this age level spelling should be incorporated with all subjects. I think that there is something wrong with the present value judgment. . . . Fortunately in our school we have found time to have four 40 minute periods without cutting any subject short.

On February 5, 1968, a questionnaire was distributed to all participants of the science in-service program. One of the questions was "Were the students able to complete the experiments within the laboratory period?" Table 23 provides a summary of the answers which show a majority responding negatively.

From interviewing many teachers, the researcher has concluded that the majority of teachers had been giving more than 100 minutes per week to science. During interviews some of the teachers noted that the time schedule would be appropriate if all the circumstances for teaching were ideal. These ideal conditions include the following six:

1. an experienced teacher with strong preparation in

college science courses,

2. a maximum of 24 students in each class,
3. motivated students with the ability to use the discovery approach in self-learning,
4. each student writing in his own laboratory manual,
5. a special well-equipped laboratory room which is used exclusively for doing experiments,
6. sufficient equipment and materials to prevent any delays in doing the experiments.

The teachers clearly expressed the recommendation not only for the increasing of the time allotment for teaching science but also for the increasing of the time available to the teachers for preparing these classes. Table 24 summarizes the answers of the teachers in one section of the in-service program on February 5, 1968, when they were asked about the adequacy of time for preparing experiments.

Probably the teachers were strongest in recommending changes in the time allotment because slight adjustments in the time schedule of a school do not present an economic problem. Although some of the other major complaints may objectively deserve even more emphatic statement, the sisters are usually reluctant to make any financial demands. For example, one sister made the observation:

> The initial expense of the laboratory equipment is overwhelming insofar as an equitable distribution of funds over all subject areas. No doubt the bills will not taper off even in the second or third years of operation.

Table 24. Summary of Teachers' Evaluation of Preparation Time.

Do you have sufficient time to set up the stations in preparation for the class?	Number of Teachers	% of 48 Questionnaires	% of Those Answering This Question (39)
"yes"	16	33.3	41.0
"no"	23	47.9	59.0
no reply	9	18.8	--

Table 25. Summary of Teachers' Evaluation of the Cost of the Program.

Questions and Answers	Number of Teachers	% of 48 Questionnaires	% of Those Answering This Question
Has the program been a financial burden to your school this year?			
"yes"	18	37.5	41.9
"no"	25	52.1	58.1
no reply	5	10.4	--
Was this burden due to the increased need to purchase materials?			
"yes"	17	35.4	37.0
"no"	29	60.4	63.0
no reply	2	4.2	--
Was this burden due to the fact that it was necessary to hire someone to teach this course?			
"yes"	3	6.3	9.4
"no"	29	60.4	90.6
no reply	16	33.3	--

The Sharing of the Laboratory Text

On April 28, 1967, the following directions were mailed from the Department of Education of the Archdiocese of San Francisco to all principals of the elementary schools:

> . . . Grades 7 and 8 will take the same course and use the same textbook and equipment during the first year of the program. . . . Patterns and Processes of Science, Book I, by Brock, Paulsen, and Weisbruch, published by D. C. Heath and Company, is a paper-bound laboratory text, which contains material for a two-year course, based on the time allotment of 100 minutes per week. Cost will be approximately $2.25 per book. Note that one set of books will serve both grade levels.

If each student owned his own copy of the laboratory text, the total cost would have been doubled. Nevertheless, the teachers clearly recognized that much time and effort was wasted during the year 1967-68 because either the students were laboriously copying out sections of the laboratory text or the teacher was forced to reproduce these sections. Although additional textbooks would increase the financial burden, more than one third of the teachers in their final evaluations condemned the directions of the Department of Education. Moreover, the teachers made this complaint despite the fact that many teachers regarded the 1967-68 science program as a financial burden. Table 25 gives a summary of the answers from 48 teachers in one section of the in-service program on February 5, 1968. This table demonstrates that they often described the new science program as a financial burden.

Class Size

The third major complaint of the teachers was against the large number of students in each classroom. In their final evaluations, almost one third of the teachers explicitly criticized this situation. Because Catholic schools in recent years have traditionally tended to have large numbers of students in each classroom, it is remarkable that such a large percentage of the teachers have written against this situation. From interviews, the researcher has observed that many teachers believe that Catholic educators must either reduce the numbers in the classroom or acknowledge that the parochial schools cannot provide an education of the quality found in the public schools.

The following six quotations from the papers of final evaluation describe the attitudes of many teachers:

> (1) Class size is our main stumbling block.
>
> (2) Class size should be limited to twenty-five.
>
> (3) Class size must be reduced to no more than 24.
>
> (4) The large class size is really two classes.
>
> (5) Thirty-five students using two balances are expected in three to four laboratory periods to master and retain the knowledge of the correct use of the balance. This is an impossible task, especially if this newly acquired skill is immediately dropped to proceed to different teaching materials.

> (6) As I worked under many handicaps, I did not enjoy teaching the course this year as much as I have enjoyed teaching science in previous years. My class consisted of two classes of seventh and eighth graders in the sixties. I did not have enough materials and equipment for those large numbers. I found with five rows of thirteen desks, half of which were converted into stations of four, I could not carry out the lecture-experiment type experiment effectively due to the congestion. After two months of vocal straining down the long rectangular room, I resorted to using a tape recorder and microphone as an amplifier. That solved the most pressing problem of communication. . . .
>
> Next year, we plan to have smaller numbers in the science classes. Under different circumstances, I think I would have enjoyed teaching the science course. I found the whole year an experiment in itself as I had to keep changing my own procedures.

Quantity of Laboratory Equipment

The fourth and final major complaint was against the insufficient quantity of laboratory equipment and materi als. More than one fourth of the teachers in their final evaluations made this complaint while no teacher described the supply as adequate. Each school was required to pay $268.00 for the laboratory materials distributed through the in-service program. To prevent possible complaints against a financial burden, the quantity of laboratory materials was kept at a minimum.

One teacher gave the following description of the quantity of laboratory equipment and materials supplied through the in-service program:

> In some instances the amounts purchased for us were grossly inadequate. Since some pastors and administrators are purse clutchers, please raise the mandatory expenditures above the frustration level so we shall have a more realistic and workable situation. At least four balances are needed for a class of fifty children if the experiments are not to drag on and the students become bored.

In general, the teachers seemed to want at least twice as much equipment as the amount purchased for them. Because of the shortage of equipment, some teachers abandoned the most basic goal of the course, that is, to provide laboratory experiences. On February 5, 1968, 48 teachers in one section of the in-service program were asked the question: "Are all the members of the class involved in doing all or most of the experiments?" Although 39 teachers (81.3%) replied "yes," 9 teachers (18.7%) said "no."

Quality of the Laboratory Materials

Only four teachers (5.1% of those writing final evaluations) mentioned the quality of the materials supplied by the in-service program. One of these teachers praised the quality while the other three made complaints. An example of the complaint is the following:

> None of the blocks given to us were cut to the exact required dimensions, and nothing is more confusing than an object which is supposed to illustrate a definite piece of information and doesn't.

On several occasions during the year 1967-68, there were delays in the arrival of equipment and materials which had been ordered from various scientific companies. Nevertheless, the staff of the in-service program was able to provide the required equipment and materials at every monthly workshop meeting. In order to manufacture the missing block of wood or metal, the staff of the in-service program on several occasions spent many hours in the shop building at Serra High School in San Mateo on the eve of a monthly meeting. Unfortunately when the staff was forced to work under such pressures, the quality of the materials produced was inferior to that of commercial scientific companies. However, it seemed better to supply materials of inferior quality than to omit the anticipated materials.

Use of a Classroom as a Laboratory

Less than 36 percent of the schools had a room available for doing experiments other than the ordinary classroom. On February 5, 1968, 48 teachers in one section of the in-service program were asked the following question: "Is the greatest problem in teaching this program concerned with the physical setup in your school?" The following table gives a summary of their answers.

Table 26. Summary of Teachers' Evaluation of the Physical Setup

Is the greatest problem the physical setup in your school?	Number of the Teachers	% of 48 Questionnaires	% of Those Answering This Question (43)
"yes"	28	58.4	65.1
"no"	15	31.3	34.9
no reply	5	10.3	-

The answers on the questionnaire seem to indicate a rather strong request from the teachers for special laboratory rooms. Nevertheless, in their final evaluations only 13 of the teachers (16.5% of those writing the papers) commented on the adequacy of using an ordinary classroom for doing the experiments. Three of the teachers (3.8%) observed that the experiments were done successfully in ordinary classrooms. Ten teachers (12.7%) quite strongly condemned the situation. The following quotation from one teacher is typical of those asking for improved facilities:

> At present the practical problems greatly outweigh the advantages of the new program. The children are not caught by any real interest or area of intrigue. . . . The philosophy of the text is excellent. But no laboratory instructor ever enrolled fifty young students with a limited supply of equipment in a sink-lacking classroom with no free period to set up the experiment after sharing with other classes.

In general the students themselves did not seem unhappy with the usual physical conditions. In one school the following question was asked: "Was it difficult to work in the classroom?" Twenty students (20%) said "yes" while eighty students (80%) replied "no." Because these students had never experienced the use of a laboratory, their answers were made without reasonable knowledge of the possible difference between working in a laboratory and working in a classroom.

On February 5, 1968, a questionnaire was distributed to all participants in the in-service program. They were asked: "Do you have a laboratory or do you use a conventional classroom for the course?" Eighty-eight teachers (64.2% of those returning the questionnaire) wrote that they used a conventional classroom. The remaining 49 teachers (35.8%) replied that they had facilities other than a conventional classroom. Nevertheless, these other rooms were very rarely laboratories according to the usage of this word by high school teachers. The participants of the in-service program were using rooms which usually provided only one advantage over the conventional classroom, that is, tables. Approximately one third of the teachers were using rooms which they described as the library, the hall, the multipurpose room, the auditorium, the basement, or the cafeteria. The staff of the in-service program encouraged the use of cafeterias which have sinks.

Only one participant in the in-service program was teaching this science course in more than one school. This sister had a special "laboratory" room in one school but had only conventional classrooms in the other schools. She clearly asserted in her final evaluation that a special room for doing experiments is necessary. Probably many of the junior high school teachers were not equally emphatic in this demand simply because they had no opportunity to recognize the advantages of improved facilities. Moveover, the sisters are reluctant to ask for what may seem to be a financial burden.

Students Working in Groups

Brock, Paulsen, and Weisbruch (18, p. x) in the Teacher's Edition of Patterns and Processes of Science, Laboratory Text No. 1 wrote:

> This curriculum was planned so that it might be used in any regular classroom. No major remodeling or building is needed. However, there must be some flat-top working area, such as tables or combination desk-tables. The students work in teams of two or three members. No more than twelve-fifteen students are working at the laboratory stations at one time. Those students not working on that laboratory activity are working on a complementary assignment.

In general the teachers participating in the in-service program suffered many practical problems because of the crowded classrooms without sufficient equipment or tables. The majority of these teachers would find practical difficulties with every part of the paragraph given above except the direction by which the students work in teams of two or three members. Only ten teachers (12.7% of those writing papers) discussed in their final evaluations the situation of students working in groups. Nine of these teachers (11.4%) praised this system while only one teacher (1.3%) questioned the grouping. The following is a typical quotation from a satisfied teacher:

> The design of the experiments takes adolescent psychology into account. . . . I have found that peer support is most useful in the performing of the experiments.

On the other hand, one teacher wrote:

> I am still uncertain whether it is worthwhile for students at this age to work jointly with their fellow students.

The students themselves enjoyed working in groups. At one school the students were asked: "Did working in small groups help?" Eighty-three students (83%) replied "yes" while only seventeen students (17%) said "no." Apparently most of these adolescents were able to profit from the opportunity of discussing the experiments with their partners.

Summary

Data from questionnaires, interviews, discussions and multiple-choice tests have been presented. The data indicate that the teachers are poorly prepared in terms of college courses of science and are very dependent upon help received at the in-service meetings. The teachers did accept the philosophy of the new textbook and the quantitative approach to science. They had many problems in using the pilot edition of the text and in overcoming shortages of equipment, facilities and time.

This experimental study leads to the conclusion that the philosophy of Patterns and Processes of Science can be defended by philosophical arguments and by the opinions of teachers and students which are expressed in the questionnaires. But the Portland Science Test and probably other commercially available general science tests will not support the adoption of this new course. Perhaps within a few years new tests will be developed which will be designed explicitly to test the quantitative skills required by the new trends in seventh-grade general science. At this time the existing tests for general science seem to indicate merely that Patterns and Processes of Science is a radically new approach to science in the junior high school.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Henry W. Riecken (88, p. iii) observed: "More scientific and technological discoveries have been made in the past fifteen years than in all previous recorded time." To meet the demands of this information explosion, many new science programs have been developed within the last few years. The authors of these new programs have neglected preparing new materials especially for the seventh grade.

In the Archdiocese of San Francisco during the academic year of 1966-67, most of the seventh grade students were receiving little or no instruction in science. To introduce the best available new science program, a unique in-service program was organized to help these parochial schools. This study was designed to measure the effects, if any, of the 1967-68 science in-service program of the Archdiocese of San Francisco. The crash program involved 188 teachers of more than 14,000 students in 146 schools. Each month the teachers attended a meeting of three hours. At each meeting they received laboratory materials for the experiments of the month, the opportunity to perform each experiment, and a science test for their students. These tests and the textbook emphasized the quantitative approach to science. The textbook used in this program was the pilot edition of Patterns and Processes of Science, Laboratory Text No. 1, which demands a laboratory-centered course and the process of inquiry.

The teachers and the students expressed their evaluations of many aspects of the in-service program through questionnaires, interviews, and discussions. More than half of the participating teachers (57.5%) elected to earn two semester hours of college credit through the in-service program. These teachers wrote open-ended term papers of evaluation. The information from these many sources has been summarized in tables. The recommendations of the teachers will influence the writing of the final version of the textbook. Their statements will also affect both the quantity and quality of the laboratory materials distributed through the in-service program, the time allotment for science, and many other circumstances of teaching. Finally their statements have revealed their attitudes toward the philosophy of the process approach.

Seven schools were selected as the samples to represent the socio-economic variations of all the schools in the Archdiocese of San Francisco. The 499 seventh grade students in these schools during the academic year of 1967-68 constituted the experimental group. These students used the laboratory materials supplied through the in-service program. Their performances on the Portland Science Test will be contrasted with the performances of other seventh grade students in the two control groups.

The first control group consisted of the 475 seventh grade students of the academic year 1966-67 in the same seven schools of the Archdiocese of San Francisco. Their science curriculum was based on the Tentative Outlines Grade 7 - Science by Sister Mary Clarice. This science program presented traditional general science with little laboratory work. The emphasis was on memorizing the products of science. The teachers in these selected seven schools capably and enthusiastically taught this older program.

The second control group consisted of 351 seventh grade students of the academic year 1967-68 in six parochial schools located at a distance from the San Francisco Bay Area. Each of these schools was paired with a San Francisco school by matching the socio-economic level, the preparation of the teachers, and the use of the text (Patterns and Processes of Science, Laboratory Text No. 1). Later the investigator eliminated two of the schools because of the need for recognizing an additional criterion for the pairing: the science education of the students from grade one through grade six. The San Francisco teacher differed from the distant teacher primarily because of the San Francisco in-service program. The distant teacher had no in-service program to help in obtaining or understanding laboratory materials. This comparison was made to isolate the effect of the in-service program.

The Portland Science Test was selected as the best available instrument for comparing the effects of the three seventh-grade science programs with different laboratory materials. This test is relatively independent of reading skill and is appropriate for seventh grade students. It evaluates knowledge of the ways in which scientists learn (processes) as well as what scientists have learned (products). The Portland Science Test consists of pictures and a series of questions about the pictures. The process items require the student to link together a sequence of two or more mental responses in order to select the best of the possible answers set forth in the test. The product items demand only simple recall. None of the questions require reasoning with mathematics.

The performances on the Portland Science Test by the seventh grade students in the experimental group were compared with the performances by the students of the same schools in the first control group to test the following three major null hypotheses:

1. There is no significant difference in the performances between students enrolled in the old program and those using the new text with the in-service materials.

2. There is no significant difference in the performances between students enrolled in the old program and those using the new text with in-service materials in schools where the same teacher taught both programs (1966-68).

3. There is no significant difference in the performances between students enrolled in the old program

and those using the new text with in-service materials in schools where a new science specialist introduced the new text in 1967-68.

The performances on the Portland Science Test by the seventh grade students in the experimental group were compared with the performances by the students of the distant schools in the second control group to test the following major null hypothesis:

4. There is no significant difference in the performances between students using the new text with in-service materials and those using the new text without these materials.

Each of the major null hypotheses has two related minor null hypotheses. The first considers the students' performances in using the processes of science. The second minor null hypothesis considers the students' performances to learn the products of science. For example, the two minor null hypotheses related to the fourth and last major null hypothesis are the following:

a. There is no significant difference in the performances to use the processes of science between students using the new text with in-service materials and those using the new text without these materials.

b. There is no significant difference in the performances to learn the products of science between students using the new text with in-service materials and those using the new text without these materials.

Conclusions

An analysis of the test results requires the rejection of the first three major null hypotheses and their related minor null hypotheses. The seventh grade students of 1967-68 in the seven selected schools of the Archdiocese of San Francisco had significantly inferior performances on the Portland Science Test. The seventh grade students of the previous year in the same schools consistently had higher scores.

There is stronger evidence for the rejection of the second major null hypothesis than for the rejection of the third major null hypothesis. Probably this occured because the new science specialists (who introduced Patterns and Processes of Science into the schools where the teachers were changed) were usually younger and better prepared than the teachers whom they were replacing. The Department of Education of the Archdiocese of San Francisco had demanded departmentalization for the science teachers. This demand seemed somewhat successful in obtaining the assignment of better prepared science teachers.

Many teachers have explained that the decline in performances was chiefly from the fact that the items of the Portland Science Test favor the contents of the older science program. The new science program of 1967-68 stressed the development of the quantitative approach. The students learned to do the quantitative processes of measuring, analyzing graphs, calculating areas, volumes, and densities. None of these behaviors were required by the Portland Science Test. The processes demanded by this test were the application or use of the concepts found in the typical modern courses of general science.

Analyses of the test lead to the conclusion that the new text Patterns and Processes of Science is a radical departure from the materials usually considered in a general science course. Patterns and Processes of Science cannot be compared easily with the older programs. Probably its effects should be studied through longitudinal studies. There was a general consensus of opinion among the teachers that this new text was an excellent preparation for senior high school courses in the physical sciences.

The fourth major null hypothesis and its two related minor null hypotheses were accepted. Therefore the in-service program seems capable of producing results similar to those in distant schools where enthusiastic and capable teachers freely chose the use of Patterns and Processes of Science. Careful investigation revealed that the teachers in only eleven parochial schools at a distance from San Francisco were using the same modern textbook during the same year. Correspondence with these teachers seemed to indicate that these eleven teachers have unusual qualities of talent and interest in the teaching of science. Without the help of an in-service program, they spent many hours in ordering laboratory materials, composing examinations, and attempting to understand the contents of the program. They successfully taught the new course despite their isolation from consultants and resource centers.

The great achievement of the in-service program was the sudden introduction of modern science education into the 146 Catholic schools of the San Francisco Bay Area. The in-service program saved the San Francisco teachers both time and money in providing modern science instruction for thousands of students. Without this saving of time and money, few of the San Francisco teachers could have presented the new science course even if they had the knowledge and interest needed to present the course.

The statements made by the teachers strongly indicated that the in-service program was necessary in order to make possible a laboratory-centered curriculum in grades seven and eight of the Archdiocese of San Francisco. Without the materials and information provided by the in-service program, most of these teachers would have entirely neglected the teaching of science during the academic year of 1967-68. Approximately one dozen of these teachers would have continued to teach a traditional general science course with few experiments. Probably none of these teachers would have attempted a laboratory-centered course which emphasizes the process approach and the quantitative approach to science. The in-service program was successful in persuading the teachers of the traditional general science course (which emphasized the products of science) to accept the philosophy of the new course (which emphasized the processes of science). The teachers have explained through questionnaires and interviews the impracticality of hoping that many poorly prepared teachers may independently introduce modern science courses.

In general the 1967-68 science in-service program was extremely well received by the teachers. Most of them had felt very insecure in attempting to present any science to their students. They greatly appreciated the opportunity of receiving laboratory materials, monthly tests, information and suggestions at the in-service meetings. They were encouraged to present the best possible science program despite many practical problems and inconveniences. Many commented that the teachers need similar assistance in other subjects.

The investigator was deeply impressed by the generosity and dedication of all who were involved in the in-service program. The staff of the program consisted of four experienced senior high school teachers who volunteered to help the teachers of grades seven and eight. The program flourished without salaries, grants, or stipends. Ultimately the motivation sprang from the desire to serve better the thousands of Catholic students who in our modern times need excellence in science education. Probably the in-service program will be improved and expanded to meet the growing needs of the parochial schools in the San Francisco Bay Area.

Recommendations

This experimental study has sought to determine the effects of the in-service program for science teachers of grades seven and eight in the parochial schools of the San Francisco Bay Area during the year 1967-68. The effects of this program have been compared with those of the previous year's program and those of schools without the help of an in-service but with the same laboratory text. In making this study, the investigator became involved in studying instruments of evaluation, the qualifications of teachers, the practical problems of teaching in these parochial schools, and the selection of appropriate materials for instruction. From his findings, the investigator has formulated the following recommendations:

1. Recommendations to the principals:
   a. Increase the time allotment for science to at least 150 minutes per week.
   b. Provide each student with a consumable laboratory manual.
   c. Provide the science teacher with the use of a room

with tables for doing the experiments.

d. Reduce the class size as much as possible.

e. If the class size must be more than 30, provide the teacher with an assistant who will care for half of the class while the other half is doing the experiments.

f. If the class size is over 24 students, double the order of equipment and materials from the in-service program.

g. Allow the science teacher sufficient time to prepare the experiments in the laboratory.

h. To encourage the maximum use of the laboratory equipment, attempt to retain the same sisters as science teachers at the same schools for as many years as is reasonable.

i. Through departmentalization, the science teacher should be able to specialize in teaching mathematics and science to students in grades seven and eight.

j. If the science teacher's preparation is weak, she should be encouraged to improve her confidence and competency through participation in the in-service program.

2. Recommendations to the staff of the in-service program:

a. Seek financial support for the in-service program by applying to the National Science Foundation for a grant under the title of a Cooperative College-School Program (between the University of San Francisco and the Department of Education of the Archdiocese of San Francisco).

b. Provide a science resource center for the distribution of laboratory materials and for helping teachers with special problems, *e.g.*, to provide challenging experiments for the gifted students.

c. Divide the sections of the in-service program until there is at least one master teacher for each group with a maximum of 30 teachers.

d. Expand the in-service program to care for grades one through nine.

3. Recommendations to the authors and publishers of *Patterns and Processes of Science, Laboratory Text No. 1, Pilot Edition*:

a. Provide more adequate directions for the experiments.

b. Provide a more complete and annotated teachers' edition.

c. Make the format of the text more interesting by use of more diagrams and photographs.

d. Replace the tape recordings with film strips and simplify the grammar used.

e. Simplify the vocabulary of the text and provide at least some of the definitions.

f. Publish the text with a consumable paperback laboratory manual.

g. Include in the text more details for doing the required mathematical computations.

h. Give suggestions to the teachers for helping students at the extremes of ability, *e.g.*, more challenging experiments for the bright students and drill exercises for students needing remedial help.

i. Add suggestions and details to the sections "Investigating on Your Own" to encourage greater use of these sections.

j. Reduce to optional status or eliminate the extremely obvious or repetitious experiments.

4. Recommendations to researchers in science education:

a. There should be a longitudinal evaluation program to compare the science "process" and "product" learnings of students who were with the same teachers in succeeding years with the original control students.

b. There should be longitudinal evaluation programs to consider the effects on the science "process" and "product" learnings of students when the following three separate variables are introduced into experimental groups:

1) the use of a well-equipped laboratory with an abundance of materials.

2) the use of teaching assistants to allow the teacher to work with relatively small groups of students in the laboratory.

3) the use of the staff of the science resource center to provide the teacher with detailed assistance.

c. Because of the great variety of students in the parochial schools of the San Francisco Bay Area, a variety of texts and other materials should be considered to meet the various needs.

d. A study should be made to recommend to religious superiors the most appropriate college curriculum for preparing science teachers of grades seven and eight.

e. A study is needed to determine more precisely the appropriate quantity of laboratory materials which is needed per student.

f. A study is needed to compare two methods of introducing a new science curriculum: (1) independent work without the help of consultants, and (2) cooperative work with the help of an in-service program which provides materials and directions.

These many recommendations are the fruit of the research from this experimental study. If these recommendations are used as guidelines in the development of improved programs in science education, then this study will have served a very useful purpose. Moreover, the investigator hopes that this study will encourage not only the introduction of in-service programs in other subject areas but also the increased use of similar studies which will evaluate these new programs.

Certainly the 1967-68 in-service program for science teachers of grades seven and eight in the parochial schools of the San Francisco Bay Area was a unique crash program. Because it attempted to initiate sweeping reforms in science education, there were many practical difficulties. Nevertheless, the staff of the in-service program ended the year with deep satisfaction in the success of their efforts. The science teachers themselves overwhelmingly expressed both gratitude for the in-service program and the desire to cooperate with future programs of this type. And finally the students of grades seven and eight had the opportunity to enjoy a science program which might greatly help them to appreciate and to understand their environment.

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APPENDICES

APPENDIX I

QUESTIONNAIRE for the Science Teachers of grades 7 and 8.

Please return this questionnaire to David Stronck on August 29, 1967.

My name:

My school:

The address of my school:

city:

I have completed the following college courses. The number after the name of the course indicates the (circle one) semester/quarter hours.

Courses in science:

Courses in mathematics:

Courses in education:

My critical evaluation of the philosophy of Patterns and Processes of Science:

My suggestions for improving the in-service program:

My special needs:

APPENDIX II

February 5, 1968

Questionnaire on Patterns and Processes of Science.

Archdiocese of San Francisco * Department of Education

Elhi Science Department * D. C. Heath and Company, Boston, Mass.

Teacher's Report

Name ____________________

School ____________________

Address ____________________

Please write below any general comments you have about the program. If you have time, we would also appreciate your answering the questions that follow.

1. At what grade level (7, 8, 9) are you teaching the course? ______
2. What is the level of ability (high, medium, low, heterogeneous) of the class? ____________________
3. How many periods per week do you use for the course? ________
   How long is each period? ____________________
4. Were the students able to complete the experiments within the laboratory period? ____________________
5. Are the instructions (a) clear? __________ (b) adequate? ________
   If not, in which experiments are the directions unsatisfactory?
   ____

6. Do you have a laboratory or do you use a conventional classroom for the course? ____________________

7. Did you have any difficulty securing any particular piece of apparatus or any materials? ____________ The text is written so that substitutions in materials can be made easily. Did you have to make any substitutions? ________ If so, what were they? ____________________

8. Were there any difficulties with the problems the students had to answer? ______ If so, please make specific recommendations. ____________________

9. Did you find the mathematics commensurate with the computational skills usually associated with this grade level? ______ If not, what seemed to be the most apparent problems? ______

____

10. Do you have any general comments on the organization of the course? ____________________

Any processes you would add or delete? ____________

____

11. Do you have any suggestions for improving the Teacher's Manual? ____________________

Did you use the Literature Searches from the Teacher's Manual? ______ If not, what was your reason? ________

APPENDIX III

Questionnaire for Science Teachers of Grades Seven and Eight.

Department of Education, Diocese of Oakland. February 5, 1968

1. Do you feel that greater depth in training is necessary for teaching this course? Yes_____ No_____

2. Is the greatest problem in teaching this program concerned with the physical setup in your school? Yes_____ No_____

3. Do you have sufficient time to set up the stations in preparation for the class? Yes_____ No_____

4. Are all the members of the class involved in doing all or most of the experiments? Yes_____ No_____

5. Are you satisfied with the format of the text as it is? Yes_____ No_____

6. Has the program been a financial burden to your school this year? Yes_____ No_____

7. Was this burden due to the increase need to purchase materials? Yes_____ No_____

8. Was this burden due to the fact that it was necessary to hire someone to teach this course? Yes_____ No_____

APPENDIX IV

Questionnaire for Teachers Administering the Portland Science Test.

Name____________________ Name of School______________

City and State____________________________________

Years of teaching__________ Years of science teaching______

Semester hours of science courses________

Semester hours of mathematics courses________

Semester hours of education courses________

Last year what science course were you teaching?____________

What science text were you using last year?________________

Are you having difficulties in teaching Patterns and Processes of Science? ________________________________

What recommendations do you wish to make about teaching science?

____

What is the role of the teacher in teaching science?

____

How many seventh-grade students do you have in science?______

How many minutes per week do they study science?__________

How would you describe the social and economic level of these students?____

____

How would you describe the I. Q.'s of the members of this class?

____

____

APPENDIX V

TENTATIVE TIME SCHEDULE
7th & 8th Grade Science Program
1967-1968 School Year
(50 Minutes Class 2x/wk. OR 100 minutes/wk.)

DATES	1ST PERIOD	2ND PERIOD
September:		
5 - 8	General Introduction	Exp. 1, p. 2
11 - 15	Description of general procedures; assignment to teams; keeping of date book. Introd. to Set 1, p. 1	
18 - 22	Exp. 2, p. 4 (home assignment) Post-lab discussion - on collected descriptions	Exp. 3, p. 5 Post-lab discussion
25 - 29	Exp. 4, p. 6 Post-lab discussion Vocabulary No. 1	Exp. 5, p. 8
October:		
2 - 6	Complete Exp. 5, p. 8 Vocabulary No. 2	Exp. 6, p. 22 Post-lab discussion
9 - 13	Vocabulary No. 3 Vocabulary Understanding	Holiday
16 - 20	Problems of Observation and Measurement Discussion and Review	Practice Test
23 - 27	Review tests and clear up any remaining "ambiguities". INTRODUCTION to Set 2, p. 40. Exp. 7, p. 41 - demonstration Post-lab discussion	Class Discussion - page 43. Small group discussion. Class discussion.
October - November: (Nov.)		
30 - 3	"What Is A Scientific Experiment?" Part 1, p. 45	Holiday
6 - 10	Exp. 8, p. 48 Post-lab discussion of results	Exp. 9, p. 51 Discussion of results
13 - 17	Exp. 9, cont'd. Post laboratory, pp. 54-60 (Complete for Homework)	Exp. 10, p. 61 Discussion of results
20 - 22	Complete Exp. 10	THANKSGIVING RECESS

Tentative Time Schedule 7th & 8th Grade Science Program (continued)

DATES	1ST PERIOD	2ND PERIOD
November - December: (Dec.)		
27 - 1	Post Laboratory, p. 65 True-False Quiz (p. 22 of Teacher's Guide, green section)	"What Is A Scientific Experiment?" Part 2, p. 66
4 - 8	Class discussion of previous exercise	Holiday
11 - 15	Exp. 11, p. 71	Exp. 12, p. 73 Post-lab discussion
18 - Jan. 1	CHRISTMAS VACATION	
January:		
2 - 5	Exp. 13, p. 74; Complete Discussion of Results of Homework	Post-lab discussion of Exp. 13
8 - 12	Post Laboratory, p. 80	Quiz--True-False Discussion of quiz; clear up ambiguities
15 - 19	Exp. 14, p. 84 Post-lab discussion	Vocabulary Builder, No. 1, 2 pp. 86-89 Problems of Properties, pp. 90-93 done as homework
22 - 26	Discussion of Problems & Properties. Practice Test, p. 93. Discussion of Practice Test	Quiz - Set 2

End of First Semester (Sets 1 and 2 Completed)

2ND SEMESTER - Tentative Outline

DATE	1ST PERIOD	2ND PERIOD
Jan. 30 - Feb. 2	Introduction to Set 3, Exp. 15, p. 99 (demonstration)	Holiday
<u>February</u>:		
5 - 9	Class discussion of Exp. 15	Post Laboratory, p. 100
12 - 16	Exp. 16, p. 103; Post-lab and class discussion:	Holiday Problems of Classification
19 - 23	Exp. 17, p. 107	Holiday
26 - Mar. 1	Vocabulary Builder p. 109-111	Practice Test and Review Set 3, p. 115
<u>March</u>:		
4 - 8	Introduction to Set 4, p. 119	Exp. 18, p. 120
11 - 15	Post-lab discussion of Exp. 18	Post Laboratory, p. 125
18 - 22	Exp. 19, p. 127	Post-lab, Exp. 19
25 - 29	Exp. 20, p. 132	Post-lab, Exp. 20
<u>April</u>:		
1 - 5	Post Laboratory Conditions, p. 135	Exp. 21, p. 138
8 - 12	Post-lab, Exp. 21	Holiday - Easter Recess
15 - 19	EASTER	
22 - 26	Exp. 22, p. 140	Post-lab, Exp. 22
29 - May 3	Exp. 23, p. 143	Post-lab, Exp. 23
<u>May</u>:		
6 - 10	Exp. 24, p. 146	Post-lab, Exp. 24 Post laboratory, p. 148
13 - 17	Exp. 25, p. 149 (Homew[illegible]r (Homework Assignment)	Post-lab, Exp. 25
20 - 24	Exp. 26, p. 151 (optional) (Distillation) Vocabulary Builder, No. 1, 2, pp. 155, 156	Holiday
27 - June 1	Problems in Phase Transitions	Holiday
<u>June</u>:		
3 - 7	Practice Test and Review	Quiz, Set. 4, p. 58 of Teacher's Guide
10 - 13	Last week of school.	