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Klemm, Emily Barbara Cockcroft

RELATIONSHIPS BETWEEN SELECTED INSERVICE TEACHER CHARACTERISTICS AND CONTENT MASTERY TEST SCORES IN A PROGRAM-SPECIFIC TEACHER WORKSHOP FOR SECONDARY MARINE SCIENCE

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RELATIONSHIPS BETWEEN SELECTED INSERVICE TEACHER CHARACTERISTICS AND CONTENT MASTERY TEST SCORES IN A PROGRAM-SPECIFIC TEACHER WORKSHOP FOR SECONDARY MARINE SCIENCE

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
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OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF EDUCATION

IN CURRICULUM AND INSTRUCTION

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By

Emily Barbara Cockcroft Klemm

Dissertation Committee

Frederick G. Braun, Chairman
Mitsuo Adachi
Charles T. Araki
Robert L. Campbell
Albert B. Carr

ABSTRACT

This is a study of relationships between characteristics of teachers participating in a High School Marine Science Studies (HMSS) Workshop and teacher scores on the HMSS Content Mastery Test. The combined Hawaii and Massachusetts workshop are the total population of HMSS Workshop participants during the summer of 1979.

Data were obtained using an HMSS Workshop registration form and results from pre- and post-workshop administrations of the program-specific HMSS Content Mastery Test. The test has two components: "Subtest A. Physical Science" and "Subtest B. Biological Science." The pre-workshop test was administered in parts throughout the workshop just before each HMSS unit was introduced; the post-workshop test was administered in its entirety at the conclusion of the workshop.

Results from testing indicate no statistically significant relationship between either pre- or post-workshop HMSS Content Mastery Test scores and three of the teacher characteristics selected for the study: total years teaching experience, age, and sex. Disciplinary background, level of prior marine experience, and highest degree in science reached positive statistical significance on "Subtest B. Biological Science" scores. Level of prior marine experience also reached positive statistical significance on the pre-workshop administrations of "Subtest A. Physical Science."

Two-way interactions reached statistical significance on post-workshop scores of "Subtest A. Physical Science" with total years teaching experience and disciplinary background.

In general, teacher characteristics had (1) a closer relationship to biological science scores than to physical science scores, and (2) a closer relationship to pre-workshop scores than to post-workshop scores. The study concluded that significant relationships exist between selected teacher characteristics and teacher scores on the HMSS Content Mastery Test.

As a result of this study, HMSS Workshop leaders can use pre-registration data to predict scores of HMSS Workshop participants and to plan modifications of workshop activities to better meet individual teacher needs.

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Workshops for the purpose of training inservice teachers in the use of a specific curricular program are discussed in this chapter under the headings of (1) Preparation of Secondary Science Teachers, and (2) Program-Specific Inservice Teacher Training Workshops. The research study is presented under the headings of (3) Statement of the Problem and Hypotheses, (4) Assumptions, (5) Design of the Study, (6) Subjects of the Study, (7) Terms Used in the Study, (8) Need for the Study, and (9) Limitations of the Study.

Preparation of Secondary Science Teachers

Throughout Western history, diversity regarding what constitutes teacher education has been reflected in disagreement and controversy over the aims of education and the nature, purpose, and function of schools in society. Until the nineteenth century, to be liberally educated was to be prepared to teach, largely because of the widely held assumption that to be trained to think was synonymous with being trained to teach. The classicial curriculum, consisting of the arts, literature, and philosophy, was undoubtedly relevant subject matter preparation for individuals preparing to teach and to perpetuate the relatively static classicial curriculum.

Views about teacher education changed in the nineteenth century. Some of these changes reflected a dynamic growth of knowledge in the natural, mental, and moral philosophies which emerged as distinct disciplinary areas that are known today as the sciences, social sciences, and humanities. In terms of subject matter mastery, individuals preparing to teach could no longer study and master all fields of knowledge. Teacher education changed so that by the twentieth century secondary teachers were required to complete general coursework in the liberal arts plus coursework in a specialized subject area.

Changes in teacher education for secondary teachers also brought about the inclusion of professional study of the foundations of modern pedagogy that are reflected in the psychology, sociology, history, and philosophy of education. It also included study of the principles and practices of curriculum. Schueler refers to these courses as foundational, and to those courses which assist the teacher in applying foundational knowledge to practical teaching situations as instrumental.[1]

In 1963, Conant found that secondary teacher education programs differed widely throughout the United States. He found differences in course requirements for certification as well as in the patterns for sequencing required courses and in the rigor with which the certification requirements were enforced. Conant found that most of these differences stem from the historical origins and evolution of the teacher training institutions. He found no clear differences in the quality of teacher education between the programs offered by

teachers colleges and programs offered by colleges or departments of education in a university system.[2]

At the graduate level, teacher preparation programs generally follow the undergraduate teacher preparation programs in that both require specialized academic subject matter study and professional study. In both undergraduate and graduate teacher education programs, it is often in "methods" courses that teachers are confronted with integrating their academic study with their professional study. But, as documented in the Research in Science Education Survey (ROSES) report of 1968, even methods courses vary widely in scope, in purpose, and in the experiential opportunities that they provide for teachers.

Of interest to this study is that it is in the methods courses where secondary science teachers are usually introduced to the array of curricular programs used in intermediate and high school courses. ROSES researchers observed that 40 percent of actual classroom time is spent on four major topics:[4] (1) pedagogical problems of laboratory work (e.g., designing, setting up and supervising laboratory exercises), 12 percent; (2) discussion of "new" curricular programs, 11 percent; (3) planning, 9 percent; and (4) evaluation, 8 percent. Methods instructors who responded to a ROSES survey reported that (1) 40 percent discussed the BSCS biology program,[5] and 30 percent considered it intensively; (2) 40 percent discussed the PSSC program,[6] and 8 percent intensively; (3) 35 percent discussed the CHEMS program,[7] and 10 percent intensively; and (4) 20 percent discussed the ESCP program,[8] and 5 percent intensively; and (5) 15 percent

discussed the IPS program,[9] and 3 percent intensively. The ROSES study concluded:

> Although close to 70 percent of the methods courses study BSCS biology curricula, only about 30 percent of the instructors report studying the course "intensively." Similarly, for the other new courses, less than 10 percent of the instructors devote intensive consideration to any one. From the evidence . . . it seems that the attention given to the new courses would have to be described as "introductory" or "descriptive" rather than "preparation for teaching."[10]

It can therefore be concluded that most science teachers receive only a brief introduction in the science methods course(s) to the specific curricular program(s) they are expected to be able to teach in their specialized science subject matter area.

That institutionalized science courses at the graduate and undergraduate levels neither provide science content tailored to teacher needs nor address their curricular concerns was well recognized by the United States Congress during the past three decades. Hundreds of millions of dollars were appropriated by Congress and administered through the National Science Foundation (NSF) to support alternative forms of educational opportunities intended to promote both the academic and professional growth of teachers. The National Defense Education Act (NDEA) of 1958, and its revision in 1972, authorized more than a billion dollars for education with Titles V and VII supporting federally-funded teacher institutes. Alternate forms of federally supported inservice teacher education opportunities included Summer Institutes, Inservice Institutes, Academic Year Institutes, and Cooperative College School Programs.

Of particular interest to this study is that the NSF experience with alternate forms of inservice teacher education demonstrated how inservice teachers differ with respect to subject-matter mastery needs. NSF recognized and provided funding to support inservice teachers in five major, but not necessarily distinct ways.[11,12] Updating helped once well-prepared teachers remain abreast of advancements in scientific knowledge through refresher courses. Upgrading provided basic science and mathematics training for teachers with inadequate subject matter preparation. Reorienting helped teachers qualified to teach traditional courses to shift to newer approaches (e.g., the "inquiry style") or to the content of new curricular programs. Advanced-training in subject matter offered teachers opportunities to earn graduate credits leading to a master's degree. Specific background training equipped teachers to teach new curricular programs.

Program-Specific Teacher Training Workshops

This study looks at one form of inservice teacher education, program specific teacher training (PSTT) workshops. PSTT workshops are designed to train inservice teachers in the use of one specific curricular program. Experience with PSTT workshops at the Curriculum Research and Development Groups (CRDG), College of Education, University of Hawaii, has shown that specific objectives of PSTT workshops often include the following:[13]

1. Introducing teachers to the philosophy and objectives of one specific curricular program.
2. Acquainting teachers with the curricular program, its

instructional materials and strategies, usually by way of engaging teachers in carrying out the students' activities of the program.

3. Preparing teachers for using a specific curricular program with their students in their classroom. This includes strategies for implementing the program, activities for adapting materials to specific students and teaching assignments, and consideration of program-specific pedagogy.
4. Providing subject matter content needed by teachers specifically related to the curricular program. This specific background training may include updating, upgrading, reorienting, or advanced training, or combinations of these.

The thoroughness of PSTT workshops, and in particular of the third and fourth objectives of PSTT workshops, is directly related to the amount of training time and resources available. An Awareness PSTT Workshop (sometimes called an introductory or orientation workshop), lasting from one hour to a half or full day, serves to introduce teachers to a specific curricular program, but not to train them in using its content and strategies.[14] A Basic PSTT Workshop, the focus of this study, is of sufficient duration to prepare teachers for using an entire curricular program in their classrooms.

Extended PSTT Workshops or Institutes are of longer duration than a Basic PSTT Workshop and provide additional opportunities for program-specific subject matter presentations and other activities designed to aid teachers in improving academic and professional skills

related to teaching of the program. An Extended PSTT Workshop or an Institute includes one or two distinct but closely related subject-matter courses or their equivalent plus a subject-related methods course or PSTT workshop.

PSTT Workshops, whether basic or extended, are but one step in "a long term process requiring continued teacher involvement with people knowledgeable in a program," especially if the curricular change calls for development of new teaching skills. Additional post-PSTT Workshop follow-up supportive activities are often necessary over at least the first year of curriculum installation.[15]

Basic PSTT Workshops are not usually included in formal graduate degree programs of teachers. Although Basic PSTT Workshops are usually offered for college credits, these credits often do not apply towards a graduate degree. Given the static job market in the teaching profession today, with teachers better educated than they were twenty years ago,[16] the opportunity to earn additional college credits is no longer regarded as a primary motivation for teachers to participate in a workshop. Motivation for involvement today includes the opportunity to obtain new curricular materials, to learn new instructional ideas, and to grow both personally and professionally.[17] Still important, however, is that credits for attending a Basic PSTT Workshop (often called "inservice credits") are accepted by school boards and state departments of education as applying towards professional advancement, e.g., pay increments.

Developers and disseminators of curricular programs are interested in bringing about change in educational practice not

only by designing and implementing new curricular programs, but also by training teachers and by assisting them in implementing and adapting the new curricular programs into their classroom practice. PSTT Workshop leaders may be the developers of a specific curricular program or experienced inservice teachers who are thoroughly familiar with the curricular program. PSTT Workshop leaders often work cooperatively with professionals from colleges or universities, or with educational personnel from state or district school systems, or with both. From this point of view, persons who serve as workshop leaders are both inservice teacher trainers and disseminators of a specific curricular program.

The Basic PSTT Workshop that is the focus of this study is offered as a sixty-hour, one and one-half week training session for teachers planning to adopt all or part of the one-year High School Marine Science Studies (HMSS) Program. For brevity, this Basic PSTT workshop is referred to as the HMSS Workshop.

Statement of the Problem and Hypotheses

This study seeks to determine whether relationships exist between selected professional and personal characteristics of inservice teachers and their scores on a program-specific content mastery test. Specifically, this is a study of how inservice teachers score on the HMSS Content Mastery Test. The HMSS Content Mastery Test is composed of two subtests, "Subtest A. Content Mastery for HMSS Physical Science Units" and "Subtest B. Content Mastery for HMSS Biological Science Units."

Additionally, the study seeks to determine whether the professional and personal characteristics selected as variables in this study are related to teachers' scores on the HMSS Content Mastery Test.

The researcher served as an HMSS Workshop leader in three HMSS Workshops prior to this study during which she observed teacher reactions and performance. Experience and observations provided the basis for the hypotheses of this study.

The researcher postulated that the factors most likely to be related to entry-level, pre-workshop scores of teachers on the HMSS Content Mastery Test would be related to characteristics of teachers. More specifically, the researcher felt that (1) disciplinary area of academic subject-matter specialization, (2) level of knowledge as indicated by highest degree earned in science, and (3) amount of classroom teaching experience are three characteristics of the training and experience of all teachers that are related to knowledge of marine-related subject matter. Other factors postulated by the researcher as affecting teachers' scores on the HMSS Content Mastery Test include (4) amount of prior marine-related training and experiences, (5) age, and (6) sex of the teachers. Chapter III describes each of the six teacher characteristics in more detail and presents reasons for studying disciplinary background paired with teaching experience and level of prior marine experience paired with sex of teacher.

The researcher further postulated that if all teachers in the study had the same HMSS Workshop experiences, then these same

teacher characteristics would be related to the post-workshop scores of teachers on the HMSS Content Mastery Test. This study, therefore, examines both pre- and post-workshop scores.

Using the six teacher characteristics described above, four research hypotheses were formulated in order to determine whether statistically significant relationships exist between scores on the HMSS Content Mastery Test and selected teacher characteristics. The research hypotheses governing this study are that on both the pre- and post-workshop administrations

1. There will be a significant difference among scores on the HMSS Content Mastery Test when teachers are grouped by disciplinary background and by years of teaching experience.
2. There will be a significant difference among scores on the HMSS Content Mastery Test when teachers are grouped by their highest degree in science.
3. There will be a significant difference among scores on the HMSS Content Mastery Test when teachers are grouped by level of prior marine experience and by sex.
4. There will be a significant difference among scores on the HMSS Content Mastery Test when teachers are grouped by age.

Assumptions

This study is predicated on the following assumptions:

1. The key to inservice teacher education is the individual teacher. His or her needs must be met in order for change to occur.

2. Inservice needs of teachers are tied to their academic, professional, and personal backgrounds.
3. Teachers who attend PSTT Workshops do so as learners, and their learning gains can be measured.
4. Scores obtained on the pre-workshop and post-workshop administration of the HMSS Content Mastery Test represent the best efforts of the subjects of this study.
5. Knowledge about relationships between cognitive performance and teacher characteristics can provide a basis for planning subject-matter treatment in future HMSS Workshops.

Design of the Study

The study is organized according to what Tuckman describes as an "*ex post facto* co-relational study" design.[18] The study looks for statistical relationships between selected characteristics of teachers and both their pre- and post-workshop performances on the HMSS Content Mastery Test. Chapter III discusses the design of the study in greater detail.

Subjects of the Study

Subjects of the study are the combined population of inservice teachers (N = 47) who voluntarily participated in an HMSS Workshop during the summer of 1979. One workshop was held in Massachusetts (N = 24), the other was held in Hawaii (N = 23). No prerequisites were placed on participation in either workshop other than interest in learning how to use the multi-disciplinary materials and strategies

of the one-year HMSS Program. In Massachusetts, the HMSS Workshop was held at Salem State College from June 25 to July 5, 1979. In Hawaii, the HMSS Workshop was held at the University Laboratory School, College of Education, University of Hawaii, from July 23 to August 3, 1979. The same two workshop leaders taught both workshops following the same workshop agenda and format.

Terms Used in the Study

Terms used in this study, their definitions, and some examples are given below.

Advanced training in subject matter refers to opportunities for teachers to earn graduate credits applicable to a master's degree. Enrichment is sometimes used in a similar way.

Content, Program Specific refers to the subject matter of a curricular program. Content includes concepts (general ideas or understandings derived from specific occurrences or instances) and principles (statements of relationship between two or more principles).

Course refers to a component of a subject area curriculum, usually of one-semester or one-year duration. Instructional materials used in teaching a given course may be a curricular program like the HMSS Program.

Curricular Program is used interchangeably with the term Program. Program is used for brevity. See Program for definition of term.

Curriculum, School includes all learner experiences under the direction of the school. It also refers to the sum total of all courses in the school.

Curriculum, Structured refers to a curriculum that has connections and relations among its elements in terms of sequence and scope.[19] Structured curriculum usually refers to a curricular program, but may refer to a school curriculum, a subject area curriculum, or a course.

Curriculum, Subject Area is a planned series of encounters for learners with related disciplines normally grouped together within the school curriculum. It is the sum total of all courses taught in school within a disciplinary subject area. A secondary science curriculum, for example, usually includes chemistry, physics and biology courses.[20]

Disciplinary Area Study or Disciplinary Background of teachers refers to the field of specialized subject area study completed by a teacher. Teachers in this study are classified as having a biological sciences background, a physical sciences background or another, nonscience background. Syn. Academic Major or Academic Subject-Matter Specialization

Disciplinary Areas of Science, following Phenix's epistemology describing the sciences as an empirical realm of knowledge,[21] refers to two major subcategories of science that are used in this study. They are the physical sciences which include physics, chemistry, and geology; and the biological sciences which include botany, zoology, and ecology. In this study, "nonscience disciplinary areas" includes elementary education, social studies, and art.

Disciplinary Content is defined as structured subject matter of a disciplinary area. In this study, because the subject matter of

the HMSS Program is viewed as being derived from several of the science disciplines which study the ocean; content is viewed as primarily based on the structure of those component science disciplines. According to Schwab, "the structure of the discipline consists, in part, of a body of imposed conceptions which define the investigated subject matter of that discipline and control its inquiries."[22]

Disciplinary, Multi- describes a course or program which includes planned series of encounters for learners with selected content and process from several disciplines applied to the study of a central or common phenomenon. The HMSS Program and other courses in marine sciences or oceanography are, therefore, multi-disciplinary.

Disciplinary Process refers to the inquiry processes of a discipline which involves "the pattern of its procedures, its methods, how it goes about using its conceptions to attain goals."[23]

Disciplinary Theory includes these two components: (1) the theory of the discipline which deals with various theories, laws, generalizations, etc., that are the product of the disciplinary practitioners; and (2) the theory about the discipline which is the concern of philosophers of science in examining the evolution of the disciplinary domain and the process of knowledge-generation by the discipline.[24]

Disciplines of Knowledge are semi-independent, logically organized fields of inquiry which are distinguished by their scholarly prestige.[25]

Domain, Affective refers to that part of human experience which describes changes in interest, attitude, and values.[26]

Domain, Cognitive refers to that part of human experience which deals with the recall or recognition of knowledge and the development of intellectual abilities and skills.[27]

Inquiry, understood in this study to be Scientific Inquiry, is a systematic approach for seeking information which includes the use of observation, experimentations, questioning, and the use of literature.[28]

Institute refers to teacher education that is often federally or industrially funded. An institute usually includes one or two distinct but closely related subject-matter courses or their equivalent plus a subject-related methods course. Two types of institutes are distinguished: (1) discipline-centered institutes designed for general improvement of teachers' subject-matter mastery (regarded in this study as foundational and a form of continuing teacher education); and (2) program-specific institutes designed to improve teachers' program-specific or course-specific mastery of subject matter and methodology (regarded in this study as instrumental and a form of inservice teacher education).

Institute, NSF refers to one or more of the following National Science Foundation-funded teacher institutes: Summer Institutes (intensive discipline-centered institutes or Extended PSTT Workshops usually recruiting teachers nationally for on-campus summer resident study); Inservice Institutes (similar to Summer Institutes but offered by colleges as a commuter program throughout the academic year); Academic Year Institutes (a full-time program of advanced training); and Cooperative College-School Science Programs

(involvement of college scientists with school-based curricular change and inservice teacher training, including PSTT Workshops).

Intensive Institute or Workshop are those which cover an academic year's work during a few condensed weeks, usually in the summer. A Basic Program-Specific Teacher Training Workshop (Basic PSTT Workshop) like the HMSS Workshop is an intensive workshop that presents a one-year curricular program (High School Marine Science Studies Program) in one and one-half weeks. An Extended Program Specific Teacher Training Workshop (Extended PSTT Workshop) which may also be called a Summer Institute, is an intensive workshop or institute that may range from four to nine or ten weeks and consist of one to three courses.

Institute, Teacher's is an historical term identifying short-term professional training courses for employed teachers conducted prior to the Civil War on a voluntary basis that were arranged by local or state school districts but taught as an extension service provided by normal schools or colleges. Many *Teacher's Institutes* were state or locally supported, providing courses lasting two to eight weeks, including teaching methods and common school subjects.[29] *Teacher's Institutes* provided remedial training for teachers lacking preservice teacher education.

Integration, Content refers to the combining of content from various disciplines into a course, program, or instructional unit of a program. In the HMSS Program, for example, the instructional unit "Transportation" has content integration of buoyancy and density from physics with design concepts from engineering to explain ship capacity and efficiency.

Interdisciplinary Concept Reinforcement refers to the process of applying conceptual understanding from one disciplinary area to conceptual understanding of phenomena in another disciplinary area. An example is the application of the concepts of biological structure and function to the design of ships in ocean engineering.

Marine traditionally refers to the oceans and to salt water phenomena. In the context of marine education it includes coastal and fresh water phenomena as well.

Marine and Aquatic Education is "that part of the total educational process which enables people to develop a sensitivity to and a general understanding of the role of the seas and fresh water in human affairs and the impact of society on the marine and aquatic environments."[30] For brevity, this study uses the term marine education.

Marine Biology is a branch of biology devoted to the study of life in the oceans. Marine biology is a component of oceanography and the marine sciences. Marine biology and biological oceanography are used interchangeably in this study. Courses which are predominantly the biological study of the ocean are called marine biology in this study and are classified in the disciplinary area of the biological sciences.

Marine Experiences, Prior refers to avocational and non-school vocational experiences of inservice teachers prior to an HMSS Workshop which might contribute to their cognitive knowledge of the marine sciences.

Marine Sciences are those sciences which study the ocean and the technologies which seek to use the ocean. Examples of theoretical marine sciences are physical oceanography and biological oceanography. Ocean engineering and aquaculture when put to practical ends are examples of marine technologies. The HMSS Program includes the traditional science areas of oceanography plus marine technologies.

Ocean is included in this list of terms to emphasize that the ocean is a place; it is not a discipline.

Oceanography is a multi-disciplinary science dedicated to the study of the oceans. Traditionally, oceanography includes physical oceanography, chemical oceanography, geological oceanography and biological oceanography. For this study, because three out of the four major components of oceanography are in the physical sciences, oceanography is classified as predominantly a physical science.

Program and Curricular Program are terms used interchangeably in this study to refer to a unique combination of educational processes, content, personnel, facilities, equipment, and supplies which operate together to accomplish specified educational goals and objectives.[31] The specific program that is the focus of this study is the High School Marine Science Studies (HMSS) Program[32] developed by the Curriculum Research and Development Group, College of Education, University of Hawaii.

Program-Specific Background Training. One of the objectives of a program-specific teacher training workshop refers to assisting teachers in mastering the subject matter of a specific curricular program.

Reorienting refers to helping teachers who are adequately prepared to teach in a traditional subject matter area to shift to newer approaches (e.g., the "inquiry" method) or to new subject matter areas.[33] The trend for teacher reorientation is often associated with teacher reassignments.

Teacher Characteristics, Personal refer to the age and sex of teachers who participated in HMSS Workshops.

Teacher Characteristics, Professional include (1) disciplinary background, (2) highest degree in science, (3) years of classroom teaching experience, and (4) level of prior marine experience. These professional characteristics were selected for this study because they are postulated as affecting teachers' cognitive knowledge of the marine sciences.

Teacher Education refers to (1) all the formal and informal activities and experiences that help to qualify a person to assume the responsibilities of a member of the educational profession and to discharge responsibilities more effectively; and (2) the program of instructional activities and experiences developed by teacher education institutions. Syn. Teacher Training[34]

Teacher Education, Continuing refers to post-graduate teacher education that is more general or foundational in nature than job-specific or instrumental. It is designed to supplement and extend the foundational preservice education of individual teachers, to update them on recent approaches and findings, and to develop their proficiencies as professional teacher-scholars.[35]

Teacher Education, Foundational refers to the study of generalizations and principles in other subject areas as well as education.

This term was adapted from Schueler who refers to foundational teacher education as the study of the foundations of modern pedagogy that are reflected in the psychology, sociology, history, and philosophy of education.[36] In this study, it refers to disciplinary area study as well.

Teacher Education, Inservice refers to teacher education that meets the needs of the school system. It is therefore more job-specific and instrumental than general or foundational in nature. This term was adapted from Hawson who refers to inservice teacher education as the post-undergraduate employment-oriented teacher education activities intended to prepare for specific program demands which decisions within the system have created.[37] Staff training and staff development are similar terms.

Teacher Education, Instrumental, according to Schueler, refers to those courses which assist the teacher in applying foundational knowledge to practical teaching situations.[38]

Teacher Education, Professional refers to the formal study by teachers of the foundations of modern education (philosophy, history, psychology, sociology) and principles and practices of curriculum and instruction.

Teacher Education, Subject Area Specialization refers to the formal academic training of teachers in one or more disciplinary areas. Chemistry teachers, for example, have completed academic study which usually includes mastery of content and processes from the constituent disciplines of chemistry (i.e., physical chemistry, organic chemistry and inorganic chemistry). In this study, such

formal academic training is regarded as foundational in nature.

Updating refers to helping once well-prepared teachers remain abreast of advancements in scientific knowledge.[39] Similar terms are renewal and refresher.

Upgrading refers to providing basic training for teachers with inadequate subject matter or professional preparation.[40] A closely related term is remedial.

Workshop is a general term encompassing a wide range of teacher education activities. It is used in this study to refer to instrumental inservice teacher education. The term workshop usually implies a format in which teachers are actively engaged in carrying out educational activities, often in a field or laboratory setting.

Workshop, HMSS is the High School Marine Science Studies Teacher Training Workshop. This is a basic 60 hour, one-and-one-half week program-specific teacher training workshop designed to enable teachers to successfully implement the one-year High School Marine Science Studies (HMSS) Program with their students in their classrooms.

Workshop, Program-Specific Teacher Training (shortened to PSTT Workshop) is an instrumental inservice workshop designed for familiarizing inservice teachers with one specific curricular program, its philosophy and rationale, subject matter content, and instructional design. PSTT Workshops also include consideration of alternatives for implementing and adapting the curricular program to specific teaching assignments and as well consideration of the application of pedagogical principles to the use of the specific curricular program in instructing students.

Workshop, Awareness PSTT (also called Introductory, Descriptive or Orientation PSTT Workshops) introduces teachers to a specific curricular program. An Awareness PSTT Workshop may be from one hour to one or two days' duration. Although it acquaints teachers with a specific curricular program, it does not provide sufficient training for full adoption and implementation of an entire curricular program. Some Awareness Workshops are designed specifically for administrators and decision-makers.

Workshop, Basic PSTT is a PSTT Workshop of sufficient duration to train teachers in the use of one specific curricular program (including philosophy and rationale, subject matter content, instructional design, and evaluation strategies) so that teachers can successfully use that program for the instruction of their students. The Basic PSTT Workshop in this study is the 60 hour HMSS Workshop.

Workshop, Extended PSTT includes the Basic PSTT Workshop plus additional or extended opportunities for teachers to improve their program-specific mastery of subject matter and instructional skills. An Extended PSTT Workshop can be considered an institute that is instrumental in nature.

Workshop, Teachers' is an historical term identifying a distinct type of workshop that originated under the auspices of the Progressive Education Association (PEA) in 1936 as a six-week intensive work experience for inservice teachers on educational problems that had come to light as a result of the Eight-Year Study. Characteristics of this workshop are (1) experience-centered study based on interests and needs specified by participating inservice

teachers; (2) consultants, rather than instructors, served as resource persons provided assistance when called upon to lead group discussions and to help individuals explore and define their own educational problems and plans; (3) flexible rather than structured scheduling of workshop time and division of participants into groupings for activities; and (4) embodiment of many of the principles of PEA, including the idea of democratic group processes.[41]

Need for the Study

Motivation for this study arises first from the researcher's experience as a leader of earlier HMSS Workshops. Teacher responses indicated that there were differences of opinion as to the appropriateness of subject-matter presentations via inquiry activities during the Basic HMSS Workshop. For some teachers, portions of the subject matter were entirely new; for others the workshop activities provided essentially a review. Still others indicated a thorough familiarity with the subject matter and the desire to pursue more advanced topics. Relationships among teachers' expressed needs, the content of the instructional materials, and their actual scores on the HMSS Content Mastery Test were not clear. Although anecdotal records and workshop registrations provided some information on the earlier HMSS Workshops, the researcher recognized the need for systematic study.

As was described earlier in this chapter, the research literature reveals only that patterns for teacher education vary widely. At most, it can be assumed that inservice secondary science teachers

have had academic study in at least one of the component science areas of the HMSS Program (physics, chemistry, biology, geology, etc.). In addition, most secondary science teachers have earned degrees with academic subject matter specialization either in the physical sciences or in the biological sciences.

The HMSS Program, however, is multi-disciplinary. Each HMSS Instructional unit is designed to reflect the content and process of one or more of the theoretical and applied disciplines which study the ocean. Logically, therefore, teachers are likely to have greater subject matter mastery of those component disciplinary areas of marine science for which they have had prior formal academic study. From prior workshop experience, it was also apparent that some teachers had little or no formal training in some of the component areas of marine science (especially in aspects of geology, geography, and botany). Teachers do learn on the job through the process of teaching and so differences in subject mastery of marine science stemming from teaching experiences, particularly in teaching marine science, also were apparent. Teachers, therefore, differ in their pre-workshop knowledge of the multi-disciplinary content of the HMSS Program.

Unless pre-registration procedures are used which collect information on the professional characteristics of the inservice workshop participants, workshop leaders do not know until a workshop begins (a) in which academic areas the teachers have been trained, (b) the highest degrees in science the teachers have earned, (c) what kinds of classroom teaching experiences they have had,

and (d) the nature of their prior marine-related experiences and training.

Once an HMSS Workshop begins, its highly compressed and complex schedule makes adjustment for individual learner differences difficult. In practice, alternatives must be planned and scheduled before the HMSS Workshop begins. Otherwise, even if a workshop leader could recognize and respond to individual teacher needs within one or two days, substantial portions of the workshop would already be completed. This is particularly a problem in the multi-disciplinary HMSS Workshop because different disciplinary areas of marine science are presented each day.

Even when information on the professional characteristics of the inservice participants is available to HMSS Workshop leaders prior to HMSS Workshops, the leaders, at present, are limited in the use of this information to plan for individual teacher differences. Systematic study is needed which relates the professional characteristics of teachers to their cognitive performance in an HMSS Workshop.

It is hoped that ultimately this study will enable future HMSS Workshop leaders to use pre-workshop registration data together with pre-workshop HMSS Content Mastery Test scores to preview the population of inservice teachers and to predict their cognitive performance. Workshop leaders would then be able to design both Basic and Extended HMSS Workshops that provide alternative, appropriate subject-matter treatments for subpopulations of teacher participants. Information from post-workshop scores could also

provide a basis for planning supportive follow-up services for teachers who adopt and implement the HMSS Program.

Motivation of the study was reinforced by preliminary analysis of the pre- and post-workshop scores on the HMSS Content Mastery Test administered to the inservice teachers who are the subjects of this study. Findings of the preliminary analysis, given in Appendix B (Tables 10 through 12), indicate that

1. An effect of the HMSS Workshop training is a statistically significant gain (equal to or less than the $p = .05$ level of significance) in teachers' scores on the HMSS Content Mastery Test. Using a one-tailed t-test, differences in pre- and post-workshop scores were found to be statistically significant below the $p = .05$ level. These were found for both workshop groups (Massachusetts and Hawaii).
2. There were no statistically significant differences (equal to or less than the $p = .05$ level of confidence) between the means of the two workshop groups (Massachusetts and Hawaii) using a two-tailed t-test.

In addition, the preliminary analysis indicated that there are relatively large standard deviations in both pre- and post-workshop scores. Had this population consisted of secondary students, not secondary science teachers, the spread in scores would not have appeared wide. The presumption here is that because the inservice teacher participants in the HMSS Workshop are science teachers, they would, in general, perform well on a test based on a secondary science curricular program.

Speculation as to how to account for this gave rise to questions of whether differences in teachers' scores are related to their professional and personal characteristics. Observing also that the teachers on the average scored lower on "Subtest A. Physical Science Content" than on "Subtest B. Biological Science Content" gave rise to speculation as to whether differences in academic subject matter and professional preparation of teachers, their professional experiences and personal characteristics, or combinations of these were related to their performance on the HMSS Content Mastery Test.

If through this research relationships can be found between teacher characteristics and performance, it is hoped that this knowledge will enable HMSS Workshop leaders to more rationally plan future HMSS Workshops to better meet the specific needs of participating inservice teachers.

Limitations of the Study

A major limitation of the study is that its scope is restricted to measures of the effect of program-specific teacher training in terms of the cognitive performance of the participating inservice teachers. The researcher recognizes that an HMSS Workshop is by no means limited to inservice teacher growth in the cognitive domain. Much occurs during an HMSS Workshop that is neither described nor measured in this study that lies in the affective and psychomotor domains as well. Additional studies are needed to identify, describe, and measure the effects of HMSS Workshop training on (1) other

aspects of participating teachers' personal and professional growth, (2) post-workshop classroom performance of teachers in adapting and implementing the HMSS Program with specific students and with specific teaching assignments, and ultimately on (3) the performance of their secondary students.

It should be pointed out here that in this study investigation centered on statistical relationships between selected characteristics of teachers and both their pre- and post-workshop performances on the HMSS Content Mastery Test. Gain scores were not examined because the researcher held that for purposes of better providing PSTT Workshops tailored to the needs of inservice teachers, it is more important to know the relative level of performance of subpopulations of teachers than it is to know how many points they gain on the workshop test. For example, it is more important to know that one subpopulation of teachers had pre- and post-workshop scores of 50 percent and 60 percent and a second subpopulation had scores of 80 percent and 90 percent than it is to know that both subpopulations gained ten points.

A second limitation of this study is the way it categorizes teachers by subject area. Although secondary science teachers are often categorized into three areas as teachers of biological sciences, of physical sciences, and of earth sciences, this study uses two categories: teachers of biological sciences and teachers of physical sciences. In this study, earth sciences teachers are grouped with the physical science teachers for two reasons. First, the study follows Phenix's epistemology where earth sciences are classified

as more like the physical sciences than the biological sciences.[42] Phenix, therefore, classifies geology as a physical science, and so does the HMSS Program, as shown by inspection of their logo.[43] Second, in terms of statistical methods, grouping of earth science teachers with the physical science teachers formed a group of teachers approximatey the same size as the group of biological sciences teachers and teachers with nonscience disciplinary backgrounds.

A third limitation is the relatively small size of the population studied. As is explained in more detail in Chapter III, to achieve sample size large enough for adequate statistical analyses, the subjects of the study are the combined population of teachers in two HMSS Workshops, one held in Hawaii and the other held in Massachusetts. Even though the combined population consisted of two voluntary groups of participating teachers, the sample was in reality the entire population of HMSS Workshop participants during the summer of 1979. In addition, following the logic of Cornfield and Tukey,[44] application of conclusions to a larger group "like those observed" is both possible and desirable. Therefore, based on the need of HMSS Workshop leaders for more information with which to plan future workshops, conclusions are drawn and applied to inservice teacher participants in future HMSS Workshops.

CHAPTER NOTES

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[37]Howsam, loc. cit.

[38]Schueler, loc. cit.

[39]Krieghbaum and Rawson, loc. cit.

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[41]K. L Heaton, "The Workshop for Teachers," Harvard Educational Review, 12 (January 1942), 47-54.

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[43]The HMSS logo is a three-tiered teardrop. It represents the three themes of the program which are (1) "The Fluid Earth" (physics, chemistry and geology); (2) "The Living Ocean" (plants, animals and ecology); and (3) "Technology" (aquaculture, transportation and ocean engineering).

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CHAPTER II

REVIEW OF LITERATURE

This chapter reviews the historical literature on inservice teacher workshops viewing them as temporary systems formed to provide supplementary training for teachers that is needed but not provided by contemporary teacher training institutions. Sections of the chapter include (1) Teacher Workshops as Supplementary Agencies of Teacher Education, (2) *Teachers' Institutes*, (3) *Workshops for Teachers*, (4) Industrial-Sponsored Institutes, (5) National Science Foundation Institutes, and (6) Commercial Publishers' Inservice Activities. The review concludes with (7) Present Need for Program-Specific Teacher Education, and (8) Commentary on the Future of Program-Specific Teacher Training Workshops.

Teacher Workshops as Supplementary Agencies of Teacher Education

> The formal history of American teacher education and professionalization is conventially a story of one triumphal march from Samuel R. Hall's Concord, Vermont, normal school in 1823 to the modern National Education Association and the great graduate schools of education. This version of history is misleading.[1]

Borrowman went on to explain that although histories of teacher education talk of upgrading the profession, "on relative grounds the teacher educators were doing little more than holding their own." He explained that by 1940 a baccalaureate degree was essential if teaching was to

be considered a learned profession. By the 1950s and 1960s, with higher proportions of Americans as college graduates, fifth year and graduate programs for teachers had become the norm.[2]

Whether viewed conventionally or in light of Borrowman's comments, a history of teacher education that considers only formal preservice, fifth year and graduate programs for teachers does not present a complete picture of the history of teacher education. Largely missing from the histories of teacher education are accountings of the effect of supplementary education programs provided for inservice teachers throughout the past century and a half in the form of teacher workshops and teacher institutes.

"Workshop" is a term that is familiar to educators today. Generally, workshops refer to inservice teacher activities that are experiential (sometimes called "hands-on") and instrumental in nature (i.e., they provide a practical, job-related aspect of inservice education). Furthermore, a workshop is often distinctly labeled as such and set apart from the foundational courses that are required for graduate degrees in science or education.[3] Although workshops are classified in the educational literature as inservice teacher education activities, hands-on, subject-related experiential workshops are qualitatively different from other forms of inservice teacher education that are school-based and variously described as staff development or organizational development activities.[4] Yet the literature on inservice teacher education largely addresses the school-based activities, not the collegiate-based forms of inservice teacher workshop activities.[5]

That the terms "teacher workshop" and "teacher institute" are neither well defined nor consistently used becomes apparent when using computer searches of the ERIC data base and of the Comprehensive Dissertation Abstract data base.[6] A brief example is that an activity reported in the literature as a "teacher workshop" could refer to an activity that lasts for days or even weeks. Activities reported in the literature as "teacher workshops" cover a wide range of purposes, expectations, organizational structures, funding, and types of administrative control.

This chapter is organized to present an historical review of major types of teacher workshops that have appeared from the post-Civil War era to the present time. Each type of workshop served as a temporary system[7] organized by contemporary permanent education institutions to provide ad hoc, job-specific training that was perceived as needed, but not provided by the permanent teacher education institutions of each era. Each of these workshops was therefore a supplementary form of inservice education.

Teachers' Institutes

Teachers' Institutes were probably the first of the ad hoc temporary systems devised in the United States as a means of providing job-specific training for inservice teachers that was otherwise not available in contemporary teacher education institutions. *Teachers' Institutes* appeared after the Civil War typically as one to four week summer sessions providing intensive education in common school subjects and in rudiments of school keeping for inservice common school teachers.

Need for the establishment of *Teachers' Institutes* arose largely because of a lag in the establishment of the normal school as a permanent teacher education institution capable of preparing an adequate supply of teachers to meet the demands of the then rapidly expanding public common school system.[8] Most pre-Civil War common school teachers had taught school with no professional preparation. Earlier teachers of older children were largely young men from private colleges or academies who spent a few years teaching as a transient activity before entering a profession. With the Civil War disrupting the education of young men, unmarried women were permitted for the first time to teach older children.[9] Whether male or female, most of the post-Civil War teachers were young, inexperienced as teachers, and poorly educated themselves. Most had completed common school, but very few were able to afford or had access to private academies or colleges for further education. Certification requirements of that time permitted poorly qualified persons to teach.[10]

As Heffernan stated, the Civil War was "a tragic obstacle to educational progress throughout the nation."[11] Referring to the devastated public education system of the southern states, Knight described teachers of the post-Civil War period as a class as being ignorant, incompetent, incapable of making a living at other employment and recommended only by their cheapness.[12] In some states, schools were closed; in others conditions were so deplorable that Heffernan described these as the "dark decades" in education.[13] Prevailing public sentiment was that public instruction was degraded, public funds squandered and public opinion debauched.[14]

The *Teachers' Institute* originated in this period when there was a shortage of even partially trained inservice teachers. Richey described *Teachers' Institutes* as established to correct deficiencies of the education and pretraining of culturally deficient and untrained teachers.[15] In 1888, the U.S. Commissioner of Education explained that *Teachers' Institutes* were supplementing the efforts to establish normal schools for the training of common school teachers. He wrote

> The normal schools furnish but a small proportion of the teachers of the public schools; the vast majority having never received professional training. To educate this majority a peculiar and American institution has been established called an institute. In this, at annual intervals, the teachers of the county or "institute district" are assembled for periods varying from one week to four or more and receive instruction of uncertain kinds at the expense of the State, the county, or in some cases, in part at their own expense.[16]

Early *Teachers' Institutes* were established not only for inservice teachers but also for preservice teacher candidates. According to Richey, *Teachers' Institutes* spread and became widely accepted because of their value as a needed agency of inservice teacher education.[17] Until the end of the nineteenth century, *Teachers' Institutes* were particularly important for educating rural school teachers, city elementary school teachers, and to a lesser extent, for high school teachers without access to college or normal schools.[18]

Teachers' Institutes became an anachronism in the early decades of the twentieth century. The need for *Teachers' Institutes* had ceased to exist. Teachers were no longer just elementary school graduates, and state normal schools with little or free tuition had succeeded not only in replacing expensive private colleges and

academies as teacher education institutions, but also in producing adequate numbers of preservice-educated teachers. By this time, other more advanced teacher education programs were also being provided for inservice teachers through normal school summer sessions and through college extension courses.[19]

During the decades of their demise (1900s-1920s), *Teachers' Institutes* received harsh criticism, largely on the grounds that they provided only mediocre and unsystematic training.[20] Nevertheless, during the post-Civil War period, they served to provide inservice teacher training not otherwise available. The ad hoc nature of *Teachers' Institutes* was reflected in comments by Barnard who described them as "temporary expedients"[21] and by Seeley who described them as "makeshift" and "not originally intended to be a permanent part of the educational system of any state."[22]

To this day, the term "institute" is sometimes still used to designate teachers' meetings, orientation programs, and other inservice activities that are organized by local school districts or by teacher labor unions. In addition, as is described later in this historical review, another type of ad hoc teacher institute appeared in the middle of the twentieth century in the form of federally-funded subject matter institutes.

Workshops for Teachers

The first *Workshop for Teachers* originated during the summer of 1936. Thirty-five science and mathematics teachers met together with leading educators at Ohio State University for intensive work on

educational problems encountered in their experience as teacher participants in the Eight Year Study.[23]

Heaton states that the *Workshop for Teachers* arose out of concern by Tyler and others on the staff of the Eight Year Study that "teachers had too little time in the course of their regular duties to work together on the problems involved in the new experimental program."[24] The original *Workshop for Teachers* had two purposes. The first was the development of curriculum plans with teachers in schools associated with the Eight Year Study. The second was to give opportunity for intensive work in some of the studies of the Progressive Education Association (PEA), sponsors of the Eight Year Study. These included exploring the needs of normal youth as a basis for educational programs under the auspices of the Adolescent Study and searching into new kinds of measurement and evaluation.[25]

Need for *Workshops for Teachers* during the decade from mid-1930s to mid-1940s arose largely because of a schism perceived by teacher educators between the formal academic and the professional preparation of teachers. Eurich explains

> Workshops--at least under that name--are new in the professional education of teachers. Like most developments in secondary schools and colleges they evolved from a recognition of inadequacies in current programs and from better understanding of needs. In recent years there has been a growing belief that teacher education, particularly for experienced workers, was too far removed from the actual problems of the school. Either the gap between practice and theory was too wide or the theory was so spun out of whole cloth that it could not be applied. As a result teachers in summer schools and those pursuing graduate work while on leave from their jobs thought of further professional education and of regular classroom work as two wholly different lines of effort never to cross each other. Much of the research of the professional educator contributed unwittingly to this schism. Workshops provide

> for the reunion of real teaching or administrative problems and educational theory.[26]

Workshops for Teachers of that era were devised to provide a means for reorienting inservice teachers, helping them to shift from a subject-centered approach to curriculum to a curriculum approach based on the needs of children. *Workshops for Teachers* were designed to encourage teachers to relate their professional problems to educational theory.[27] Ryan and Tyler were particularly concerned that the *Workshops for Teachers* served also as models for operationalizing precepts of progressive education as reflected in a comment by one teacher participant who described his experience in a *Workshop for Teachers* as "living a philosophy of education."[28]

Until the appearance of the *Workshop for Teachers,* inservice programs in the early 1930s were not aimed primarily at helping teachers meet new problems but rather at filling gaps in college requirements. The prevailing belief was that the quality of American public schools could be improved by requiring all teachers to have a bachelor's degree, and at that time, 50 percent of inservice teachers had about two years of college. Normal Schools had been evolving into Teachers' Colleges that offered four year baccalaureate degrees. Inservice courses in Teachers' Colleges of that period consisted of standard college courses that teachers had not previously taken. Thus, educational programs of the Teachers' Colleges were not designed to meet the need for reorientation of inservice teachers from traditional subject-centered curricular approaches to the newer child-centered pedagogy of the progressive era.[29]

Because they met the need for reorienting inservice teachers in the newer approaches of progressive education, as an innovative supplementary form of inservice teacher education, *Workshops for Teachers* were adopted by others and spread. Heaton stated that "in three years a temporary program planned for the benefit of a small group of teachers in the Eight Year Study had developed into a program of teacher education which gave promise of some permanence and growth."[30] Ryan and Tyler, however, felt that the greatest danger the *Workshop for Teachers* faced was that others would try to imitate the externals and would "succeed in capturing the form only and not the spirit."[31] Heaton stated "the term 'Workshop for Teachers' has not even represented a uniform program, in fact, no two have been alike except in purpose and guiding principles."[32] Their unique value was summarized by Hill as (1) providing assistance that is relevant to the real and specific needs of participants, but given within a framework of modern education (i.e., progressive education), and (2) giving recognition to individual ability and achievement and making these contributions to the "democratic process of group life."[33]

In 1939, a Committee of the Eight Year Study reviewed ten of the *Workshops for Teachers* which they had sponsored. They concluded that teachers would always be in need of such assistance and that the experimental *Workshop for Teachers* had provided certain effective methods. Their view was to incorporate *Workshops for Teachers* as a permanent part of the university curriculum.[34]

The commission on Teacher Education of the American Council on Education in 1944 described workshops as complementing, not supplanting

other modes of teacher education. With the development of the workshop, the Commission said, came a change in point of view about teacher education. Before the *Workshops for Teachers*, the implied view was that once teachers had earned their bachelor's degrees or some equivalent certification, then their education would be complete. With the involvement of inservice teachers in workshops, attitude shifted "to one that holds that self-improvement is continuously possible and ought universally be striven for."[35]

Workshops for Teachers as they were originally conceived were not institutionalized as a permanent part of the four year undergraduate curriculum of Teachers' Colleges because by the mid-1940s, a new generation of teacher candidates had been exposed to the progressive educational philosophies in their preservice education courses. Therefore, by the mid-1940s, *Workshops for Teachers* provided instrumental enhancement of the foundational studies of progressive principles incorporated in the formal courses of the four-year programs of Teachers' Colleges. The need for inservice teacher reorientation had lessened also because progressivism had largely been adopted and implemented in the schools. By mid-1940s, *Workshops for Teachers* complemented, but did not supplant, other modes of inservice education, provided that "complement" is here construed as enhancing rather than completing the education of inservice teachers.

Reflecting over the contributions of the Eight Year Study and the experience of the *Workshops for Teachers*, Tyler said, "We learned something of great importance to in-service education of teachers . . . that the constructive involvement of teachers is a powerful instrument

of continuing education."[36] The notion of workshops as a means of engaging teachers in inservice education activities that are not regularly scheduled in undergraduate or graduate teacher education programs is now widely accepted. Today the term "workshop" is used in a generic sense to refer to a wide range of instrumental inservice teacher education activities. Some focus on common academic or professional problems in subject fields; others focus on local school problems or aspects of staff development. Thus workshops today, though different from the original *Workshops for Teachers* with respect to purposes and organizing principles, still function to supplement the education of inservice teachers.

Also of note is that it was the professional education associations and not the colleges of education nor the state or local school systems which "have been and largely continue to be, preoccupied with inservice education."[37]

Industrially-Sponsored Teacher Institutes

Industrial and philanthropic institutions pioneered in establishing a new form of teacher institute from the mid-1940s through the late 1950s.[38] In 1944, General Electric Company (GE) officials involved with recruitment of scientists and engineers were concerned about the weak academic backgrounds of public and parochial science and mathematics teachers. GE decided, therefore, to offer teachers opportunities for bringing their subject matter up-to-date and for seeing modern industrial applications of the curriculum materials they taught.[39] This, in turn, GE officials felt, would bring GE to the attention of

high school students and encourage the bringing of exceptional high school students to the attention of GE.

In the summer of 1945, the first six-week Summer High School Teacher Fellowship Program was held at Union College, in close proximity to GE facilities in Schenectady, New York. Selected high school teachers, called "fellows," were expected to attend classes five days per week to take two graduate-level courses in physics. Prerequisites were two physics courses and a mastery of differential calculus. Fellows were also expected to spend almost half their time at the GE facilities learning about the company's operations. Thus, fellows were to be "brought into personal contact" with GE "celebrity" scientists and engineers who included a Nobel prize winner and reknown developers of contemporary technological innovations. Addressing the issue of subject matter versus pedagogy, GE President Fox said, "The program of study has been designed, not immediately to influence pedagogical methods, but to enlarge each Fellow's grasp of recent developments in physical science."[40] Thus, the sessions sponsored by GE were discipline-centered institutes concerned with foundational knowledge of subject matter.

GE offered sessions again in 1946 and 1947. Chemistry courses were added, and the program expanded to Case Institute of Technology in Cleveland. A course on the history and philosophy of science was added in 1949, and in 1952, a program was established for secondary mathematics teachers. GE led the way in including women and blacks. It decided, however, not to offer refresher courses for updating teachers for advanced training of participants. From 1945 through

1959, approximately 1,600 science and 900 mathematics teachers had attended GE institutes.[41]

The GE experience became the model and set precedents for other subsequent discipline-centered industrial and philanthropic-funded teacher institutes. Westinghouse Education Foundation began a similar institute program in 1949 for a six-week program for science teachers at the Massachusetts Institute of Technology (MIT).[42] During the 1950s, other industries and foundations supported similar programs. These included E.I. du Pont de Nemours and Company with institutes at Harvard, Ohio State, Columbia and St. Louis Universities, and the Shell Companies Foundation with programs at Cornell and Stanford. The Crown Zellerbach Foundation awarded money to Oregon State College for a program through the National Science Teachers Association. Focusing on mathematics, the Burroughs Adding Machine Company sponsored a project at Marquette University. Four physics institutes were sponsored by the Fund for the Advancement of Education of the Ford Foundation.[43,44]

Richardson described other similar efforts which he called community action programs. These were designed to stimulate improvement in science and mathematics programs in the schools. Most of these, he said, failed to recognize and gain access "to the mainsprings of curriculum reform." Four programs he cited as having promise were (1) the Industry-Schools Committee on Science and Mathematics Education of Indianapolis, (2) the International Paper Company Foundation, (3) the Thomas Alva Edison Foundation, and (4) the Frontiers of Science Foundation of Oklahoma, Inc.[45]

During this period several universities, without industrial or government support, also began offering special subject-oriented courses designed for inadequately prepared teachers. One of the earliest and most successful was a ten-day mathematics institute held yearly from 1941 to 1956 at Duke University. Others, less successful at attracting teachers, were held at the University of Vermont, Pennsylvania State University, and Alabama Polytechnic Institute.[46]

Experience in early industrially-sponsored institutes pointed to several problems in discipline-centered inservice teacher institutes which persisted throughout the later period of the federally-funded institutes (circa 1955-1980). The first problem was the selection of a homogeneous group of qualified teachers.[47] The second problem was the need to tone down the courses so that subject matter would be presented in a more elementary, and more appropriate manner.[48] These institutes quickly found that teachers needed special subject-matter courses not available in traditional graduate or undergraduate college programs. Richardson explained that because of their often-diversified teaching schedules, teachers need more breadth of preparation in several fields of science. This breadth, in turn, all too often means that a teacher may not have gained sufficient depth in any one area to pursue traditional academic graduate work.[49] In addition, teachers once well prepared for graduate work were found to have had so little use of their knowledge that they were no longer prepared for graduate study. Another recurring problem was the need for upgrading through remediation and review, particularly in mathematics.[50]

As a result, two types of special subject courses for teachers were offered in the institutes; (1) an advanced general course with laboratory work that provided breadth and enrichment, and (2) a "recent advances" type of course that provided depth in a limited number of topics. From the early GE institutes, questions were raised as to whether traditional graduate credits should be offered because "without such credit there would be greater freedom in adjusting the work to the improvement of those participating in the program."[51]

Industrially-sponsored teacher institutes pointed also to other concerns related to inservice teacher education. First, teachers expressed need for training in materials immediately applicable to their teaching (i.e., more instrumental materials). Second, university scientists expressed concern in being drawn from research time during summers to spend this time in less professionally recognized or rewarded activities associated with teacher training.

The appearance of industrially-sponsored sessions in the 1940s demonstrated a need perceived by industry and by scientists at that time to provide supplementary, discipline-centered foundational study tailored for inservice science teachers. These sessions provided educational opportunities for inservice teachers not otherwise available to them in contemporary Teachers' Colleges or newly emerging universities. Even though the most highly qualified teachers were selected, this experience showed that teachers needed subject matter review (i.e., upgrading) in addition to subject matter updating and some advanced training. Of note also is that although these sessions were

organized and funded by industries, they were located on college and university campuses in the science or mathematics departments. These sessions, therefore, involved neither colleges of education nor state or local education agencies.

Clearer understanding of the appearance of these industrial institutes as a supplementary form of inservice teacher education during this era requires additional historical research that goes beyond the scope of this paper. For example, understanding the issues of that era related to academic versus professional control over teacher preparation and teacher certification help explain the involvement of industries and scientists in teacher workshops.[52] Similarly, political and technological understanding of the nature of the post-World War II political and technological changes helps explain the mounting criticism of those times towards the adequacy of schools and of inservice teachers.[53]

Industrial institutes were phased out by the end of the 1950s, and replaced by teacher institutes that were funded in the order of hundreds of millions of dollars by the federal government. Early federally-funded teacher institutes, particularly those sponsored through the National Science Foundation, were largey modeled on the precedents and lessons of the discipline-centered industrial and philanthropic teacher institutes of the 1940s and 1950s.

National Science Foundation Institutes

The National Science Foundation Act of 1950 established the National Science Foundation (NSF), authorizing NSF among other

functions to "develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[55] NSF was established largely because of perceived critical shortage of scientific and technical manpower to meet the civilian and military needs of the United States, and because indications were that the shortage would continue for at least another decade.[54]

According to Atkinson, the development and evolution of NSF science education can best be viewed in terms of three periods roughly corresponding to the decades of the fifties, the sixties and the seventies.[55] During the first decade, NSF experimented with ways to develop programs and philosophy. Initial programs aimed at updating college teachers' subject matter mastery, encouraging basic research and supporting graduate and post-doctoral science fellowships.

By mid-1950s, NSF emphasis shifted following the logic that the scientific and technical manpower shortages were not due to a lack of bright students, but due rather to the failure of these students to enter college and pursue scientific careers. First NSF, and then Congress, viewed high schools as the bottleneck. NSF pointed also to the "widening gap between demand and supply of teachers" caused largely by the post-war baby boom.[56] After World War II, there was a marked increase in student enrollment both in absolute numbers and in relative percentage of the 14-17 year old age group. The resulting demand for more teachers had caused the relaxation of certification requirements and the employment of non-professionally trained "emergency teachers."[57]

In 1955, NSF supported discipline-centered Summer Institutes conducted by scientists for high school teachers that were modeled

largely on the experiences of the industrially-funded teacher institutes described in the preceding section of this chapter. NSF general guidelines stressed (1) that lectures and activities for NSF Summer Institutes be specifically designed for teacher participants, (2) that skillful presentations of concepts and methods of modern scientific inquiry be made by the best scientists in the country, (3) that selection procedures for staff and participants be well described, and (4) that proper location, adequate duration, and suitable living accommodations be arranged for by the institute. NSF chose not to prescribe institute specifics. Grants were, and still are awarded on the basis of competitive merit as perceived by a panel of peer reviewers, rather than on allocation by geography, population or subject field. NSF also chose to allow NSF directors maximum autonomy in designing and carrying out institutes.[58] The resulting hands-off policy led to diversity among the NSF institutes, with government funding but neither controlling nor operating the institutes.

In the mid-1950s, NSF also began curriculum development activities. NSF was charged with (1) discussing new developments and their place in secondary curriculum, (2) devising "syllabi-broad outlines of topics with examples of presentations of concepts and methods of science, (3) convening conferences between scientists and teachers to develop experimental programs to improve teacher quality and the quality of teaching aids, and (4) undertaking special studies to "determine the nature of the problem in improving science curriculum and the training of science teachers."[59]

Atkinson wrote, "NSF poineered curriculum development in a new way by involving practicing scientists and mathematicians directly

in the projects it supported," and by applying research and development methodology to the curriculum development process.[60] During the 1950s, millions of dollars were allocated, first to support the program-specific training of inservice teachers for trial testing and implementation of innovative curricular programs, and later for localized adaptations of these materials. Because NSF institutes were designed to reorient inservice teachers into new inquiry approaches to teaching, it is clear that NSF institutes were concerned with instrumental as well as foundational training for teachers.

Thus, NSF efforts aimed to engage scientists directly in the education of teachers. Involvement of scientists in many of the large NSF-funded curriculum development projects (e.g., BSCS and ESCP)[61] was through professional scientific associations. NSF also continued the precedent of the industrially-sponsored institutes in directly engaging scientists through colleges and universities in inservice teacher education. Although NSF largely bypassed colleges of education, they did involve some state or local education agencies, first in the decision to adopt, and then in coordinating inservice teacher workshops, many of which included Basic Program-Specific Teacher Training (PSTT) Workshops.[62] (Basic PSTT Workshops train teachers to use a specific curricular program.)

Kireghbaum and Rawson stated that the original intent prior to 1956 was to support NSF Summer Institutes and Academic Year Institute (AYI) programs (full-time college coursework) as experimental demonstrations to be phased out over time. The plan was to encourage industries to assume financial support and for colleges and universities to institutionalize these teacher education programs.[63]

This did not happen. Instead, NSF activity in teacher education programs accelerated during the late 1950s. NSF Director Waterman credits the 1955 publication, Soviet Professional Manpower, Its Education, Training and Supply, in bringing to the attention of the U.S. Congress the seriousness of America's science and technology manpower shortage.[64] By then, prominent scientists had direct contact with teachers in industrial and NSF Institutes, and were expressing both concern and shock that teachers' science backgrounds were so weak and out of date.[65] In addition, other vocal critics of the schools charged that because of excessive requirements of professional courses prior to certification, teachers were not being liberally educated and therefore had insufficient knowledge of the subjects they were teaching.[66]

Public alarm over the Soviet achievement in launching Sputnik in October 1957 "resulted in increased appropriations that transformed plans and experiments--for teacher education and curriculum development--into programs."[67] Education, particularly in science and technology, became linked to national security. Annual science education funding through NSF jumped from one million dollars in 1956 to nine million dollars in 1957-1958, then to thirty million dollars in 1959-1961, and thirty-seven million dollars in 1962-1965.[68] Additional billions of dollars were appropriated by Congress to support education and training in other subject fields through other federal agencies. Perhaps the largest was the National Defense Education Acts (NDEA) of 1958 and 1964 which was established in the Department of Health, Education and Welfare.[69] Although this study focuses only

on federally-funded teacher NSF Institutes in science, it is clear that in the period roughly from 1955 to 1975, the federal government supported thousands of teacher institutes.

A comparison of the purposes of the NSF Institutes as described by Krieghbaum and Rawson[70] with the purposes of the NDEA institutes as described by Gray[71] shows that the goals of most institutes sponsored by federal agencies were similar. Most institutes sought (1) to improve teacher knowledge of subject matter and teaching methodology, (2) to acquaint teachers with curricular and instructional materials so as to encourage the adoption and implementation of educational innovations, (3) to stimulate direct interaction of college and university professors with elementary and secondary teachers, and (4) to promote the development of more appropriate and more effective courses and programs for teachers at colleges and universities.

The structure of most NSF and NDEA Institutes was also similar. Most offered two or three courses in one or more related subjects. Institutes varied, however, in level of difficulty of instruction, and in the narrowness or breadth of subject matter coverage.[72] In most institutes, one of the courses, often called a "workshop," was designated for discussion of methods and materials of instruction. An estimated 20 percent of the NSF Summer Institutes, Inservice Institutes and Cooperative College-School Science Programs[73] included as the methods course explicit training in the use of specific, innovative curricular programs. Gibney described these as "implementation institutes";[74] Robeson described them as "explicit inservice training of teachers";[75] and Gray referred to them as "a concretely articulated

elementary or secondary school course."[76] Krieghbaum and Rawson used the title "Summer Institutes for Secondary Teachers Designed Specifically to Provide Background for Teaching One of the Revised Curricular Programs."[77] No consistently used terminology appeared in the educational literature with which to clearly identify the 20 percent of the NSF institutes which included Basic PSTT Workshop components.

NSF Institutes were designed to help teachers with updating, upgrading, reorienting, advanced training, and specific background training. Other goals were to renew teacher interest and motivation and to improve communications between teachers and scientists. The earliest NSF institutes were of the six to nine week intensive variety that focused on updating and advanced training of teachers. These were followed by institutes which focused on teacher upgrading and reorientation. By the late 1960s, NSF institutes also focused on the need for dissemination through advanced specialized training for teachers and supervisors preparing for positions of leadership in science education.[78]

In 1965, NSF reported to Congress that besides a major difference in format, the NSF Summer Institutes and Academic Year Institutes

> generally recruited nationally and attracted as participants the younger, better trained teachers. Participants in the NSF In-Service Institutes were the older, less well-trained teachers who were unable to leave home in order to undertake a full-time program of study.[79]

NSF Institutes organized during the post-Sputnik period allowed "sequential institutes" and multiple year funding. These provided opportunities for advanced training so that some teachers made substantial progress towards their master's degree in science.

Institutes designed for different groups of participants each summer were called "unitary institutes." Although NSF had to set limits on how often an individual inservice teacher could participate, approximately 40-50 percent of inservice teachers never attended any NSF institute.[80]

By the end of the 1960s, the shortage of scientific personnel had become less acute. NSF science programs to identify and develop talent, according to Atkinson, were considered successful. Consequently, in the 1970s, NSF Science Education programs underwent reorientation. Focus shifted to programs on specific problem areas of national concern. Three themes pervaded: (1) equal opportunity for scientific training (specifically, opportunities for underrepresented minorities and women); (2) education to improve science literacy in daily living; and (3) public understanding of science. Towards the mid-1970s, NSF also focused on science education for the young adolescent (ages 10 to 15 years old).[81]

During the 1970s, NSF no longer supported teacher institutes organized around one specific curricular program, although they did permit a workshop component or a PSTT Workshop component to be included. Computer searches of the ERIC and Comprehensive Dissertation Abstract data bases produced no doctoral studies or other studies of discipline-centered, course-centered or program-specific NSF institutes after 1972-1973.

Effectiveness of NSF Institutes

NSF spent well over a hundred million dollars on training opportunities for thousands of science teachers in hundreds of federally

funded Summer Institutes, Academic Year Institutes, and Inservice Institutes. Rutherford described this period as the "golden age of science education."[82] It was therefore reasonable to expect that the research literature would contain evidence of the effectiveness of these NSF programs in improving the subject matter mastery of participating inservice science teachers. Three types of evidence are reviewed below, including testimony, descriptive and subjective studies, and objective studies.

Testimony. One substantial body of evidence that the NSF teacher programs had been effective is testimony by independent observers. Several examples are given here. In 1975, Conant referred to the NSF Institutes of the 1950s and 1960s with the following statement which he italicized:

> *The use of institutes for bringing teachers up to date in subject-matter fields has been perhaps the single most important improvement in recent years in the training of secondary school teachers.*[83]

Other testimony from the Director for Science Education of the New York City Public Schools, the U.S. Commissioner of Education, National Education Association officials, journalists, and others may be essentially summed up as stating that

1. the NSF institutes have achieved a substantial upgrading of the subject matter competency of science and mathematics teachers,
2. universities must keep teachers up to date in an evolving subject by providing appropriate content course instruction for them on a substantial regular basis,

3. the quality of education in the classroom is amenable to swift improvement by concentrating on the competence of the teacher, and
4. federal support can produce substantial educational improvement.[84]

Descriptive and Subjective Studies. The second and largest portion of the literature reporting the effectiveness of the NSF institute program for improving the subject matter backgrounds of teachers consists of descriptive and subjective studies.

Blosser's 1969 survey of 120 documents provided one of the most complete reviews of the literature on NSF institutes. Blosser stated that although the literature is not definitive, "NSF institutes have been a definite factor in improving the science teaching to which our students are exposed."[85]

The literature indicates that NSF institutes were effective in securing teacher usage of materials from innovative curricular programs,[86] and in motivating teachers to continue graduate study and to become more active professionally.[87] Teachers who had participated in a NSF-sponsored institute were also found to be more likely than other science teachers to use the manipulative activities of the newer inquiry-oriented curricular programs[88] and to sustain the use of these programs over longer periods of time.[89]

Conversely, research on barriers to the implementation of innovative inquiry-oriented curricular programs found the major potential barriers to include lack of program-specific teacher training, and lack of program-specific subject matter mastery.[90,91]

However, other than doctoral studies, Blosser states that few reports contain information on procedures used to evaluate activity effectiveness. She says, "It would appear that many individuals or school systems developing inservice programs or activities rely on intuitive feelings about a particular program's effectiveness." Blosser added that the majority of the evaluative studies reviewed teacher characteristics and the subjective judgments of participants as to the value of their experiences. The majority of responses indicated that "teachers did feel that they had improved, not only in knowledge, but also in enthusiasm and self-confidence."[92]

Blosser also stated that "more studies need to be done in which the primary investigation is that of measuring changes in participant understandings rather than determining satisfactions and dissatisfactions."[93] Blosser called for more research on the effect of NSF institutes on school programs, on high school students, and on the long-range professional careers of institute participants.

Examples which follow report on participants' opinions or reactions, some as post-institute studies, and others as follow-up studies. Dzara, for example, reports that when teachers applied to the NSF institute, they felt inadequately prepared to teach science or mathematics. Teachers felt they had gained in subject matter knowledge and in knowledge of teaching techniques as a result of participating in a chemistry section of a NSF institute in Alabama.[94]

Irby surveyed participants of institute programs held during 1961-1966 at the University of Mississippi. His study reported that teacher respondents felt "they were more effective in the classroom

because of their increased subject matter." His conclusion was that academic competency was upgraded in the institute program. Irby noted that some teachers may have been excluded from such an opportunity because of a poor prior academic record. Participants in his study were selected from those best academically prepared rather than from those most in need of help.[95]

Using post-institute questionnaires to study the effectiveness of institute programs held in 1957-1958 at North Dakota in meeting their goals, Brekke included items on strengthening content background and supplying up-to-date information. He sent two questionnaires to participants and their principals, one in the fall and another in the spring. His findings revealed higher participant assessment of their institute experience on the second survey than on the first survey. His study also indicated that (1) teachers were pleased with their growth in content knowledge, and that (2) the majority of the respondents felt that participation in the institutes "had been beneficial and had resulted in increased enthusiasm for science and mathematics as well as a desire to gain a graduate degree through further study."[96]

A similar investigation, however, by Berger and Berger of the academic year institute programs at Ohio State University found that after a year had lapsed, teachers tended to rate benefits of the program somewhat lower than they had originally.[97]

In a study of the first five academic year institutes at the University of Utah, Jenkins used information about teachers contained in their application forms, responses to a questionnaire sent to

participants, and reactions obtained from staff members. He reported that respondents were of the opinion that teachers had increased in knowledge of subject matter and had improved in some aspects of teaching.[98]

Highwood and Mertens studied the effectiveness of the summer institutes held at Ball State University from 1966 to 1970. They mailed questionnaires comprised of questions used by NSF for academic year institute evaluations, and of questions used by Ball State University at the end of each summer institute. Their purpose was to evaluate the usefulness of twelve subject-matter lectures and sixteen laboratory exercises that were presented in the institutes. Participants were asked to select one of the following responses to rate each lecture or laboratory activity: (1) had increased their understanding of material, (2) had increased their ability to present material in a classroom, or (3) had been of no value. Highwood and Mertens found that in the opinions of the biology teachers who participated in these institutes, biologically-oriented topics and laboratory activities were of more value than activities that were more biochemically or chemically oriented. In their words

> The data indicate that the institutes have succeeded in upgrading the subject matter competence of the participants. Coursework has been judged by the participants to be effective in increasing their understanding of and their ability to teach the concepts treated in the institute. Similarly, laboratory work was regarded as effective in increasing the participants' understanding of the concepts illustrated.[99]

Other subjective and descriptive studies looked at different aspects of NSF institutes. Studies like those by Martinen,[100] by Heideman,[101] by Roye,[102] and by Gibney[103] describe the effect of the

NSF institute experience on the subsequent professional activities and growth of teachers. Horner's study compared NSF academic year institute participants with a control group of teachers who did not participate.[104] Other studies looked at characteristics of teachers, largely for the purpose of better meeting their inservice needs. Information given in teachers' applications to NSF institutes also provided data for studies which looked both at teachers who had been accepted and those who had been rejected. The work by Jorgensen[105] and by Sarner and Edmund[106] are examples. Other studies like those by Orr[107] and by Moore[108] looked at the characteristics of non-applicants as well as applicants. Studies of non-applicants contributed to better understanding of how to communicate with and motivate non-applicants. Dorsey's study[109] looked at selection procedures and criteria for improving institute effectiveness.

Post-NSF experience studies also looked for evidence of the effectiveness of the NSF institutes on changed student or teacher behavior. Some reported on changes in terms of revisions of courses,[110] implementation of new materials[111] or increased teacher confidence.[112] Others studied changes in student attitude or achievement.[113,114] Evans reviewed ten studies conducted from 1966 to 1971 that used systematic post-institute observation to determine the influence of inservice training in one of the "New Science" (e.g., BSCS) programs on the classroom behavior of intermediate and secondary science teachers and students.[115]

Objective Studies of Subject Matter Gains. Only a few objective studies of subject matter gains were found in the

educational literature on NSF Institutes. Selser,[116] for example, administered the STEP ("Sequential Test on Educational Progress") test[117] in science and the TOUS ("Test on Understanding Science")[118] to participants in Florida inservice institutes. Selser reported that participants had gained in their understanding of the nature of science and in their ability to identify and define scientific problems.

Two studies reported other teacher gains. Gruber rated talks prepared by AYI participants to determine "the extent to which the teachers were concerned with presenting science as an established body of knowledge."[119] Lavach found that teachers made statistically significant gains in understanding the historical development of science as a result of participation in an inservice institute in the historical development of physical science.[120]

Wittwer[121] found that teachers who had participated in NSF Research Participation Institute Programs scored significantly higher on the SPI ("Science Process Inventory") test[122] than did a comparable control group with research experience.

Welch and Walberg decided that few experimental studies had been conducted to determine whether attendance at a summer institute increases participants' knowledge of scientific processes and understanding of science and of scientists. Using the SPI and TOUS tests, they demonstrated that participants in inservice institutes in Florida gained both in knowledge and understanding of science and of scientific processes.[123]

Welch and Walberg also used the TSTP ("Test on Selected Topics in Physics") test, comprised of selected Harvard Project Physics test

items to measure program-specific subject matter gains. They reported gains in all four of the NSF Institutes studied. They then further suggested that a study be made "to identify the relationship of objectives and teacher activities in various institutes to the differential gains in general understanding of science."[124]

In 1973, Welch and Gullickson devised a strategy for evaluating NSF teacher education programs with a battery of test instruments, including the "Test of Achievement in Science," and items in biology, chemistry-physics and general science from the 1968 National Teacher Exam. Because of financial limitations, they did not carry out planned achievement testing of the 800 teachers in their study. They did, however, give other instruments to the teachers, largely pertaining to their attitudes.[125]

Stoller's study was undertaken as an exploratory cost-analysis of NSF Institutes for teachers adopting the Harvard Project Physics curricular program. She used the same teachers' scores on the pre- and post-workshop tests administered by Welch and Walberg in 1968 (TOUS, SPI and TSTP). One of their cost-analysis figures was based on her calculations of the cost per percentage gain on these three tests for 154 teachers who completed the four NSF Institutes studied. Referring to TSTP, a program-specific test for the Harvard Project Physics, she reported

> It is obvious that these teachers are demonstrating significant gains on these measures. The problem to be pondered is whether it is worth $166,130 to raise 154 teachers three points on a test of physics achievement? Put differently, is it worth $58.40 to raise one teacher one percentage point on a test? Perhaps a partial answer lies in whether or not students are receiving benefit from their teachers' attendance in these institutes.[126]

Blosser also reported that information she culled from reading the newsletters issued by NSF-supported curriculum projects was of a "general nature." She reported that Issue #7 of the Earth Science Curriculum Project (ESCP) Newsletter described an ESCP-specific objective test scheduled for administration to students and teachers. Blosser reported that "no subsequent analysis was located."[127]

Other NSF-funded curriculum projects with newsletters mentioned by Blosser were the Biological Sciences Curriculum Study, the Chemical Education Material Study, and Harvard Project Physics. According to Blosser, the Harvard Project Physics (HPP) staff also issued an interim report on the evaluation component of its program. The HPP study purpose was to describe what happens to different kinds of students in different kinds of classes. The pre- and post-test battery for students included TOUS and other standardized tests. Blosser summarized the information content of newsletters as "of the informal feedback type."[128]

Summarized Evidence of Effectiveness. Text-scanning and title-searches of the ERIC and Comprehensive Dissertation Abstract data bases revealed no additional studies of the subject-matter gains of NSF participants measured in terms either of science achievement tests or of program-specific content mastery tests. Even though the NSF-funded curriculum improvement projects which produced such "new science" curricular programs as CHEMS or PSSC included the development of student concept mastery tests,[129] only one reference was found in the literature (Welch & Walberg, 1968)[130] indicating that program-specific tests were used to measure the pre- and post-workshop

performance of the teachers who were being trained in the use of specific curricular programs.

The literature does contain evidence indicating that teachers did achieve increased subject matter mastery. Sequential Summer Institutes and Academic Year Institutes provided funded opportunities for teachers to pursue additional coursework. However, although teachers did receive grades in these courses, these were not reported systematically in the literature. Irby[131] and Berger and Berger[132] found, moreover, that NSF Institute selection procedures favored teachers who had higher college grades, more graduate credits in science or mathematics, and stronger professional orientation than teachers who either were not selected or did not apply for NSF institutes. NSF institutes also tended to attract more males than females, perhaps because of the long periods away from home.

Referring to instances where teachers who applied to NSF institute programs were rejected because their academic records were too weak to qualify them for institutes which required that participants also be admitted to graduate school, Blosser said, "In such situations it would appear that the good tend to become superior and the poor continue in mediocrity."[133]

A wealth of other information is undoubtedly contained in the NSF "Final Technical Reports" which each NSF Project Director was required to complete at the termination of his or her granting period.

Thus, the literature on the National Science Foundation institute period shows that hundreds of millions of dollars were categorically funded by the U.S. Congress for the purpose of improving subject matter

knowledge of inservice teachers. About 50 percent of all secondary science and mathematics teachers were involved in some form of institute study by the late 1960s.[134]

In summarizing her review of the literature, Blosser stated that "it is easy to determine if a teacher has acquired information by administering an achievement test or a battery of tests." She also concluded that "teachers did feel that they had improved, not only in knowledge, but in enthusiasm and self-confidence as teachers."[135] However, this researcher, after examining the same literature included in Blosser's review, in the reviews of others, and in subsequent literature, found little objective evidence that teachers had achieved gains either in terms of general improvement of their subject matter mastery or in terms of program-specific concept mastery.

Commercial Publishers' Inservice Activities

Under the heading "organization-sponsored inservice programs," Blosser included only two references to workshop-like activities sponsored by publishers.[136] Blosser describes an unpublished, mimeographed paper of the Educational Research Council of America (ERC) that describes ERC inservice activities as ranging

> from half or full-day orientation sessions to workshops lasting four or five days. Teachers who are using the materials for the first time may also attend "briefing sessions" held on Saturday mornings or after school. During these sessions a new or improved technique, a piece of apparatus, or an experiment is explained and demonstrated.[137]

Newsletters and memoranda are also used to send teachers other "how-to-do-it" information. Feedback seminars are also held for teachers

to talk directly with program developers. Blosser said, "The ERC personnel feel that this fluid and flexible approach to inservice education is more useful than that of providing help via an established course dealing only with predictable difficulties."[138]

The second reference cited by Blosser was that Rand McNally, publishers of the intermediate physical science program, Interaction of Matter and Energy (IME), invited teachers who planned to use IME to attend two-day "briefing sessions." Teachers were asked to assume the role of students as they carried out IME laboratory investigations and participated in discussions. IME program developers or experienced IME teachers served as leaders in explaining the rationale, content, technique and goals of the IME program.[139]

As a result of searching the ERIC or Dissertation Abstracts data bases, no other specific references to commercially-sponsored inservice workshops were found reporting that commercial textbook and workbook publishers engage in PSTT training. However, in testimony commissioned by NSF for presentation to Congress in 1975, BCMA Associates stated that within seventeen years after Sputnik

> the elementary-high school publishing industry has become transformed from publishers of "printed materials of instruction"--basic clothbound textbooks (with correlated workbooks, test booklets, and teachers' manuals) arranged in a graded series (e.g., elementary reading) or for a course (e.g., high school biology) and "supplementary materials" (e.g., classroom periodicals, paperback books)--into publishers and producers of multi-media instructional programs and systems.[140]

BCMA Associates explained that multi-media programs usually are organized around basic textbooks that serve as the "catalytic agent of the instructional materials program."[141]

BCMA listed several factors as leading to transformation of the commercial publishing industry which included (1) the entrance around 1960 of large technologically-oriented, non-publishing corporations into educational publishing; (2) the development of government-funded curriculum improvement projects; (3) advances in audiovisual technologies, including programmed instruction; and (4) new emphases on the development of educational materials for specific clientele such as "culturally deprived" minorities or for individualized instruction.

BCMA said that these changes not only transformed how publishers developed materials, but also placed new demands on them for dissemination and implementation.

> For teachers to use the materials to their best advantage, the system requires carefully prepared teachers' editions and demonstration workshops. This change is also encouraging publishers to think of themselves not only as publishers of instructional materials but as agencies for curriculum development and implementation.[142]

BCMA then described the general structure of elementary-secondary publishing organizations. The BCMA structural description indicated that publishers maintain two interlocked staffs, one for development of educational materials (editorial director, editors-in-chief, staff editors by subject area, production manager and production staff), and the second for marketing (marketing directors, consultant teams, product managers, sales managers, and sales representatives).

The marketing staff, in carrying out its dissemination and implementation functions, engages in inservice workshops, classroom demonstrations, and program-specific seminars for teachers. Consultants, persons with teaching and/or supervisory backgrounds function as (1) consultants to the editors, (2) interpreters of the philosophy

of instructional materials to selection and adoption committees, and (3) leaders of workshops or seminars for teachers adopting materials.

> The contribution of the consultants to the implementation of the curriculum is without cost, except as reflected in the prices of materials being sold. Because of their contribution and their success in the implementation of the curriculum materials, the boards of education and administration of many states and districts make the provision of consultants a part of the adoption agreement.[143]

Less directly, product managers are also involved in program-specific inservice teacher education. Their role is like that of a curriculum specialist in that they interpret education materials both to their own salesmen and to state or local education selection and adoption committees. Sales representatives, organized under sales managers, serve as a communications bridge between the publisher and the educational community. They help keep educators informed about instructional materials to implement curricula trends, and they obtain feedback from teachers and others about educational trends and needs.

BCMA Associates estimated 1975 annual sales of elementary and high school instructional materials at about one billion dollars with over half this amount representing the sales of textbooks and workbooks. Identifying the twelve companies that are the largest publishers of basic instructional materials, they included Addison Wesley; Ginn (Xerox); Gregg Division (McGraw-Hill); Holt, Rinehardt, and Winston (CBS); Houghton-Mifflin; Macmillan; Science Research Associates (IBM); Scott Foresman; Silver Burdett (Scott Foresman); South-Western (Scott Foresman); and Webster Division (McGraw-Hill). BCMA stated

> All twelve possess the ability, the resources and the inclination to develop and disseminate basic multi-media

> instructional programs that require the expenditure of up to several million of their own development and production dollars, and up to five years or more of their own effort, before a single item is sold.[144]

From this it seems clear that commercial publishing companies have vested interests in supporting Awareness PSTT Workshops as part of their marketing and sales promotion activities. Not clear is whether they have sufficient vested interest in supporting Basic PSTT Workshops or Extended PSTT Workshops (Institutes).

Present Need for Program-Specific Teacher Education

Other recent studies indicate need for inservice teacher education learning opportunities tailored to the job-specific needs of classroom teachers. Findings reported in the literature are organized in the sections below to present evidence for the present continuing need for program-specific teacher education.

The Teacher is the Key

A major conclusion of three complementary NSF-funded studies on the status from 1955 to 1975 of pre-college science, mathematical and social science education[145,146,147,148,149] was that "the teacher is the key." These 1977-1978 studies thus validated the very same notion expressed in the mid-1950s when the NSF institute program was launched.[150]

As one of the 1977 studies stated

> What science education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does--and doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in the school, the teacher is the enabler, the inspiration, and the constraint.[151]

The Problem of Inadequate Teacher Preparation is Often Related to Teacher Assignments and Misassignments

According to Smith, approximately 75 percent of secondary science teachers were assigned courses in subject areas other than the area of their specialized study. At the junior high school level, most science teachers are prepared as though they will be teaching senior high school science subjects. Junior high science teachers therefore complete specialized study in biology, chemistry, physics, or geology. Few junior high school science teachers are specifically prepared in their teacher education programs in terms of studying the foundations of education as applied to the early adolescent or of studying the multi-disciplinary subject matter of the junior high school science curriculum, i.e., general sciences, earth sciences, environmental sciences, or space sciences.[152]

At the senior high school level, Smith pointed out that problems associated with teacher preparation "are much more likely to be identified with the misassignment of teachers than with formal preparation in their specialized field." Nationwide, case studies show ample evidence that misassignment is a very real problem and a common phenomenon.[153] The problem of misassignment is further intensified by reductions in force and by retentions and reassignments that are made on the basis of seniority rather than on the basis of curricular needs or professional qualifications.[154]

Two types of reassignments are evident. First, as identified in 1977 in the three NSF studies, a serious shortage of qualified mathematics and physical science teachers was identified nationwide. In 1980, the annual vacancy rate for mathematics teachers was reported

as high as 10 percent nationwide. The shortage of qualified physical science teachers was similar, but less severe. Many of these vacancies were filled by reassigning teachers with only marginal capabilities and insufficient training.[155] Second, with courses like marine sciences or geology also evident in the senior high school curriculum, high school science teachers are being asked to teach courses in subject areas for which they have had little or no training.[156]

In 1978, Weiss reported that 13 percent of secondary teachers were teaching courses they did not feel adequately qualified to teach.[157] The Commission on Human Resources of the National Research Council stated in 1979

> Unfortunately there are not as many opportunities as there once were for teachers to improve their knowledge of subject matter and their teaching skills. Local school systems do not have the resources or capabilities to support such activities; the limited staff development funds that are available are usually targeted on efforts to implement competency-based accountability schemes. Since in the past such training was most effectively provided in the context of course-specific NSF institutes, the [NSF] Foundation's current inability to support such activities poses serious problems.[158]

In 1940, the NSF and the U.S. Department of Education in a joint report to President Carter clearly called for substantial federal initiative in recruiting, training, and supporting competent mathematics and science teachers.[159]

The record on percent of NSF budget allocated to science education shows a steady decline since 1960. In 1959, 34 percent of the NSF budget was alloted for pre-college science education (i.e., programs for elementary and secondary science education, most of which involve teacher education). In 1982, the NSF budget for such programs is less than 1 percent. NSF funding status in 1982 for higher education

science programs have fared little better. Thus, in her April 15, 1982 testimony to the Committee on Science and Technology of the U.S. House of Representatives, Sarah Klein, President of the National Science Teachers Association said, "NSF has essentially eliminated all science education activities."[160,161]

Klein went on to say, "Science education is in deep trouble." According to her, two recent National Science Foundation Studies (which she did not fully cite) revealed the following:

1. From 1971-1980, the average number of preservice teachers prepared to teach mathematics declined by 78 percent; those preparing to teach science declined by 64 percent.
2. In 1981, 2,000 principals reported that half (50.2 percent) of the science and mathematics teachers they interviewed were unqualified to teach those subjects. They were hired as "emergency replacements" because no qualified teachers could be found.
3. The problem of unqualified teachers varied by region. The worst situation was found in the Pacific States where 84 percent of newly employed teachers were considered unqualified. (This was attributed to the competition by high technology industries for the best-trained science and mathematics personnel.)
4. The decline in qualified science and mathematics teachers has already exceeded student enrollment declines by a factor of three. Figures on the states experiencing teacher shortages are as follows: (a) physics teacher shortages,

42 states; (b) mathematics teacher shortages, 43 states; and (c) chemistry teacher shortages, 38 states.

5. The mathematics and science faculties of schools are aging. The average age of science teachers is 41; the average experience is 16 years of teaching.
6. The rate of attrition for mathematics and science teachers opting out of teaching is five times the rate of retirement. One in four younger teachers intends to leave teaching.
7. Of teachers who responded, 79 percent had not completed at least a ten-hour professional course or workshop in more than ten years; 40 percent had not attended any refresher course or workshop since the outset of their teaching careers; and 69 percent reported never having received instruction in a computer course or workshop.

Based on this evidence, there is a clear and pressing need in the 1980s for relevant inservice education opportunities. Programs to update or reorient inservice experienced career teachers are needed that are designed to be attractive to these teachers on their terms because so many of them have already completed degrees and met state certification requirements. Programs are also needed to upgrade the subject matter mastery of newly hired, but marginally qualified teachers in the understanding of specific content, rationale and techniques of the courses they have been assigned to teach.

Teachers Rely on a Single Textbook as the Instructional Material for Their Courses

In a majority of cases included in the three complementary NSF-funded studies on the status of pre-college science, mathematics,

and social science from 1955 to 1975, researchers found that teachers rely on a single textbook as the instructional material for their courses.[162] One study said

> Behind nearly every teacher-learner transaction reported in the CSSE study lay an instructional product waiting to play its dual role as medium and message. They commanded teacher's and learner's attention. In a way, they virtually dictated the curriculum. The curriculum did not venture beyond the boundaries set by the instructional materials.[163]

Smith, writing for the American Association for the Advancement of Science (AAAS), reacted to this case study report stating that despite lamentations of academicians, professors of education, curriculum developers, and others about textbook-oriented instruction, the practice has continued to prevail and flourish. From the teacher's point of view, according to this AAAS spokesman, a textbook (1) provides a structure and an outline of content, (2) minimizes demands on daily preparation time, (3) serves as a reference for course requirements, and (4) offers a defensible source of authority and appropriateness for questions from parents or the community. Smith concludes

> If this is a reasonable analysis, then perhaps it is appropriate to look at the manner in which textbooks might be used more effectively since it appears that they will be a fixture in education for a long time.[164]

Not addressed by the NSF studies is that teacher reliance on a single textbook can provide a focused and purposeful point of departure for inservice education that can be tailored to needs of teachers. As Voelker points out, inservice teacher education can be viewed from a comprehensive, longitudinal framework consisting of a cyclic continuum of awareness, introductory exposures, implementation,

institutionalization, modification, and evaluation.[165] This suggests possibilities for both foundational and instrumental inservice education within the context of specific curricular programs. Adoption and implementation of a specific curricular program can be a means in inservice education, and need not be an ends in themselves.

Contemporary Formal Teacher Education Does Not Provide Adequate Program-Specific Teacher Training

Secondary science teachers are usually introduced to the array of curricular programs used in intermediate and secondary science as part of their undergraduate and graduate methods courses. However, as documented in the 1968 Research on Science Education Survey, experience would have to be described as "introductory" or "descriptive" rather than "preparation for teaching" any one or more of the specific curricular programs.[166]

Writing on behalf of the American Association for the Advancement of Science, Smith described graduate teacher preparation programs as designed around broad concepts, principles, and problems of education. It stated that inservice teachers must translate, adapt, and filter what they learn in graduate courses in applying their college of education lessons to their secondary classroom instructional needs. Although it can be argued that "a professional teacher should be able to make such a transition," teachers commonly criticize inservice education activities as not being "job-specific" enough.[167]

Wiley and Race suggested why methods courses in general do not give more intensive consideration to specific curricular programs. According to them, the developmental and dissemination processes of

many of the federally-funded curriculum projects bypassed contemporary teacher training institutions. Instead they usually involved scientists through professional associations and through the colleges of arts and sciences in working directly with teachers. Consequently, as a result of not being involved in the developmental and dissemination processes, "many methods professors had not had a chance to become familiar with the projects and had, in a sense, been made somewhat 'obsolescent' by them." Wiley and Race added that "the project approach was at odds with a common conception held by methods professors, of the teacher as developer of his/her own curricula."[168]

These observations lend further credence to the conclusion that formal teacher preparation in colleges of education today are not providing basic program-specific training either at the undergraduate or the graduate level. Over the past thirty years, contemporary formal teacher education institutions, including both academic science courses and professional education courses that are offered at the university level, have been regarded as inadequate in meeting instrumental needs of teachers. Societal response was to create temporary, supplementary Summer Institutes, Inservice Institutes and other similar programs subsidized by the federal government. These were created largely to meet the perceived need for helping teachers keep abreast of accelerating scientific, technological and social changes.

There is little evidence to indicate that federally subsidized institutes over the past thirty years have been institutionalized into either the formal teacher preparation programs or into state or district-based inservice programs. The existence of NSF institutes,

for example, seems largely to have remained reliant upon the existence of federal funding external to contemporary state or local teacher training institutions. An important exception are the many smaller, less complex, non-subsidized teacher workshops which are offered by colleges of education and other teacher training institutions. Today if President Ronald Reagan is successful in calling for substantial cuts in federal support of teacher education programs, then the Summer Institutes and other institutes as we have known them, may largely be abolished. Whether the formal teacher education institutions now institutionalize instrumental, basic program-specific teacher education remains to be seen.

Commentary on the Future of Program-Specific Teacher Training Workshops

Renewed interest in the cold war technological race in weaponry has been increasingly evident. Concern about America's ability to compete in the 1980s on the technological and economic fronts of the global marketplace had been expressed to former President Jimmy Carter in a report prepared in 1980 by the National Science Foundation and the Department of Education entitled Science and Engineering Education for the 1980s and Beyond. The report also noted faculty shortages at the university level and a documented decline in the general understanding of science and technology among secondary students. Frank Press, Science and Technology advisor to President Carter, stated in his letter of transmittal accompanying this report that

> Our educational system is the key to maintaining our leadership position among the nations of the world. All of our citizens must have scientific and technical

> understanding to participate in an increasingly complex society, and our professional and technical personnel must remain on the cutting edge of scientific and technical progress.[169]

Thus, the quality of pre-college education, and in particular, the ability of the teacher, has been linked once again to national interests. This time the battlefronts are not only in terms of national defense preparedness, but along economic fronts as well. Once again, the educational practices in the United States and its practitioners are being compared unfavorably with other nations.[170]

However, faced in 1982 with President Ronald Reagan's actions to dismantle the Department of Education, his drastic cuts in the pre-college budget of the National Science Foundation, and his position that the private sector should assume a greater role in providing public services, it seems clear for now that the federal government will not be a major source of funding for PSTT Workshops.

One notable exception is the continued funding of the National Diffusion Network (NDN) charged with dissemination of curricular programs which have successfully demonstrated their educational effectiveness. Approved programs are eligible for NDN support of PSTT-like dissemination activities.[171] NDN monies, however, are limited. In general, then, it appears that during the decade of the 1980s, the federal government will not have a major role in supporting elementary and secondary education or teacher education.

The evidence is clear that there is at present a shortage of qualified science and mathematics teachers. There is also a clear, continuing need for PSTT Workshops for (1) the reorientation of experienced teachers who are reassigned to teaching new curricular

areas, and (2) the provision of basic program-specific training for all teachers because such training is not currently being provided through methods courses or other professional courses in undergraduate and graduate teacher education programs.

Thus, there is at present an unmet need for PSTT Workshops that is likely to increase during this decade. The federal government is doing little to provide for PSTT Workshops, nor are colleges of education through their formal requirements for undergraduate and graduate teacher education. Assuming that this need will not go unmet, and that some form of PSTT-like workshop training will be provided for inservice teachers in the future, then questions arise as to which institution or combination of institutions will assume leadership in providing PSTT Workshops over the next decade.

Further research is needed to provide evidence from which to predict probable alternative futures for PSTT Workshops. However, as understood from this historical review of teacher workshops, some of the most probable institutions can be identified which are most likely to give leadership for PSTT Workshops to provide for the present unmet need in inservice teacher education. These include, first, leadership from among professional educators, perhaps through the colleges of education; through state or local education agencies; through the teachers organizing themselves through teachers' centers, or their labor unions, or by educators through their professional associations.

Second, leadership for future PSTT Workshops may come from privately supported educational institutions that are external to

the colleges of education and the state or local education agencies, such as regional education research and development centers.

A third possibility is renewed interest on the part of scientists, engineers and economists, manifested either through their professional associations (as was the case during the NSF Institute era), or at the university level, or through colleges of arts and sciences or engineering.

A fourth possibility lies in commercial interest in marketing educational materials. Commercial publishers' vested interests in Awareness PSTT Workshop activities were discussed earlier. Not discussed, but not to be ignored, are the increasing interests of commercial institutions in seeing that teachers learn how to use new computer and telecomputer hardware, and that schools purchase them. Reasonably priced, sophisticated computer technologies are readily available today. They await development of PSTT software for teachers as well as students. They also await development of computer telenetworking for providing and sustaining remote and individualized program-specific teacher training and follow-up support services.

Recent evidence that science educators have begun to explore private sector industrial support is seen in the first issue of the BIE Report published by the National Science Teachers Association (NSTA) for the Business Industry Education Community in May 1982.[172] In his article, "Should Business/Industry Support Science Education?", Morris Shamos, Senor Vice President for Technicon, called for industry to allocate portions of its research and development budget for

science education. Traditionally, he stated, industry has been a poor supporter of higher education even though it is industry which derives the most benefit from the preparation of scientists and engineers by colleges and universities. Shamos suggested that 1.2 billion dollars or $20,000 per school could be raised if industry allocated as little as two-tenths of 1 percent of its revenues (or about 4 percent of its research and development budget) to elementary science education.[173]

The BIE Report also includes nine specific recommendations formulated by participants at the NSTA Business/Industry Education Conference in June 1981, charged with "exploring, discussing and planning methods of bringing the business and education communities together to improve science education across the nation."[174] The recommendations were specific in terms of what industry, the NSTA and science teachers could do, but they fell far short of meeting the pressing needs for inservice teacher education in the 1980s. Nevertheless, this indicated renewed industrial interest in education.

However, if the economically depressed conditions of the early 1980s persists, then it is also likely that PSTT Workshops of the future may have to be supported in part, or in whole, by tuition or workshop fees. However, teachers coping with inflation may have less discretionary money with which to pay entirely on their own for travel, meals, lodging and other expenses, plus tuition and other costs that are related to participation in Extended or Basic PSTT Workshops.

For PSTT Workshops to be able to survive on a self-supported tuition or fee basis, it therefore seems likely that PSTT Workshops of the future will be concerned increasingly with demonstrating cost-effectiveness as well as educational effectiveness. This points to the need in the future for well-planned, systematic study of PSTT Workshops. Logically, if they are to compete successfully for scarce funds, whatever the source, PSTT Workshops will probably be held more accountable in the future for demonstrating their effectiveness in training inservice teachers and for demonstrating their efficiency in meeting professional needs of the participants. Effectiveness should be measured in terms of program-specific gains in subject matter, in field and laboratory skills, in understanding and application of pedagogical principles, and ultimately, in improving student learning. Likewise, efficiency measures should be related to clearly identified inservice teachers' professional needs within the context of adopting and using a specific curricular program.

A likely possibility is that Extended PSTT Workshops, and perhaps even Basic PSTT Workshops, will be modularized in the future into a more narrowly defined, shorter, and therefore less expensive PSTT Workshops. Modularized PSTT Workshops would present intensive training in components of a specific curricular program, and would therefore be distinctly different from Awareness PSTT Workshops that provide general overviews. Critics could well argue that modularized Basic PSTT Workshops will not as effectively present opportunities for teachers to understand the integrity of the design of a specific program. While this may well be true, the economic realities may

necessitate shortening, streamlining and reducing the costs of PSTT Workshop training. For multi-disciplinary curricular programs such as the High School Marine Science Studies (HMSS) Program, modularization seems appropriate. It should also be pointed out that if PSTT Workshops are modularized so that their duration is in days rather than weeks (or even months as were the six to eight week NSF Institutes), then this will make the modularized PSTT Workshops less complex and more amenable to experimental study.

If modularized PSTT Workshops were available, then inservice teachers could more precisely select component PSTT Workshops to meet their professional needs. Logically, PSTT Workshop leaders should therefore be able to better anticipate teacher needs with respect to mastering a smaller unit of a specific program.

On the other hand, if modularized PSTT Workshops are to be supported on a tuition or fee basis, then it is less likely that they will be able to recruit participants nationally or to select participants from a pool of applicants. In order to be self-supporting, PSTT Workshops will probably have to anticipate serving the needs of heterogeneous groups of self-voluntarily participating teachers. Future PSTT Workshop leaders, therefore, may well be faced with planning to provide within one workshop for the upgrading of some teachers, the reorientation of others, and the updating or advanced training of still others.

If PSTT Workshop leaders in the future are to plan rationally for meeting the needs of a self-selected and heterogeneous population of inservice teacher participants, then systematic information is

needed on relationships between teacher characteristics and their performance in a PSTT Workshop. Other research is also needed that will lead to the design of alternative, individualized workshop approaches for teachers with different needs to obtain appropriate program-specific training. Further research is also needed, within the context of practical problems teachers encounter in implementing a specific curricular program, to identify and then develop learning sequences appropriate to differing teacher needs in (1) developing and practicing program-specific field and laboratory skills, and (2) understanding program-specific pedagogy and its application to their own classroom situations. Workshop leaders should also have more systematic information about inservice teachers' motivations, confidence levels and expectations with respect to participation in PSTT Workshops, and on how these attitudes are related to workshop performance.

In order to improve the cost-effectiveness of PSTT Workshops, particularly if they are modularized, exploration is needed also for using ways of presenting central program-specific ideas (i.e., philosophy and rationale or description of component materials in the program) using media and computer technologies. Ways need to be explored also for use of media computers for program-specific subject matter review or remediation.

Calling for a number of in-depth, systematic studies of PSTT Workshops in an era of uncertain funding may appear impractical. However, if the need for program-specific training is to be met through PSTT Workshops in an era of scarce funding, then the challenge

is to do so in the most educationally effective as well as cost-efficient manner. It is hoped that this review will be a contribution towards meeting this challenge.

CHAPTER NOTES

[1]Merle L. Borrowman, "Education of Teachers: History," The Encyclopedia of Education (1971), IX, p. 72.

[2]Ibid., p. 78.

[3]Workshops of interest to this study are courses conducted by school personnel or curricular innovation disseminators with or without assistance from industries, universities or professional associations. Other forms of inservice education are distinguished as (a) lecture series, travel, experimentation and individualized study sponsored by universities or local school systems; (b) staff development or professional training programs that are school-based; and (c) post-graduate foundational courses that are part of a degree program.

[4]Stanley L. Helgeson, Patricia Blosser and Robert W. Howe, The Status of Pre-College Mathematics and Social Science Education: 1955-1975. Vol. 1--Science Education, U.S., National Science Foundation Publication No. SE 78-73 (Washington: Government Printing Office, 1977), p. 97 stated: "Inservice education has traditionally been the responsibility of the local school district through its administration. Inservice education depends to a large extent on who controls the rewards system. If administrators stress graduate credits they have given control of inservice activities to the colleges and universities."

[5]Examples are (a) National Society for the Study of Education, In-Service Education for Teachers, Supervisors and Administrators (Chicago: The University of Chicago Press, 1957); and (b) "In-Service Teacher Education in Practice," Special Issue of Phi Delta Kappan, 63 (February 1982).

[6]Descriptors used in searching the ERIC (Educational Resources Information Center) and the Comprehensive Dissertation Abstract data bases were: summer institutes, institute type courses, science institutes, symposia, teacher workshops, institutes (training programs), teacher seminars, sciences, natural sciences, biological science, chemistry, physics; program planning, educational planning program evaluation.

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[13]Heffernan, loc. cit.

[14]W. Addis, The Teaching Force of New England from 1866 to 1888, U.S., Report of the Commissioner of Education for the Year 1988 (Washington: Government Printing Office, 1891), p. 338.

[15]Richey, op. cit., p. 36.

[16]Addis, op. cit., p. 329.

[17]Richey, op. cit., p. 39.

[18]W. C. Reudiger, Agencies for the Improvement of Teachers Inservice, U.S., Bureau of Education Bulletin, No. 3 (Washington: Government Printing Office, 1911), pp. 7-57.

[19]Richey, op. cit., pp. 47-49.

[20]Paul Monroe, ed., "Institutes," A Cyclopedia of Education (1912), III, p. 469.

[21]Henry Barnard quoted in Richey, op. cit., p. 40. Also, Monroe, op. cit., p. 468 credits Barnard with holding the first Teacher's Institute at Hartford in the autumn of 1939. Richey, loc. cit., also cites Samuel N. Sweet, Teachers Institutes or Temporary Normal Schools (Utica: H. A. Hawley & Co., 1848).

[22]Homer H. Seerley, "Practical View of the Institute System," Educational Review, 23 (1908), 356-63.

[23]Kenneth L. Heaton, "Program of the Committee on Workshops," Educational Method, 20 (March 1941), 292-96.

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[28]Ryan and Tyler, op. cit., p. 29.

[29]Ralph W. Tyler, "In-Service Education of Teachers: A Look at the Past and Future," Improving In-Service Education: Proposals and Procedures for Change, ed. Louis J. Rubin (Boston: Allyn and Bacon, 1971), p. 10.

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[31]Ryan and Tyler, op. cit., p. 14.

[32]Kenneth L. Heaton, "The Workshop for Teachers," Harvard Educational Review, 12 (January 1942), 47-54.

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[35]American Council on Education Committee on Teacher Education, Teachers for Our Times (Washington: American Council on Education, 1944), p. 22.

[36]Tyler, op. cit., p. 13.

[37]B. Othaniel Smith, "Pedagogical Education: How About Reform," Phi Delta Kappan, 62 (October 1980), 87-91.

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CHAPTER III

METHODOLOGY

Procedures of the study are explained in this chapter under the headings of (1) Instruments of the Study, (2) Justification for Combining Data from the Massachusetts and the Hawaii HMSS Workshops, (3) Description of the Combined Population in Terms of Variables of the Study, (4) Design of the Study, (5) Statistical Procedures, and (6) Chapter Summary.

Instruments of the Study

As stated in Chapter I, the problem in this study is to determine whether relationships exist between scores on a program-specific content mastery test and selected characteristics of inservice teachers participating in an HMSS Workshop. To do this, it was necessary to obtain data on two sets of variables: scores on the HMSS Content Mastery Test, plus data from pre-workshop registration forms on selected characteristics of the workshop participants. The sections below describe how the instruments were developed and data derived for this study.

Scores on the Program-Specific Content Mastery Test

Scores on the HMSS Content Mastery Test constitute one set of variables of the study. As shown in Figure 1, the HMSS Content

Figure 3-1. Composition of the HMSS Content Mastery Test

Subtest A. Content Mastery for Physical Science Units Based on the Following Instructional Units (Content)	Subtest B. Content Mastery for Biological Science Units Based on the Following Instructional Units (Content)
"Earth and Ocean Basins" •Contents and oceans •Landforms (topography and bathymetry) •Interpretation of maps •Location (latitude and longitude)	"Coastal Plants" •Comparison of terrestial plants and seaweeds •Structure, function and adaptation
"Waves and Beaches" •Wave patterns and movement •Beach profiles •Wave-beach interactions	"Marine Invertebrates" •Structure and function of mollusks •Organs and systems
"Transportation" •Buoyancy and density •Ship design •Forces affecting stability	"Fishes and Fisheries Management" •Form and function of fishes •Interpretation of fisheries management data

Mastery Test has two parts; "Subtest A. Content Mastery for HMSS Physical Science Units," and "Subtest B. Content Mastery for HMSS Biological Science Units." Each subtest is made up of three tests consisting of items selected from the summary questions in those instructional units that were presented during the basic HMSS Workshop. Each subtest score represents the mean of the three test scores adjusted to a 100 point scale. The entire HMSS Content Mastery Test is included in Appendix A. The pre-workshop test consisted of split-half forms of the entire test administered in parts throughout the workshop. The post-workshop test was the HMSS Content Mastery Test in its entirety.

Prior to this study, the HMSS Content Mastery Test had not been administered to teachers, although portions had been administered to secondary students. Test items were written primarily by two HMSS Project developers, one with an academic specialty in ichthyology and marine biology and the other with an academic specialty is in the physical sciences. The latter had experience as a writer of test items for the CHEMS[1] and FAST[2] programs. Content validity was determined based on the expert opinion of the HMSS program developers and workshop leaders who had written the test, reviewed it and suggested modifications which were incorporated prior to the study. Content validity is therefore assumed high.

Internal consistency of the test was determined using the scores from subjects in this study with the Spearman-Brown formula for split-half reliability.[3] The correlation coefficient was calculated to be r_1 = 0.8111 for the uncorrected reliability and r_2 = 0.896 for

the corrected reliability. These results indicate very high test reliability. Pretest sensitization of subjects to items appearing on both the pre- and post-workshop administration of the test may have inflated the reliability figures somewhat.

Data on Teacher Characteristics

The second set of data needed for this study is information on selected characteristics of teacher participants in a basic HMSS Workshop. This information was obtained from one of the registration forms used in the HMSS Workshop. This form is included in Appendix A.

The study postulated that sources of teachers' knowledge of the program-specific subject matter of the HMSS Program are related to (1) their disciplinary background, (2) the highest degree they earned in science, (3) their classroom teaching experience, (4) their prior marine experiences, (5) their age and (6) their sex. Explanations are given in the paragraphs which follow on how data on each of these six variables were derived from the workshop registration form.

Disciplinary background. The first variable, disciplinary background, was derived using information from the registration form on teachers' area of academic specialization. Using this data, teachers were categorized as having a disciplinary background in the physical sciences, in the biological sciences, or in other nonscience areas.[4] Elementary teachers with no science background and teachers with art or history majors are examples of teachers categorized in the last group, nonscience disciplinary background.

During the workshop, the researcher had interviewed all participants. Information was obtained at that time for those

individuals who indicated "natural history," "general science," "science education," or "secondary science education" as their academic majors to determine whether their subject matter background was primarily in the physical sciences or in the biological sciences. When grouping teachers for statistical analyses, years of teaching experience by subject area was also used as a secondary confirmation that the teachers were categorized appropriately.

Highest degree in science. The second variable, highest degree in science, was used to indicate level of science knowledge. Rather than using the information on highest degree attained, this variable reflects the highest degree level at which science was studied. Because the registration form called for information--not only on degree attained but also on major and minor subject matter fields, it was possible to determine where the highest level of study in science occurred. Thus, teachers with master's degrees in non-science areas (e.g. educational administration) who indicated a major or minor in science at the bachelor's degree level were classified as studying science at the bachelor's degree level. Teachers with bachelors' degrees without a major or minor in science were classified as having nonscience bachelor's degrees. Four levels of this variable were used: (1) nonscience bachelor's degree, (2) bachelor's degree in science, (3) master's degree in science, and (4) master's degree plus 45 credits in science.

Total years of teaching experience. The third variable, total years of teaching experience, was included for purposes of having a general indicator of the relationship between teaching experience and

teacher performance. Some teachers, however, had had teaching experiences at the elementary or post-secondary levels. The value used was the total years of classroom teaching experience, regardless of educational level.

Years of experience in teaching marine science was not used as a variable of this study primarily because an objective definition as to what constitutes "one year's experience" in teaching marine science was not used when the data was collected. When interviewed, some teachers who indicated "no experience" had, in fact, tried marine activities or topics in one or more of their classes. Others had used one or more marine units or modules infused into other science courses but were not sure whether this qualified as "one year's experience" or not. This reflects the current status of marine science in secondary schools in that marine science may be offered as a one-year science course, a one-semester science course, or as one or more modules or units of another science course.

Level of prior marine experience. The fourth variable, level of prior marine experience, was used as a measure of the relative level of prior marine-related research, recreation, and nonschool vocational activities of teachers before the HMSS Workshop. Based on data from the workshop registration materials and from interviews with each participant, the researcher rated each participant using an ordered category rating scale with (0) = none, (1) = little, (2) = moderate, (3) = advanced, and (4) = professional.

In rating their prior marine-related experiences, differences in the nature of prior experiences reported by the men and the women in

the study were noted. Some of the male teachers reported considerable experience and training through the military. (One was a naval captain, another had been in the Navy Seabees, and several others indicated extensive travel aboard ships. Two men indicated that they were professional fishermen, another that he had constructed his own 60-foot schooner, and a third that he certified scuba dive instructors.) None of the women reported any similar experiences, although two women did report graduate-level laboratory research experiences conducted for university studies, an activity none of the men reported.

Examination of information in the registration form (and in Appendix B, Tables 17 and 18) indicated that most teachers had very little or no prior experiences in marine education. Even if a one-day Awareness Workshop activity were counted as one credit in marine education, the grand mean for credits earned was less than one credit. In terms of prior credits earned in marine sciences and oceanography, the mean was less than two college credits. Because actual credits earned were so low for marine science and marine education, the reasonableness of subdividing teachers on the basis of fractions of prior credits seemed questionable. Consequently, the researcher decided not to use prior marine-related credits as one of the selected teacher characteristics.

Sex and age. The fifth and sixth variables of the study are sex and age. Data on age of teachers in years obtained from the registration form were cast with the following groupings: (1) 25 and under, (2) 26 to 35, (3) 36 to 45, and (4) over 45.

Justification for Combining Data From the Massachusetts and Hawaii HMSS Workshops

To provide a population of sufficient size to permit statistical analysis of the hypotheses of the study, it was necessary to combine two groups of teachers. Teachers participating in an HMSS Workshop in Massachusetts during the summer of 1979 were combined with teachers who participated in an HMSS Workshop held that same summer in Hawaii. It should be noted that these two groups together constituted the entire population of inservice teachers participating in a basic HMSS Workshop during the summer of 1979.

Justification for combining the two workshops to form one large population was based on a feasibility study comparing the two workshops with respect to workshop treatment, workshop outcomes (e.g. scores on the HMSS Content Mastery Test) and characteristics of teacher participants. Each comparison is described in a separate section below.

HMSS Workshop Treatment and Outcomes

HMSS Workshop treatment was equated across both groups with respect to workshop agenda and the selection of HMSS instructional materials and activities. Leaders were the same for both HMSS Workshop groups.

The workshop outcome at each site was a statistically significant gain in scores on the HMSS Content Mastery Test. This was demonstrated using a *t*-test to compare to compare pre-workshop scores with post-workshop scores for each workshop. Results are presented in Appendix B, Table 11.

Scores of the teachers in the Massachusetts HMSS Workshop, as expected, indicated statistically significant differences between pre- and post-workshop scores. For "Subtest A. Physical Science Content," t (22) = -5.48, $p < .001$; for "Subtest B. Biological Science Content," t (22) = -4.38, $p < .001$.

Scores of the teachers in the Hawaii HMSS Workshop, also as expected, indicated statistically significant differences between pre- and post-workshop scores. For "Subtest A. Physical Science Content," t (17) = -2.21, $p < .05$; for "Subtest B. Biological Science Content," t (18) = -3.25, $p < 0.01$.

Scores Compared Between the HMSS Workshops in Massachusetts and Hawaii

Mean scores of teachers in the Massachusetts HMSS Workshop were compared with mean scores of teachers in the Hawaii HMSS Workshop using the t-test. As shown in Appendix B, Table 12, no statistically significant differences were found between workshop groups.

Pre-workshop scores compared between workshop groups showed no statistically significant differences on "Subtest A. Physical Sciences Content," with t (40) = 1.37, p = .179. Pre-workshop scores compared between workshop groups also showed no statistically significant differences on "Subtest B. Biological Science Content," with t (42) = 0.17, p = .865.

Post-workshop scores compared between workshop groups showed no statistically significant differences on either subtest. For Subtest A. Physical Science Concepts," t (39) = -0.06, p = .953; for "Subtest B. Biological Science Concepts," t (41) = 1.01, p = .319.

Characteristics of Participating Teachers Compared Between the Massachusetts and Hawaii HMSS Workshops

The two HMSS Workshops were also compared in terms of the teacher characteristics selected for the study. The results given in Appendix C, Tables 21 through 26, can be summarized as follows:

1. Disciplinary background data subjected to chi-square analysis failed to reject the null hypothesis that "there is no significant difference in frequency distribution of teachers by disciplinary background and site."
2. Highest degree earned in science data could not be subjected to chi-square analysis because of small population of some cells. However, similarities within group patterns appeared at both sites.
3. Total years of classroom teaching experience was compared between sites using the t-test. No statistically significant differences were found.
4. Level of prior marine experience, measured using a Likert-type scale from 0 to 4, was also compared between groups. Data subjected to the t-test showed no statistically significant differences between sites.
5. Sex of teachers data subjected to chi-square analysis revealed no statistically significant differences in the frequency distribution of teachers by site and by sex.
6. Age of teachers data subjected to chi-square analysis revealed no significant differences between sites.

Summary of Comparisons Between HMSS Workshops in Massachusetts and Hawaii

During the summer of 1979, two intact, voluntary groups of teachers participated in HMSS Workshops, one held in Massachusetts and the other held in Hawaii. Comparisons were made between these two HMSS Workshops to determine whether statistically significant differences existed between them in terms of the variables of the study. Finding no statistically significant differences between the workshops on the variables of the study, the researcher concluded that there was no apparent reason for not combining the two groups to form a larger population for testing of the hypotheses of the study.

Description of the Combined Population in Terms of Variables of the Study

Using the variable of the study for the combined population, the grand mean for pre-workshop scores on "Subtest A. Physical Science Content" is 60.17 (N = 42), and on "Subtest B. Biological Science Content" is 71.75 (N = 44). For post-workshop scores, the "Subtest A. Physical Science Content" the grand mean is 68.39 (N = 41); for "Subtest B. Biological Science Content" the grand mean is 81.95 (N = 43).

Subgroups formed when mean scores of teachers in the combined population were categorized according to the teacher characteristics selected for the study are shown in Tables 13 through 19 in Appendix B. By selected teacher characteristics, the resulting subgroups appeared as follows:

Disciplinary Background

Size of the resulting subgroups are physical science teachers (N = 14), biological science teachers (N = 20), and nonscience teachers (N = 13). (See Appendix B, Tables 13 and 14.)

Highest Degree in Science

Each teacher in the combined population was categorized into one of four ordinal groups as follows: bachelor's degree without science major or minor (N = 10), bachelor's degree with science major or minor (N = 21), master's degree (or equivalent) with study in science (N = 11), and master's degree plus at least 45 credits in science (N = 5). (See Appendix B, Tables 15 and 16.)

Years of Teaching Experience

Examination of the data given in Appendix B Tables 13 and 14 reveals that the grand mean for total years of teaching experience is 9.8 years (N = 47). However, it is interesting to note that the distribution of teachers by experience when the data is recast into ordinal form is as follows: no teaching experience (N = 12), six years teaching experience (N = 12), seven to ten years teaching experience (N = 17), and eleven or more years teaching experience (N = 18). This data indicates that it is the more experienced teachers who attended the HMSS Workshop.

Prior Marine Experience

Referring to the relative level of teachers' marine-related research, recreation and vocational experiences before their

participation in an HMSS Workshop, nineteen teachers had no experience, or little experience and twenty-five teachers had moderate to advanced prior marine-related experiences. (See Table 17 in Appendix B.)

Sex of Teachers

Data arranged by sex of teachers and by site in Table 18 (Appendix B) and Table 25 (Appendix C) show that in Massachusetts the females outnumbered the males 15 to 9, but in Hawaii the males outnumbered the females 14 to 9. However, within the two workshops combined, the combined population includes 24 females and 23 males, a convenient division for statistical purposes.

Age of Teachers

Data on age of teachers for the combined population appears as follows: (1) = under 25 years old (N = 4), (2) = 25-35 years old (N = 21), (3) = 36-45 years old (N = 15), and (4) = over 45 years old (N = 7).

Design of the Study

As was stated in Chapter I, the study is organized according to what Tuckman describes as an "*ex post facto* co-relational study" design. Tuckman explains that this design refers to

> . . . an experiment in which the researcher, rather than creating the treatment, examines the effects of a naturalistically occurring treatment after that treatment has occurred. The experimenter attempts to relate this after-the-fact treatment to an outcome or dependent measure.[5]

Here the treatment is included in the study by selection rather than by experimental manipulation. A co-relational study involves the

collection of two or more sets of data from a group of subjects with the attempt to determine the subsequent relationship between these sets of data.

Tuckman states, "Co-relational studies serve a useful purpose in determining the relationship among measures and suggesting possible bases for causality."[6] A strong relationship between two variables suggests one of three possible interpretations. Expressed using the variables of this study, the three possible interpretations are that

1. Selected professional and personal teacher characteristics have a causal relationship to HMSS Content Mastery Test scores. (Professional characteristics include disciplinary background, highest degree in science, teaching experience, and level of prior marine experience. Personal characteristics are sex and age of the teachers.)
2. HMSS Content Mastery Test scores have a causal relationship to the professional and personal characteristics selected.
3. Some third, unmeasured variable(s) has (have) caused changes (either in the selected personal and professional characteristics of teachers or in their scores on the HMSS Content Mastery Test).

Tuckman explains that either no relationship or a weak relationship suggests that all three possibilities be rejected. He adds that a strong relationship does not suggest which of the three interpretations is valid.[7]

Logical and temporal analyses eliminate the second possibility by showing that teacher characteristics are a priori givens. Therefore scores on the HMSS Content Mastery Test are considered the outcome or dependent variables of the study and the selected teacher characteristics are considered the independent variables.

The third possibility is also greatly weakened and therefore rejected by the following logic. First, the study selected six largely qualitative teacher characteristics each of which is logically, but broadly, related to teachers' cognitive knowledge. Three of the variables are characteristics common to the education and experience of all teachers (e.g. disciplinary background, highest degree in science and total years teaching experience). A broad, ordered category rating scale is used to describe teachers' prior marine-related experience. Thus the six variables cover a very broad range with respect to possible sources of knowledge.

Second, the intent of the study is to determine whether or not there are differences in scores among subpopulations of teachers that can be found by classifying teachers by one or more of the variables of the study. An HMSS Workshop leader does not need to know whether a teacher characteristic caused difference in scores or is merely an indicator of something else causing differences in scores. The workshop leader does need to know whether there are differences in scores and how subpopulations of teachers who score differently can be identified so that appropriate alternatives can be planned for the divergent needs of workshop participants.

Keeping in mind both the first and third possibilities for interpreting the data, statistical procedures are used in this study which test the independent and paired effects of teacher characteristic variables on the dependent variable, scores on the HMSS Content Mastery Test. Because of the non-random nature of the study, however, additional replications with other groups of teachers are necessary for external validation of the findings.

However, according to the logic of Cornfield and Tukey, if the subjects of the study consist of the populations of voluntary teachers, the findings can be extrapolated to generalizations to other populations "like those observed."[8] Furthermore, because no significant differences were found between the two HMSS Workshops that occurred five thousand miles apart in terms of scores or teacher characteristics, this further enhances the external validity of generalizing to other future HMSS Workshop groups.

It should be pointed out here also that this study looks for statistical relationships between selected characteristics of teachers and both their pre- and post-workshop performances on the HMSS Content Mastery Test. The study did not examine gain scores because the study held that for purposes of better providing PSTT Workshops tailored to the needs of inservice teachers, it is more important to know the relative level of performance of subpopulations of teachers than it is to know how many points they gain on the workshop test.

Statistical Procedures

To test the hypotheses of the study, data on scores and teacher characteristics for the combined population were arranged to permit separate analysis of results from "Subtest A. Content Mastery for HMSS Physical Science Units" and from "Subtest B. Content Mastery for HMSS Biological Science Units." Data were also organized to permit separate analysis of the pre- and post-workshop administration of the HMSS Content Mastery Test.

Because of the exploratory nature of this study, the significance level of all statistical tests was arbitrarily set at $\alpha = .05$. In all cases, a two-tailed test of probability was used because the hypotheses cast in null form do not indicate direction. Exact probabilities are given in the data tables in Chapter IV. Statistically significant probabilities are reported in the discussion as $p \leq .05$.

The paragraphs which follow describe how the hypotheses recast into null form, were subjected to statistical analyses.

Univariate Analysis

One-way analysis of variance (one-way ANOVA) was selected in order to test for statistically significant relationships between pre-workshop and post-workshop scores on the HMSS Content Mastery Test for testing of the following null hypotheses:

1. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by their highest degree in science;

2. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by age.

Because the statistical process of one-way ANOVA assumes homogeneity of variance, data were examined using the Bartlett-Box *F* test to be sure variances were homogeneous. If the *F* value is not large enough to reach statistical significance at the $\alpha = .05$ level of confidence, it may be concluded that the variances are homogeneous and that they therefore meet the prerequisite assumption of the one-way ANOVA statistical procedure.[9]

In addition, *a posteriori* contrasts were computed using the Tukey test with the permissible level of significance at $\alpha = .05$. This procedure compares all possible pairs of group means to determine whether differences in pairs of means are significant. The Tukey test is most exact for even group sizes.[10]

Bivariate Analysis

Two-way analysis of variance (two-way ANOVA) was selected in order to test for statistically significant relationships between pre- and post-workshop scores from the combined population on the HMSS Content Mastery Test for testing of the following hypotheses cast into their null form:

1. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by disciplinary background and by years of teaching experiences; and

2. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by their level of prior marine experience and by sex.

Two-way analysis of variance (ANOVA) was chosen for the first pair of variables (disciplinary background and level of experience) because teachers are most likely to be assigned at least some courses in the subject area of their academic specialization, and because both prior formal academic study and prior on-the-job learning as a result of teaching are held to be interactive sources of knowledge. The study seeks to determine whether these sources of knowledge are related to scores on the program-specific concept mastery test.

Two-way ANOVA was also chosen for the second pair of variables (sex and prior level of marine experience) because the preliminary analysis described earlier indicated that the prior experiences of men and women differ.

The first step used in interpreting and reporting the results of the two-way ANOVA procedure that are given in Chapter IV was to determine the effect of both variables in interaction. Using two hypothetical variables A and B, interaction refers to the following:

> If the interaction is significant, it may be concluded that the effect of A varies from one category of B to another. A significant interaction also implies that the effect of B is not uniform across different categories. Therefore, there is no compelling reason to test the significance of each main effect separately. If, on the other hand, the interaction effect is not significant, one may proceed to test the main effects.[11]

Consequently, in Chapter IV if the interaction effect was non-significant, then the results were examined to determine whether the main effect of each teacher characteristic had a statistically

significant independent effect on the dependent variable, scores on the HMSS Content Mastery Test.

Correlation Ratios

Significance tests in the one-way and two-way ANOVA procedures do not provide information about the pattern of effects, however. Consequently, additional statistical procedures were performed using multiple classification analysis (MCA). Data provided by MCA

> can be viewed as a method of displaying the results of analysis of variance especially when there are no significant interaction effects. It is particularly useful when the factors examined are attribute variables that are not experimentally manipulated and therefore are correlated.[12]

Additional statistics in the form of correlation ratios were computed to estimate the proportion of variance in the dependent variable (i.e. score) explained the variables of the study.

Data in this study are assumed to be nonorthogonal (i.e. unequal cell frequencies in the factorial design). However, for hypothesis three where teachers classified by sex formed two almost equal sized groups (N = 23, 24), experimental mortality may have affected the cell frequencies causing the data to become orthogonal. Consequently, as described below, Multiple R^2 was calculated to provide an overall estimate of strength of association for linear correlations and the omega squared indices were calculated for nonlinear correlations.

Multiple R^2. Multiple R^2 ratio measures the strength of association, or equivalently, the amount of variation in the dependent variable that can be explained by linear dependence upon two or more independent variables operating jointly. Based on

orthogonal data, multiple R^2 relates both independent (teacher characteristics) and dependent (scores) variables and their nonsignificant interaction. Its value ranges between 0 and 1, representing the proportion of variation in scores associated with the additive effects of all factors. For nonorthogonal data, the multiple R^2 underestimates the degree of relationship.[13]

Omega squared. Omega squared (ω^2) ratios[14] were computed to provide a measure of the strength of association between variation in the dependent variable (scores) and (1) a statistically significant main effect of one independent variable, (2) the overall combined effect of a pair of variables, and (3) the interaction between a pair of variables. Omega squared is used for nonlinear correlations. Values range between 0 and 1. Omega squared values were calculated as follows (where SS = Sum of Squares):

$$\text{main effect } \omega^2 = \frac{\text{SS (Main Effect)}}{\text{SS (Total)}}$$

$$\text{overall } \omega^2 = \frac{\text{SS (Explained)}}{\text{SS (Total)}}$$

$$\text{Interaction } \omega^2 = \frac{\text{SS (Interaction)}}{\text{SS (Total)}}$$

The omega squared index was used because

> ". . . statistical significance is not the only, or even the best, evidence for a strong statistical association. A significant result implies that it is safe to say some association exists, but the estimate of ω^2 tells how strong that association appears to be. It seems far more reasonable to decide to follow up on a finding that is both significant and indicates a strong degree of association than to tie the course of action to significance level alone.[15]

According to Scriven, omega statistics provide a partial correction for the possibility which increases with sample size that "tiny differences become statistically significant though they may have no educational value at all."[16]

Chapter Summary

The purpose of this study is to determine whether selected characteristics of teachers participating in a Basic PSTT Workshop (i.e., the HMSS Workshop) are related to their scores on a program-specific content mastery test (i.e., the HMSS Content Mastery Test). Data on scores were obtained using the HMSS Content Mastery Test which was tailored to the activities in the Basic HMSS Workshop. Data on selected teacher characteristics (i.e., disciplinary background, highest degree in science, years teaching experience, prior level of marine experience, age and sex) were obtained from a registration form used in the HMSS Workshop.

Two HMSS Workshops were held during the summer of 1979, one in Massachusetts and the other in Hawaii. Voluntary participants in those workshops are the subject of the study. A feasibility study was conducted to determine whether there were any significant differences between workshops with respect to HMSS Workshop treatment and the workshop outcome in terms of gains in scores on the HMSS Content Mastery Test and on selected characteristics of the participants. Finding no significant differences between workshops provided justification for combining the two workshop groups for the purpose of obtaining a larger population to support further statistical analyses.

Using data from the combined population, pre- and post-workshop scores together with data on selected teacher characteristics were arranged for computer processing. One-way analysis of variance was selected for examining differences in mean scores of teachers grouped first by highest degree in science and then by age. Two-way analysis of variance was selected to examine differences among mean scores when teachers were grouped (a) by disciplinary background and by teaching experience and (b) by level of prior marine experience and by sex. In addition, correlation ratios were calculated to provide a measure of the strength of association between scores and teacher characters. Multiple $\underline{R}^2$ was calculated as an overall linear correlation ratio. For nonlinear correlations, omega squared ratios were calculated for the main effects, for overall combined effects, and for interactions.

CHAPTER NOTES

[1]George C. Pimental, ed., Chemical Education Material Study (San Francisco: W. H. Freeman Company, 1960).

[2]Francis M. Pottenger and others, Foundational Approaches in Science Teaching (Honolulu: University of Hawaii Curriculum Research and Development Group, 1978).

[3]The Spearman-Brown formula for split-half reliability (where r_2 = corrected reliability, r_1 = uncorrected reliability and n = number of parts) is

$$r_2 = \frac{nr_1}{1 + (N - 1)r_1}$$

[4]Philip H. Phenix, Realms of Meaning (New York: McGraw-Hill, 1964), pp. 93-114. Science is categorized either as physical science or as biological science.

[5]Bruce W. Tuckman, Conducting Educational Research (2d ed.; New York: Harcourt Brace Jovanovich, 1978), pp. 147-149.

[6]Ibid.

[7]Ibid.

[8]John Cornfield and J. W. Tukey, "Average Values of Mean Squares in Factorials," Annals of Mathematical Statistics, 27: 907-949, 1956.

[9]Quinn McNemar, Psychological Statistics (4th ed.; New York: John Wiley and Sons, 1969), pp. 285-286.

[10]Norman Nie and others, SPSS: Statistical Package for the Social Sciences (2d ed.; New York: McGraw-Hill, 1970), pp. 125-428.

[11]Ibid., p. 403.

[12]Ibid., pp. 409-410.

[13]Ibid.

[14]Leonard A. Marscuilo, Statistical Methods for Behavioral Science Research (New York: McGraw-Hill, 1971), pp. 364-365.

[15]William L. Hays, Statistics (New York: Holt, Rinehart and Winston, 1963), p. 328.

[16]Michael Scriven, Evaluation Thesaurus, 2d ed. (Inverness, Ca.: Edgepress, 1980), p. 128.

CHAPTER IV

ANALYSIS OF DATA

Analysis of data collected in testing of the hypotheses of the study are presented in this chapter under the headings of (1) Problem and Hypotheses, (2) Description of Findings Pertinent to Each Hypothesis, (3) Other Findings and (4) Chapter Summary.

Problem and Null Hypotheses

The purpose of this study is to determine whether statistically significant relationships exist between program-specific content mastery test scores and selected characteristics of teacher-participants in a PSTT workshop. Subjects of the study are a combined population of teachers who participated during the Summer of 1979 in a multi-disciplinary HMSS Workshop given in Massachusetts and in Hawaii. Subjects were given the HMSS Content Mastery Test at the beginning and at the end of the HMSS Workshop. The study examines both pre- and post-workshop performances. It looks for relationships between teachers' scores and several of their professional and personal characteristics postulated as sources of prior knowledge affecting performance on the HMSS Content Mastery Test.

Questions which the study attempted to answer, stated in the form of null hypotheses are

1. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by disciplinary background and by years of teaching experience;
2. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by their highest level of study in science;
3. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by their level of prior marine experience and by sex; and
4. there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by age.

One-way ANOVA was used to analyze hypotheses two and four. Hypotheses one and three were analyzed by the two-way analysis of variance (ANOVA) statistical procedure. Statistical techniques involved in one-way ANOVA and in two-way ANOVA were described in Chapter III. Because of the exploratory nature of this study, the significance level of all statistical tests was arbitrarily set at $\alpha = .05$. All statistically significant probabilities are reported in the discussion as $p \leq .05$.

Description of Findings Pertinent to Each Hypothesis

Data for testing of all four null hypotheses were arranged to permit separate testing of the scores from "Subtest A. Physical Science" and from "Subtest B. Biological Science." Pre- and

post-workshop scores were subjected to the one-way ANOVA statistical procedure for hypotheses one and three. Tabularized results are presented and discussed in the following paragraphs. Although additional statistics are presented in each table, they are discussed only when independent effects or their interactions reach statistical significance in the ANOVA procedure.

Scores Arranged by Disciplinary Background and by Years of Teaching Experience

Hypothesis one examined the relationship between scores on the HMSS Content Mastery Test and the variables disciplinary background and years of teaching experience. These two variables were paired because the teaching experience of most teachers is largely in the subject areas related to their disciplinary backgrounds. Table 1 presents the results when scores on "Subtest A. Physical Science" from both the pre- and post-workshop administrations were subjected to two-way ANOVA. On the pre-workshop administration, two-way interactions were not statistically significant with F (4, 33) = 1.872, p = .139. Neither independent variable reached statistical significance. For total years teaching experience, F (2, 33) = 1.947, p = .157; for disciplinary background, F (2, 33) = 1.918, p = .163.

On the post-workshop administration, the two-way interactions were statistically significant with F (4, 32) = 2.729, $p \leq .05$. Because this indicates that the effect of one variable varies across categories of the other variable, the significance of each main effect is not discussed here.

Table 1 Two-Way Analysis of Variance of Scores Arranged by Years of Teaching Experience and by Disciplinary Background on "Subtest A, Content Mastery for HMSS Physical Science Units"

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-workshop Scores					
Total Years Teaching Experience	671	2	443	1.947	0.159
Disciplinary Background	662	2	336	1.918	0.163
Two-Way Interactions (Total Teaching Experience-Disciplinary Background)	1292	4	323	1.872	0.139
Residual	5691	33	172		
B. Post-Workshop Scores					
Total Years Teaching Experience	559	2	280	1.577	0.222
Disciplinary Background	778	2	389	2.193	0.128
Two-Way Interactions (Total Teaching Experience-Disciplinary Background)	1936	4	484	2.729	0.046 *
Residual	5676	32	177		

Additional Statistics

Pre-Workshop Scores		Post-Workshop Scores	
Interaction ω^2	0.148	Interaction ω^2	0.148
Main Effect ω^2:		Main Effect ω^2:	
Total Years Teaching Experience	0.077	Total Years Teaching Experience	(N/A)
Disciplinary Background	0.076	Disciplinary Background	(N/A)
Overall ω^2	0.350	Overall ω^2	(N/A)
Multiple R Squared (R^2)	0.202	Multiple R Squared (R^2)	(N/A)

*$p < .05$.

Table 2 presents the results when scores on "Subtest B. Biological Science" from both the pre- and post-workshop administrations were subjected to two-way ANOVA. On the pre-workshop administration, the two-way interactions were not statistically significant with F (4, 35) = 2.422, p = .067. The first independent variable, total years teaching experience, failed to reach statistical significance with F (2, 35) = .134, p = .875. The second independent variable, disciplinary background, did reach statistical significance with F = (2, 35) = 17.219, $p \leq .05$.

Looking at the additional statistics presented at the bottom left of Table 2, the main effect omega squared ratio for the statistically significant independent effect of disciplinary background is ω^2 = .417. Assuming nonorthogonal data, overall omega squared ratio reached ω^2 = .577. This indicates 42-58 percent of the variance in pre-workshop scores in "Subtest B" is associated with the two variables, total years teaching experience and disciplinary background, and that disciplinary background independently is associated with 46 percent of the variance.

On the post-workshop administration of "Subtest B," the two-way interactions were not statistically significant with F (2, 34) = 1.407, p = .253. The first independent variable, total years teaching experience, failed to reach statistical significance with F (2, 34) = 1.528, p = .232. The second independent variable, disciplinary background, did reach statistical significance with F (2, 34) = 5.432, $p \leq .05$. Thus, the same pattern appears on the

Table 2 Two-Way Analysis of Variance of Scores Arranged by Years of Teaching Experience and by Disciplinary Background on "Subtest A. Content Mastery for HMSS Biological Science Units"

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-workshop Scores					
Total Years Teaching Experience	27	2	14	0.134	0.875
Disciplinary Background	3518	2	1759	17.219	0.***
Two-Way Interactions (Total Teaching Experience-Disciplinary Background)	990	4	247	2.422	0.067
Residual	3575	35	102		
B. Post-Workshop Scores					
Total Years Teaching Experience	365	2	182	1.528	0.232
Disciplinary Background	1297	2	649	5.432	0.009**
Two-Way Interactions (Total Teaching Experience-Disciplinary Background)	672	4	168	1.407	0.253
Residual	4060	34	119		

Additional Statistics

Pre-Workshop Scores		Post-Workshop Scores	
Interaction ω^2	0.117	Interaction ω^2	0.103
Main Effect ω^2:		Main Effect ω^2:	
Total Years Teaching Experience	0.003	Total Years Teaching Experience	0.056
Disciplinary Background	0.417	Disciplinary Background	0.200
Overall ω^2	0.577	Overall ω^2	0.375
Multiple R Squared (R^2)	0.459	Multiple R Squared (R^2)	0.272

** $p < .01$.
*** $p < .001$.

post-workshop administration of "Subtest B. Biological Science" as appears on the pre-workshop administration.

Examination of the additional statistics computed for "Subtest B. Biological Science" shows that a somewhat lower proportion of variance in scores is associated with disciplinary background on the post-workshop administration than is associated on the pre-workshop administration. Independent omega squared for the statistically significant variable disciplinary background was $\omega^2 = .200$ for the post-workshop administration compared to $\omega^2 = .417$ on the pre-workshop administration. The overall omega squared index dropped to 0.375 from 0.579 on the pre-workshop administration. Thus, on the post-workshop administration of "Subtest B," 37 percent of variance is associated with the two variables, disciplinary background and teaching experience, and of that 20 percent of variance is associated with disciplinary background independently.

Summarizing the findings for hypothesis one on "Subtest A. Physical Science," neither the independent nor the interactive effects of disciplinary background and teaching experience reached statistical significance. On the post-workshop administration of "Subtest A. Physical Science," however, two-way interactions reached statistical significance.

Summarizing the findings from "Subtest B. Biological Science," the independent effect of disciplinary background reached statistical significance on both the pre- and post-workshop administrations. The main effect omega squared ratio indicates that

42 percent of variance on pre-workshop scores and 20 percent of variance on post-workshop scores is associated with disciplinary background.

Based on these findings, it is apparent that acceptance or rejection of the first null hypothesis must be made with separate references to the two subtests which comprise the HMSS Content Mastery Test. First, the findings fail to reject the null hypothesis that there are no statistically significant differences among scores on "Subtest A. Physical Science" when teachers are grouped by disciplinary background and by years of teaching experience. Second, the findings support the rejection of the null hypothesis that there are no statistically significant differences among scores on "Subtest B. Biological Science" when teachers are grouped by disciplinary background and by years of teaching experience.

Scores Arranged by Highest Degree in Science

Hypothesis two examined the relationship between highest degree of study in science and scores on the HMSS Content Mastery Test. Table 3 presents the results when scores from both the pre- and post-workshop administrations of "Subtest A. Physical Sciences" were arrayed by highest degree in science and then subjected to the one-way ANOVA statistical procedure. Pre- and post-workshop data met the prerequisite assumption of homogeneity of variances as measured by the Bartlett-Box F test. For pre-workshop scores, the Bartlett-Box test yielded $F = 0.66$, $p = .51$; for the post-workshop scores, the Bartlett-Box test yielded $F = .732$, $p = .533$.

Table 3 One-Way Analysis of Variance of Scores Arranged by Highest Degree in Science on "Subtest A. Content Mastery for HMSS Physical Science Units"

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio	F Probability
A. Pre-Workshop Scores					
Between Groups	3	499	166	0.766	0.5204
Within Groups	38	8255	217		
Total	41	8755			
B. Post-Workshop Scores					
Between Groups	3	49	16	0.064	0.9787
Within Groups	37	9481	256		
Total	40	9530			

Additional Statistics:

Pre-Workshop Scores

Bartlett-Box $F = 0.66$ ($p = 0.51$)

Tukey's Test: No two groups are significantly different at 0.05 level.

Main Effect $\omega^2 = .057$

Post-Workshop Scores

Bartlett-Box $F = 0.732$ ($p = 0.533$)

Tukey's Test: No two groups are significantly different at 0.05 level.

Main Effect $\omega^2 = .005$

On "Subtest A. Physical Science," differences among groups classified by highest degree in science were not statistically significant with either the pre- or post-workshop scores according to the results of the one-way ANOVA procedure. The pre-workshop scores yielded F (3, 38) = .766, p = .520 and the post-workshop scores yielded F (3, 37) = .064, p = .979.

Table 4 presents the results when scores from both the pre- and post-workshop administrations of "Subtest B. Biological Science" were also arrayed by highest degree in science and then subjected to the one-way ANOVA procedure. Both pre- and post-workshop scores met the prerequisite assumption of homogeneity of variances as determined by the Bartlett-Box F test. For the pre-workshop scores, the Bartlett-Box test yielded F = 1.23, p = .30; for the post-workshop scores, the Bartlett-Box test yielded F = 1.26, p = .286.

On "Subtest B. Biological Science," differences among groups classified by highest degree in science reached significance in the one-way ANOVA procedure on the pre-workshop scores, but not on the post-workshop scores. Pre-workshop scores yielded F (3, 43) = 4.002, $p \leq .05$; post-workshop scores yielded F (3, 42) = 1.692, p = .185. The Tukey test further showed that in the pre-workshop administration of "Subtest B" one pair of groups, nonscience bachelor's degree and science bachelor's degree, was significantly different at the α = .05 level of significance. For pre-workshop scores, highest degree in science is associated with 23 percent of variance in scores on "Subtest B. Biological Science," according to the main effect omega squared index.

Table 4 One-Way Analysis of Variance of Scores Arranged by Highest Degree in Science on "Subtest B. Content Mastery for HMSS Biological Science Units"

Source of Variation	D.F.	Sum of Squares	Mean Square	F Ratio	F Probability
A. Pre-Workshop Scores					
Between Groups	3	1949	650	4.002	0.0139 *
Within Groups	40	6493	162		
Total	43	8442			
B. Post-Workshop Scores					
Between Groups	3	748	249	1.692	0.1846
Within Groups	39	5751	147		
Total	42	6500			

Additional Statistics:

Pre-Workshop Scores

Bartlett-Box $F = 1.23$ ($p = 0.30$)

Tukey's Test showed the following pair of groups is significantly different at 0.05: nonscience bachelor and science bachelor

Main Effect $\omega^2 = .231$

Post-Workshop Scores

Bartlett-Box $F = 1.26$ ($p = 0.286$)

Tukey's Test: No two groups are significantly different at the 0.05 level.

Main Effect $\omega^2 = .115$

* $p < .05$.

The findings presented in Tables 3 and 4 therefore fail to reject null hypothesis two that there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by highest level of study in science for the following three test administrations: (1) pre-workshop scores on "Subtest A. Physical Science," (2) post-workshop scores on "Subtest A. Physical Science," and (3) post-workshop scores on "Subtest B. Biological Science." The findings support the rejection of the second null hypothesis only on one test situation, the post-workshop administration of "Subtest B. Biological Science."

Scores Arranged by Level of Prior Marine Experience and by Sex of Teachers

Hypothesis three examined the relationship between scores on the HMSS Content Mastery Test and the two variables level of prior marine experience and sex of teacher. These two variables were paired because preliminary analysis of data indicated that there might be some systematic difference by gender as to the level of prior marine-related experiences of participants. Table 5 presents the results when scores from both pre- and post-workshop administrations of "Subtest A. Physical Science" were arrayed by the two variables and then subjected to the two-way ANOVA statistical procedure.

On the pre-workshop administration of "Subtest A. Physical Science," two-way interactions failed to reach statistical significance, yielding F (1, 38) = 1.453, p = .236. The first independent variable, level of prior marine experience, reached statistical significance with F (1, 1) = 6.609, $p \leq .05$. The second

Table 5 Two-Way Analysis of Variance of Scores Arranged by Level of Prior Marine Experience and by Sex of Teachers on Subtest A. Content Mastery for HMSS Physical Science Units"

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-Workshop Scores					
Marine Experience Level	1222	1	1222	6.609	0.014*
Sex of Teacher	2	1	2	0.013	0.908
Two-Way Interactions (Marine Experience-Sex)	269	1	269	1.453	0.236
Residual	7025	38	185		
B. Post-Workshop Scores					
Marine Experience Level	698	1	698	3.031	0.090[a]
Sex of Teacher	10	1	10	0.045	0.834
Two-Way Interactions (Marine Experience-Sex)	236	1	236	1.027	0.318
Residual	8516	37	230		

Additional Statistics

Pre-Workshop Scores		Post-Workshop Scores	
Interaction ω^2	.031	Interaction ω^2	0.025
Main Effect ω^2		Main Effect ω^2:	
Marine Experience Level	0.140	Marine Experience Level	0.073
Sex of Teacher	0.001	Sex of Teacher	0.001
Overall ω^2	0.198	Overall ω^2	0.106
Multiple R Squared (R^2)	0.167	Multiple R Squared (R^2)	0.082

*$p < .05$.

[a]Denotes that the probability approaches the $p \leq .05$ level of confidence.

independent variable, sex of teachers, failed to reach statistical significance with F (1, 1) = .013, p = .908. The main effect omega squared ratio for level of prior marine experience is associated with 14 percent of variance in pre-workshop scores on "Subtest A. Physical Science."

On the post-workshop administration of "Subtest A. Physical Science," two-way interactions failed to reach statistical significance with F (1, 37) = 1.027, p = .318. Neither independent variable reached statistical significance: for level of prior marine experience F (1, 37) = 3.031, p = .090; for sex of teacher, F (1, 37) = .045, p = .318.

Table 6 presents the results when both the pre- and post-workshop scores from "Subtest B. Biological Science" were arrayed by level of prior marine experience and sex of teacher and then subjected to the two-way ANOVA procedure. Two-way interactions failed to reach statistical significance with the pre-workshop scores which yielded F (1, 40) = .354, p = .556 and with the post-workshop scores which yielded F (1, 39) = 1. 707, p = .181.

The first independent variable, level of prior marine experience, reached statistical significance on both the pre- and post-workshop administrations of "Subtest B. Biological Science" with the pre-workshop scores F (1, 1) = 4.785, $p \leq .05$ and the post-workshop scores F (1, 1) = 4.737, $p \leq .05$. The second independent variable, sex of teachers, failed to reach statistical significance on either the pre- or post-workshop administration of "Subtest B. Biological Science." For the variable, sex of teachers, pre-workshop scores

Table 6 Two-Way Analysis of Variance of Scores Arranged by Level of Prior Marine Experience and by Sex of Teachers on "Subtest B. Content Mastery for HMSS Biological Science Units"

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-Workshop Scores					
Marine Experience Level	884	1	884	4.785	0.035*
Sex of Teacher	22	1	22	0.119	0.732
Two-Way Interactions (Marine Experience-Sex)	65	1	65	0.354	0.555
Residual	7368	40	185		
B. Post-Workshop Scores					
Marine Experience Level	698	1	698	4.737	0.036*
Sex of Teacher	315	1	315	2.135	0.152
Two-Way Interactions (Marine Experience-Sex)	754	1	252	1.707	0.181
Residual	5746	39	147		

Additional Statistics

Pre-Workshop Scores		Post-Workshop Scores	
Interaction ω^2	0.008	Interaction ω^2	0.002
Main Effect ω^2:		Main Effect ω^2:	
Marine Experience Level	0.105	Marine Experience Level	0.107
Sex of Teacher	0.003	Sex of Teacher	0.045
Overall ω^2	0.125	Overall ω^2	0.116
Multiple R Squared (R^2)	0.117	Mulitple R Squared (R^2)	0.114

* $p < .05$.

yielded F (1, 1) = .119, p = .732 and post-workshop scores yielded F (1, 1) = 2.135, p = .152.

Looking at the additional statistics for "Subtest B. Biological Science," main effect omega squared ratio for level of prior marine experience is associated with approximately 11 percent of variance in pre-workshop scores and with 7 percent of variance in post-workshop scores.

On the pre-workshop administration of "Subtest B. Biological Science" the pair of variables, level of marine science and sex of teachers, are proportionally distributed as can be seen by inspection of mean score data given in Appendix D. Because of the orthogonal nature of the pre-workshop data on "Subtest B," multiple R^2 is an appropriate linear statistic to describe the degree of association between the combined variables and scores. Looking at the additional statistics for Table 5, the pair of variables, level of prior marine experience and sex of teachers, yielded multiple R^2 = .117 and overall ω^2 = .125 on the pre-workshop administration. On the post-workshop administration of "Subtest B. Biological Science," the combined association based on the nonorthogonal nature of the data is overall ω^2 = .116.

In summary, Tables 5 and 6 show that the independent variable level of marine experience reached statistical significance with the following three test administrations: (1) pre-workshop scores on "Subtest A. Physical Science," (2) pre-workshop scores on "Subtest B. Biological Science," and (3) post-workshop scores on "Subtest B. Biological Science." Independent omega squared ratios indicate that

the percentage of association between the independent variable level of marine experience and scores is 14 percent on the pre-workshop administration of "Subtest A," 11 percent on the pre-workshop administration of "Subtest B," and 11 percent on the post-workshop administration of "Subtest B."

Combined effects of the two variables level of marine experience and sex of teachers yielded overall $\omega^2 = .198$ and multiple $\underline{R}^2 = .167$ for the orthogonal pre-workshop scores on "Subtest A. Physical Science." For nonorthogonal pre-workshop scores on "Subtest B. Biological Science," the overall $\omega^2 = .125$; for nonorthogonal post-workshop scores on "Subtest B. Biological Science," the overall $\omega^2 = .105$.

Based on these findings, it becomes apparent that the acceptance or rejection of the third null hypothesis must be made with separate reference to the two subtests of the study. Consequently, the study fails to reject the null hypothesis that there are no significant differences among the post-workshop scores on "Subtest A. Physical Science" when teachers are grouped by their level of prior marine experience and by their sex. The findings support the rejection of the following three null hypotheses: that when teachers are grouped by their level of prior marine experiences and their sex, there are no significant differences among scores (1) on the pre-workshop administration of "Subtest A. Physical Science," (2) in the pre-workshop administration of "Subtest B. Biological Science," and (3) on the post-workshop administration of "Subtest B. Biological Science."

Scores Arranged by Age of Teachers

Hypothesis four examined the relationship between age of teachers and scores on the HMSS Content Mastery Test. Table 7 presents the results when both the pre- and post-workshop scores from "Subtest A. Physical Science" were subjected to one-way ANOVA. Data on pre- and post-workshop scores met the prerequisite assumption of homogeneity of variances as measured by the Bartlett-Box F test. For the pre-workshop scores the Bartlett-Box test yielded $F = .702$, $p = .551$; for the post-workshop scores, the Bartlett-Box test yielded $F = .695$, $p = .555$.

Differences in scores among teachers classified by age were not statistically significant for either the pre- or post-workshop administrations of "Subtest A. Physical Science." One-way ANOVA of the pre-workshop scores yielded $F\ (3, 41) = .702$, $p = .557$. Post-workshop scores yielded $F\ (3, 40) = .978$, $p = .413$.

Table 8 presents the results when both pre- and post-workshop scores from "Subtest B. Biological Science" were subjected to one-way ANOVA using the variable age of teacher. Both sets of data met the prerequisite assumption of homogeneity of variances as determined by the Bartlett-Box F test. For the pre-workshop scores the Bartlett-Box $F = 1.393$, $p = .243$; for the post-workshop scores the Bartlett-Box $F = .060$, $p = .981$.

Differences in scores among groups classified by age of teachers failed to reach statistical significance on both the pre- and post-workshop administrations of "Subtest B. Biological Science." For the pre-workshop scores, one-way ANOVA yielded $F\ (3, 43) = .915$,

Table 7 One-Way Analysis of Variance of Scores Arranged by Age of Teachers for "Subtest A. Content Mastery for HMSS Physical Science Units"

Groups by Teacher Age	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-Workshop Scores					
Between Groups	460	3	153	0.702	0.557
Within Groups	8294	38	218		
Total	8754	41			
B. Post-Workshop Scores					
Between Groups	700	3	233	0.978	0.413
Within Groups	8829	37	239		
Total	9530	40			

Additional Statistics

Pre-Workshop Scores

Bartlett-Box $F = 0.702$ ($p = 0.551$)

Tukey's Test: NSD between pairs

Main Effect $\omega^2 = 0.053$

Post-Workshop Scores

Bartlett-Box $F = 0.695$ ($p = 0.555$)

Tukey's Test: NSD between pairs

Main Effect $\omega^2 = 0.073$

Table 8 One-Way Analysis of Variance of Scores Arranged by Age of Teachers for "Subtest B. Mastery for HMSS Biological Science Units"

Groups by Teacher Age	Sum of Squares	DF	Mean Square	F	Significance of F
A. Pre-Workshop Scores					
Between Groups	542	3	181	0.915	0.4424
Within Groups	7900	40	198		
Total	8442	43			
B. Post-Workshop Scores					
Between Groups	255	3	85	0.531	0.664
Within Groups	6245	39	160		
Total	6500	42			

Additional Statistics

Pre-Workshop Scores

Bartlett-Box $F = 1.393$ ($p = 0.243$)

Tukey's Test: NSD between pairs

Main Effect $\omega^2 = 0.064$

Post-Workshop Scores

Bartlett-Box $F = 0.060$ ($p = 0.981$)

Tukey's Test: NSD between pairs

Main Effect $\omega^2 = 0.033$

p = .442. For the post-workshop scores, one-way ANOVA yielded F (3, 42) = .531, p = .664.

The findings presented in Tables 7 and 8 therefore fail to reject null hypothesis four that there are no significant differences among scores on the HMSS Content Mastery Test when teachers are grouped by age.

Other Findings

Effects found to reach statistical significance with both the pre- and post-workshop administrations of "Subtest A. Content Mastery for HMSS Physical Science" and "Subtest B. Content Mastery for HMSS Biological Science" are arranged by hypothesis in Table 9. Additional statistics computed for each of the statistically significant effects are also included.

Inspection of the summarized findings in Table 9 shows the following:

1. Scores on the HMSS Content Mastery Test (including both "Subtest A. Physical Science" and "Subtest B. Biological Science") were not affected by the following three teacher characteristics tested as independent variables of the study: (a) total years teaching experience, (b) sex of teachers, and (c) age of teachers.
2. Scores on the two component subtests of the HMSS Content Mastery Test were affected during some test administrations by the following three teacher characteristics tested as independent variables of the study: (a) disciplinary

Table 9 Summary of Findings from Testing of the Four Null Hypotheses of the Study

		"Subtest A. Content Mastery for HMSS Physical Science Units"		"Subtest B. Content Mastery for HMSS Biological Science Units"	
		Pre-Workshop	Post-Workshop	Pre-Workshop	Post-Workshop
Tables 1,2	HYPOTHESIS 1 (Two-Way ANOVA)				
	Total Years Teaching Experience	NSD	NSD	NSD	NSD
	Disciplinary Background	NSD	NSD	***ω^2=0.417	**ω^2=0.200
	Two-Way Interactions	NSD	*ω^2=0.148	NSD	NSD
	Additional Statistics:				
	Overall ω^2	---	NA	0.577	0.375
	Multiple R^2	---	NA	0.459	0.272
Tables 3,4	HYPOTHESIS 2 (One-Way ANOVA)				
	Highest Science Degree	NSD	NSD	*ω^2=0.231	NSD
	Tukey's Test	--	--	Nonscience Bachelors & Science Bachelors	--
Tables 5,6	HYPOTHESIS 3 (Two-Way ANOVA)				
	Level of Marine Experience	*ω^2=0.140	NSD	*ω^2=0.105	*ω^2=0.107
	Sex of Teacher	NSD	NSD	NSD	NSD
	Two-Way Interactions	NSD	NSD	NSD	NSD
	Additional Statistics:				
	Overall ω^2	0.198	--	0.125	0.116
	Multiple R^2	0.167	--	0.117	0.114
Tables 7,8	HYPOTHESIS 4 (One-Way ANOVA)				
	Age of Teacher	NSD	NSD	NSD	NSD
	Tukey's Test	--	--	--	--

*$p < .05$.
**$p < .01$.
***$p < .001$.

background, (b) level of prior marine experience, and (c) highest degree earned in science.

3. Scores on "Subtest B. Biological Science" were more affected by the independent variables disciplinary background, highest degree earned in science, and level of prior marine experience than were scores on "Subtest A. Physical Science."
4. Scores on the pre-workshop administration of the HMSS Content Mastery Test were more affected by the independent variables disciplinary background, level of prior marine experience, and highest degree earned in science than were scores on the post-workshop administration of the test. Values computed for strength of association were also higher on the pre-workshop administrations than on post-workshop administrations.
5. The variable level of prior marine experience had a statistically significant independent effect on three out of four test administrations in the study. In addition, although this variable did not reach statistical significance on the post-workshop administrations of "Subtest A. Physical Science," it did reach the $p = .090$ level of confidence. This indicates some effect on the dependent variable for this test administration, too. However, in terms of strengths of association as determined by omega squared ratios, level of prior marine experience is associated with only a moderate proportion of

variance on the pre-workshop scores on both "Subtest A. Physical Science" (14 percent) and "Subtest B. Biological Science" (11 percent). It is associated with the same proportion of variation in post-workshop scores on "Subtest B. Biological Science" (11 percent).

6. The variable disciplinary background had a statistically significant independent effect on the pre- and post-workshop administrations of "Subtest B. Biological Science," but failed to reach statistical significance on the pre- and post-workshop administrations of "Subtest A. Physical Science." Of the three independent variables in the study which had a statistically significant effect on "Subtest B. Biological Science," the variable disciplinary background is associated with the highest proportion of variance in scores on both the pre- and post-workshop administrations of "Subtest B."
7. The variable highest level of study in science had a statistically significant effect on only one of the four test administrations carried out in the study. Highest level of study reached statistical significance on the pre-workshop administration of "Subtest B. Biological Science." Differences in scores of teachers with nonscience bachelor's degrees as compared to teachers with science bachelor's degrees reached statistical significance at the .05 level of confidence. The strength of association for this effect reached ω^2 = .281 higher than the strength of

association for the paired variables level of prior marine experience and sex of teacher (ω^2 = .125) but lower than the paired variables disciplinary background and years of teaching experience (ω^2 = .577).

Chapter Summary

The purpose of this study is to determine whether statistically significant relationships exist between the dependent variable, scores on the HMSS Content Mastery Test and the independent variable, selected characteristics of teachers participating in a basic HMSS Workshop. Subjects of the study are the combined population of voluntary inservice teacher participants from the two HMSS Workshops that were held during the summer of 1979, one in Massachusetts and the other in Hawaii. Data on the combined population were obtained using an HMSS Workshop registration form and results from the pre- and post-workshop administrations of the HMSS Content Mastery Test.

Results from testing of the null hypotheses indicate no significant relationship between either pre- or post-workshop scores and three of the teacher characteristics selected as independent variables of the study: total years teaching experience, age, and sex. Statistically significant effects and low to moderately high degrees of association were found between three of the independent variables--disciplinary background, level of prior marine experience, and highest degree earned in science--in the dependent variable scores on "Subtest B. Biological Science." Only one independent variable, level of prior marine experience, had a statistically

significant effect on "Subtest A. Physical Science" on its pre-workshop administration. Two-way interactions reached statistical significance on the post-workshop administration of "Subtest A. Physical Science."

In general, independent variables which reached statistical significance had a greater effect on (1) "Subtest B. Biological Science" than on "Subtest A. Physical Science," and on (2) the pre-workshop administrations of both subtests than on their post-workshop administrations.

CHAPTER V

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

This chapter presents the conclusions of the study, discusses their implications and makes recommendations for further study.

Conclusions

The purpose of this study was to determine whether relationships exist between selected characteristics of inservice teachers in HMSS Workshops and their pre- and post-workshop scores on the HMSS Content Mastery Test. Participants' pre- and post-workshop scores on the HMSS Content Mastery Test were the dependent variables of the study. Independent variables were the following teacher characteristics: (1) disciplinary background, (2) highest degree in science, (3) total years teaching experience, (4) level of prior marine experience, (5) sex of teachers, and (6) age of teachers.

Based on the results from testing using the null hypotheses, the following conclusions can be drawn:

1. Teacher characteristics (a) total years teaching experience, (b) sex of teachers, and (c) age of teachers had no effect on HMSS Content Mastery Test Scores.
2. Teacher characteristics (a) disciplinary background, (b) level of prior marine experience, and (c) highest degree in science showed an effect on some scores on the HMSS Content Mastery Test.

3. Scores on "Subtest B. Biological Science were more affected than were scores on "Subtest A. Physical Science" by the variables (a) disciplinary background, (b) level of prior marine experience, and (c) highest degree in science.
4. Pre-workshop scores were more affected than were post-workshop scores on the HMSS Content Mastery Test by the variables (a) disciplinary background, (b) level of prior marine experience, and (c) highest degree in science.

Because this study was organized under an *ex post facto* co-relational design, strong relationships cannot be interpreted as causal, but can suggest possible bases for causality. Temporal logic, however, indicates that teacher characteristics which existed prior to the workshop are more likely to be causally related to scores on the HMSS Content Mastery Test than are scores likely to be causally related to prior teacher characteristics. Consequently, whether measured teacher characteristics have a causal effect on scores, or whether they are indicators of other inherent more primitive factors causing differences in scores is not of prime concern to this study.

Underpinning this study was the hope that the findings could be applied to future groups of participants in HMSS Workshops. Justification for extrapolating findings to the larger group of teachers who will ultimately be trained in the use of the HMSS materials is based on the assumption that new teachers will be "like those observed." This assumption is enhanced knowing that even though the subjects in the combined population were from two geographic

extremes of the United States, general commonalities were found in the composition of the two workshop groups. Therefore, the conclusions of the study which can be generalized to other groups of teachers who voluntarily participate in an HMSS Workshop are:

1. Differences in scores on the HMSS Content Mastery Test are related to the following three characteristics of HMSS Workshop participants: disciplinary background, prior level of marine experience, and highest degree in science.
2. These selected teacher characteristics can therefore be used to predict the probable cognitive performances of teachers participating in an HMSS Workshop.
3. HMSS Workshop registration forms calling for information on these selected characteristics can be used by HMSS Workshop leaders to preview the composition of workshop participants and to predict their cognitive strengths and weaknesses.
4. Working with information provided by this study, HMSS Workshop leaders can evaluate the effectiveness of the Basic HMSS Workshop approach of teaching content through the inquiry activities of the HMSS Program.
5. HMSS Workshop leaders can therefore plan alternative strategies for future teacher groups with expected different cognitive performances.

Implications

Because of this study, HMSS Workshop leaders are now in a position to make more informed decisions about modifying the Basic HMSS

Workshop treatment. At present, participation in an HMSS Workshop is a requirement to gain access to use of the HMSS materials. One obvious decision then is whether to establish a minimal score criterion for post-workshop HMSS Content Mastery Test performance for all teacher participants. Arguing against a uniform minimal standard is that not all teachers attend an HMSS Workshop with the intent of adopting the full HMSS Program. A possible alternative to uniform cognitive performance criteria would be to develop individualized workshop performance contracts through which participants in consultation with the HMSS Workshop leader agree to work towards selected cognitive performance goals appropriate to the participants' intent in adopting and using the HMSS Program.

Whether or not performance contracts are used, HMSS Workshop leaders are in a position as a result of this study to consider using individualized diagnosis of program-specific content mastery together with consultative prescription to help teachers improve their subject matter mastery. To do this would require the development of additional complementary program-specific learning aids which provide updating, upgrading or reorientation. Development of complementary program-specific learning aids for teachers is technically feasible in the form of selected readings, programmatic exercises, self-tutorial slide-tape presentations, or computer assisted instructional modules. Whether these complementary program-specific instructional aids are educationally effective remains to be demonstrated in further studies.

Providing teachers time to interact with complementary program-specific learning aids would necessitate redesigning the Basic HMSS

Workshop format and schedule. One possibility is to alter the schedule to half days of formal HMSS Workshop training combined with half days of individualized complementary program-specific activities, including additional laboratory or field work. Thus, the basic HMSS Workshop would be offered over a three or four week period with afternoons reserved for individualized activities.

Two disadvantages, however, are inherent. First, individualized activities based on the professional interests of teachers are least appropriate for those teachers for whom the HMSS units of greatest interest are presented towards the end of the workshop. Teachers with special interest in materials covered early in the workshop would likely profit most from opportunities for afternoon individualized activities.

Second, and perhaps the more serious concern, is that doubling the length of the Basic HMSS Workshop and making afternoon activities of the workshop responsive to individual teacher's professional interests increases both the cost and the complexity of the workshop. Individualized activities would have to account for varying needs in upgrading, updating or reorientation of teachers with respect to program-specific subject matter mastery.

In effect, this transforms the Basic HMSS Workshop into an Extended HMSS Workshop. In an era of scarce and uncertain funding, future HMSS Workshops are likely to have to be self-supporting on a tuition or fee basis. This means that an HMSS Workshop leader will probably have neither a laboratory assistant nor workshop support services available. Faced with the present economic reality that

federal grants to support Extended PSTT Workshops are essentially not available, PSTT Workshop expectations will have to be scaled down. If extended HMSS Workshops are still desired, then revenues will have to be generated from teachers willing to pay the costs of supporting Extended HMSS Workshops or from state or district school systems adopting the HMSS Program. The purchase price to school systems adopting classroom sets of HMSS materials could be structured to include all or part of the Basic HMSS Workshop costs.

Modularization of HMSS Workshops into shorter components seems another attractive alternative. Two advantages are, first that teachers could select program-specific HMSS Workshop training modules in accord with their needs and interests. Presumably this would result in a more homogeneous workshop population because, for example, biology teachers are more likely than physics teachers to attend HMSS biology modules. Even among biology teachers in a biology training modular workshop, however, teachers are likely to vary with respect to their entry-level content mastery. A second advantage to modularized HMSS Workshops is that they would be shorter and therefore less expensive for participants and less complex logistically for workshop leaders.

Counterbalancing disadvantages, however, are first, that modularization may weaken or destroy the conceptual design of the HMSS Program in its entirety. In the HMSS Program, instructional units are designed specifically to provide interdisciplinary concept reinforcement as well as to develop conceptual understanding of component disciplinary areas. Lost, too, through modularization are

opportunities for teacher growth and stimulation for teachers to extend their expertise or to reorient their knowledge to related disciplines.

In addition, the multi-disciplinary nature of marine education reflects the global complexity of the oceans and the hydrosphere and of human interactions with them. Recognizing the complexity of marine studies, basic questions arise as to the wisdom of promoting single-topic or single-disciplinary approaches to training teachers for teaching multi-disciplinary subject matter.

A last concern about workshop modularization is whether or not teacher enrollment would be sufficient to support modularized workshops on a tuition basis, as this seems the most likely scenario for the immediate future. On a tuition-sustained basis, the basic multi-disciplinary HMSS Workshop draws from the entire population of local secondary science teachers. A modularized HMSS Workshop is likely to appeal to only a portion of these teachers. Clearly, more study is needed on the feasibility and effectiveness of transforming the basic HMSS Workshop into a series of modularized HMSS Workshops.

It has now been demonstrated that HMSS Workshop leaders can use pre-registration as a means for previewing HMSS Workshop participants' characteristics and as a means for either predicting their scores or for actually administering in advance a program-specific content mastery test. Consequently, other options are now open to HMSS Workshop leaders related to pre-planning the scheduling and grouping of teachers. No matter what modifications, if any, the HMSS Workshop leader decides to make on the Basic HMSS Workshop, the underlying

implication of this study is that there are systematic, probablistic relationships between professional teacher characteristics and their cognitive performance and that these probabilities can be used advantageously by HMSS Workshop leaders to better provide for the training of inservice teacher participants.

Recommendations for Further Research

As a result of this study which demonstrated systematic relationships between selected teacher characteristics and cognitive performance on a program-specific content mastery test, it is hoped that other types of teacher characteristics studies will be undertaken also for the purpose of improving the effectiveness and efficiency of inservice teacher training. Several areas for possible further study are

1. Can the findings of relationships between professional characteristics of teachers with their cognitive performances on a program-specific content mastery test within the context of the Basic HMSS Workshop be generalized to other program-specific teacher training workshops? If so, then knowledge about relationships can be used as a basis for predicting PSTT Workshop cognitive performance, and based on these predictions, PSTT workshop leaders can make more informed planning decisions to better meet the needs of inservice participants.
2. How can differences in cognitive performance among inservice science teachers be explained? If, according to Phenix, the

content and processes of the physical sciences are qualitatively different from the content and process of the biological sciences, and if most secondary science teachers have earned degrees with academic subject matter specialization either in the physical sciences or in the biological sciences, have the subject matter experiences with content and process of science been qualitatively different for these two groups of teachers? Also, are there intrinsic differences between these two groups of teachers with respect to their cognitive learning styles (e.g., are they likely to view the world differently as manifested in their approaches to defining and investigating science problems)?

3. Given the opportunity to adopt and implement a multidisciplinary curricular program, what relationships, if any, are there between professional characteristics of teachers and their selection and use of portions of the program? What supportive follow-up services do teachers need in the early stages of program-specific implementation? What relationships, if any, are there among teacher characteristics, teacher program-specific content mastery and actual student learning outcomes?

Thus, it is hoped that this study points the way for other studies of teacher characteristics and the needs of teachers in program-specific teacher training workshops and in other inservice training activities.

APPENDICES

APPENDIX A

INSTRUMENTS USED IN THE STUDY

— — — —
Last four digits of your social security number

Your Name _____

Name of School _____

Address of School _____
(number) *(street)*

_____
(city) *(county)* *(state)* *(zip)*

PART I. MARINE SCIENCE TEACHERS

Directions: Please check (√) the item or items which best apply to you.

I. TEACHER CHARACTERISTICS

A. On what basis are you now employed by the school system?

____ 1. Full-time (regular) ____ 3. Substitute

____ 2. Part-time (regular) ____ 4. Other (specify) _____

B. Are you tenured?

____ 1. Yes ____ 2. No ____ 3. No such thing as tenure at your school

C. Age in years

____ 1. 25 and under ____ 4. 46 to 55

____ 2. 26 to 35 ____ 5. 56 to 65

____ 3. 36 to 45 ____ 6. Over 65

D. Sex:

____ 1. Female ____ 2. Male

II. PROFESSIONAL TRAINING

A. Place a check (✓) to the left of the items which describe what degree(s) you now hold. Specify the major and minor subject matter fields of the degree(s).

Degree(s) Held	Major	Minor
____ 1. Bachelors	_____	_____
____ 2. Masters	_____	_____
____ 3. Doctorate	_____	_____
____ 4. Other (specify)	_____	

B. Are you now working on a formal degree program? ____ 1. Yes
____ 2. No

If yes, what degree? _____ Major
_____ Minor

III. TEACHER PREPARATION

A. What training have you had in marine science? Please specify numbers of credits in either quarter hours or semester hours.

	Quarter Hours (Q)	Semester Hours (S)
1. College courses in Oceanography	_____	_____
2. Other marine-related courses	_____	_____
3. Education methods courses (marine)	_____	_____

4. Teacher workshops:

Workshop Title	Institution	How many credits (Q or S)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

5. Other types of marine courses/programs
(If additional space is needed, use reverse side)

Type	Title	Sponsoring Agency	How many credits (Q or S)
a) marine course by newspaper	_____	_____	_____
b) marine course by television	_____	_____	_____
c) marine course by aquarium or museum	_____	_____	_____
d) marine course by professional assoc.	_____	_____	_____
e) marine course through non-school federal or state agencies	_____	_____	_____

B. Other marine-related training or experience that has helped you as a marine science teacher: (give details)

1. Research experience(s):

2. Non-secondary school vocational experience(s):

3. Avocational experience(s):

4. Work experience (e.g., fishing, running a scuba dive shop, military)

E. Indicate the number of years teaching experience you have had in each of the categories listed below. (Include this year)

1. Teaching in an elementary school ____ years
2. Teaching in a secondary school ____ years
3. Teaching at a college or university ____ years
4. Total years teaching experience ____ years
5. Number of years at present school system or district ____ years

F. Please indicate the number of years teaching experience you have had in teaching each of the following subjects/courses:

1. Marine sciences ____
2. Chemistry ____
3. Earth science ____
4. Outdoor educ. ____
5. Marine biology ____
6. Physics ____
7. Mathematics ____
8. Other (specify): _____
9. Biology ____
10. Physical sciences ____
11. Environ. sciences ____

G. Did you teach marine science as a course/subject during the 1978-1979 school year?

____ 1. Yes ____ 2. No ____ 3. Other (explain): _____

H. Will you be teaching marine science as a course/subject during the 1979-1980 school year?

____ 1. Yes ____ 3. Maybe
____ 2. No ____ 4. Other (explain): _____

I. In general, how well prepared do you feel to teach marine science?

____ 1. Very well prepared ____ 3. Somewhat prepared
____ 2. Prepared ____ 4. Not very prepared

HMSS CONTENT MASTERY TEST
SUBTEST A. CONTENT MASTERY
FOR HMSS PHYSICAL SCIENCE UNITS

PART A: CONTINENTS AND OCEANS

On the right is a globe showing an Equatorial view of its only continent.

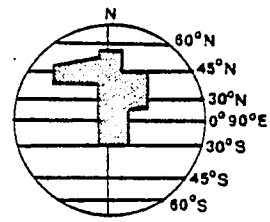


Fig. 1 Globe.

1. Draw the continent on the Equal-Area gores below in Fig. 2.

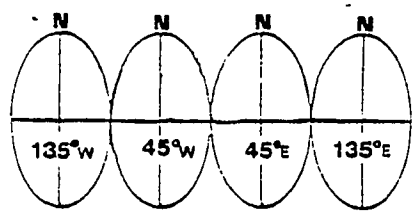
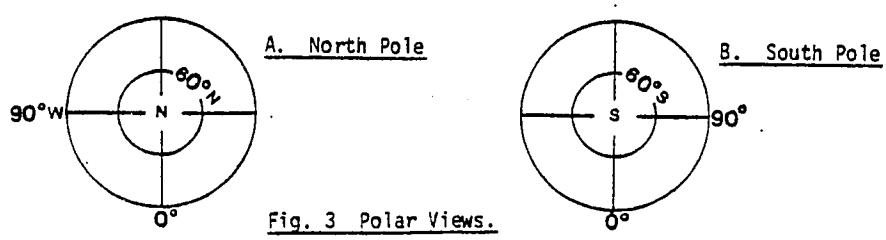


Fig. 2 Equal-Area Gores.

2. Draw the continent as it would appear from the North Pole.

3. Draw the continent as it would appear from the South Pole.



A. North Pole

B. South Pole

Fig. 3 Polar Views.

4. Draw a Mercator projection of the continent in Fig. 4 below.

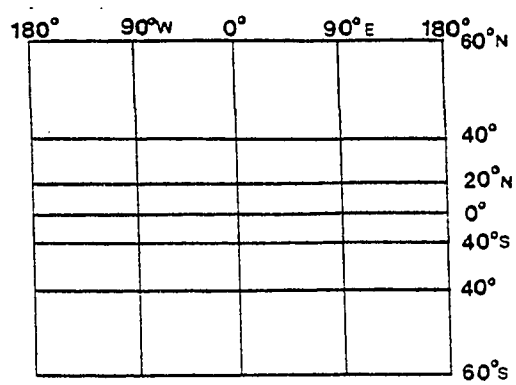


Fig. 4 Mercator Projection.

PART 8: LANDFORM FEATURES

Below is a contour map. Match the lettered boxes with the descriptions given.

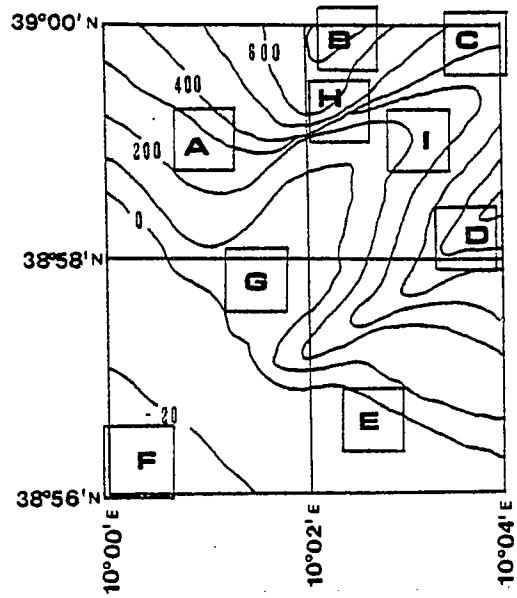


Fig. 5 Contour Map.

_____ 1. contains an ocean area.

_____ 2. contains a cliff.

_____ 3. contains a valley.

_____ 4. contains a ridge.

_____ 5. contains the most southern point.

_____ 6. contains the most western point.

_____ 7. contains the lowest spot on the map.

_____ 8. contains the highest spot on the map.

_____ 9. contains a point 38° 59' N, 10° 01' E.

_____ 10. contains a point 38° 58' 50" N, 20° 02' 30" E.

PART C: BEACH PROFILES

A diagram showing the profile of an area is given in Fig. 6. Match the appropriate letter(s) in the dagram with each item below:

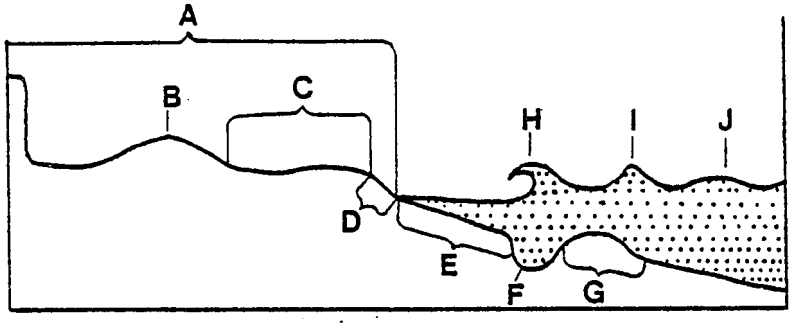


Fig. 6 Profile of Coastal Features.

_____1. Berm

_____2. Berm Scarp

_____3. Breaker

_____4. Channel

_____5. Coastal Area

_____6. Dune

_____7. Peak Wave

_____8. Plunge Point

_____9. Sandbar

_____10. Swell

PART D. WAVE PATTERNS AND MOVEMENT

In Fig. 7 below, an island (I) interacts with waves, causing them to move in different directions (N, S, E, W). Complete each statement using the correct letter(s) or number(s).

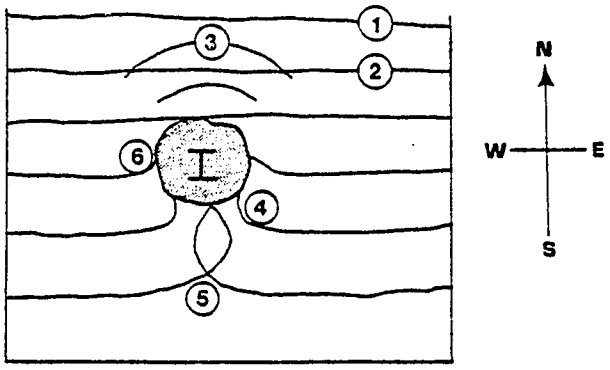


Fig. 7 Diagram of Waves Interacting with an Island.

_____1. Waves at (1) are coming from the _____.

_____2. A wave moving West is shown at _____.

_____3. A refracted wave is shown at _____.

_____4. Two waves that represent parallel waves are _____ and _____.

_____5. An example of a reflected wave is _____.

_____6. Converging waves are shown at _____.

_____7. A wave moving North is _____.

_____8. A wave moving toward the Southeast is _____.

_____9. The point of greatest wave energy is at _____.

____10. The wave with the least energy is shown at _____.

HMSS CONTENT MASTERY TEST
SUBTEST A. CONTENT MASTERY
FOR HMSS PHYSICAL SCIENCE UNITS

PART E: HYDROMETERS

A density graph used to interpret hydrometer readings is shown in Fig. 8 below. Place the proper answer in the blank to the left of each of the items. Use appropriate units.

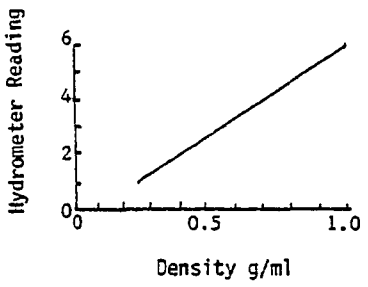


Fig. 8 Density Graph for One Type of Hydrometer.

_____1. The lowest density this hydrometer would appear to measure is _____.

_____2. A hydrometer reading of 2.0 is equivalent to a density of _____.

_____3. The density of a 0.60 g/ml solution is diluted by half (made half as dense). The hydrometer reading of the diluted solution is _____.

_____4. This hydrometer is intended for use with solutions less than (<), equal to (=), or greater than (>) the density of water.

HMSS CONTENT MASTERY TEST
SUBTEST A. CONTENT MASTERY
FOR HMSS PHYSICAL SCIENCE UNITS

PART F: SHIP

The three hulls shown in Fig. 9 were each made of 80 g of clay. All have walls of the same thickness and float. Place a (+) in front of each correct statement and a (o) in front of each incorrect statement below.

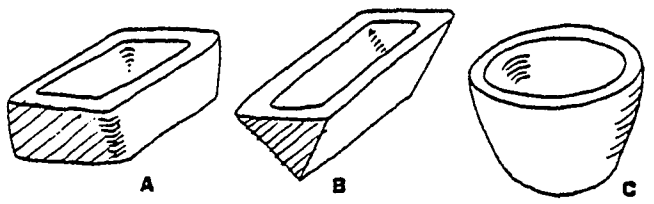


Fig. 9 Three Hull Shapes.

____1. Each displaced the same mass of fresh water.

____2. Each displaces the same volume of fresh water.

____3. Each is supported by the same buoyant force in fresh water.

____4. Each exerts the same gravitational force.

____5. Each will carry the same volume of sand.

____6. Each will carry the same weight of sand.

____7. The volume of (A) > (C).

____8. The volume of (B) > (C).

____9. The buoyant force on (A) is 80 gf.

____10. If (A) displaces 50 g of water, the net buoyant force is 50 gf.

PART G: FORCES AFFECTING BOAT STABILITY

A boat has the cross-sectional structure shown below in Fig. 10. It is shown in 3 independent positions. Use the letters and position numbers to answer the following statements:

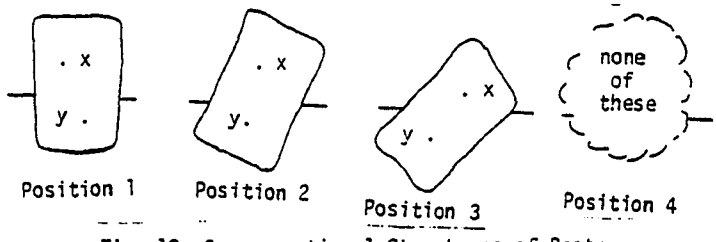


Fig. 10 Cross-sectional Structures of Boats.

_____1. The center of buoyancy is represented by the letter _____.

_____2. An upward-pointing arrow would represent the forces at _____.

_____3. The forces do not appose each other at Position _____.

_____4. In still water the boat would start to capsize at Position _____.

PART H: SHIP DESIGN

A model of a ship is shown below in Fig. 11. Use letters or numbers to complete the following statements correctly:

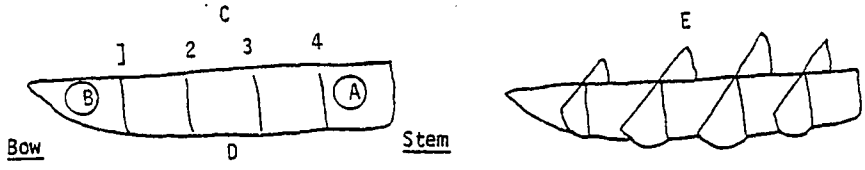


Fig. 11 Model of a Ship.

_____1. The ship has _____ (number of) bulkheads.

_____2. The front of the boat will be at _____.

_____3. The top of the boat will be at _____.

_____4. The boat will have the most stability if a weight is placed between ribs _____and ; and at _____. (A, B, C, D, or E).

HMSS CONTENT MASTERY TEST
SUBTEST B. CONTENT MASTERY FOR
HMSS BIOLOGICAL SCIENCE UNITS

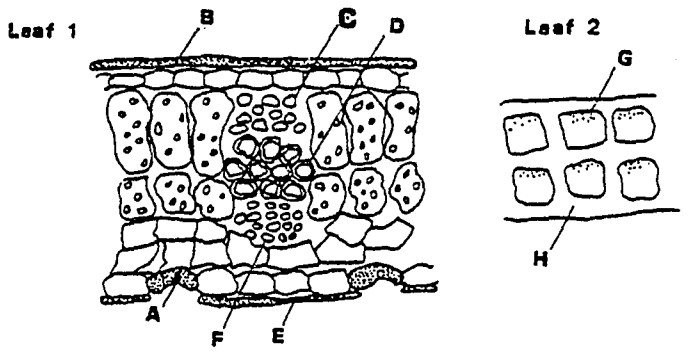


Fig. 1. Cross-Section of an Algae and a Coastal Plant

PART A: COMPARISON OF SEAWEEDS AND COASTAL PLANTS

Use the letter on the drawings in Fig. 1 to complete the following statements:

_____1. _____ is a drawing of a seaweed.

_____2. _____ and _____ are protective outer coverings of wax.

_____3. _____ is a passage for gases.

_____4. The cell in a seaweed is found at _____.

_____5. Lignin is found at _____.

_____6. Parts of a vascular system are at _____ and _____.

_____7. The cell wall of a seaweed is at _____.

PART B

Note the plant type in Table 1. Place a (+) in all boxes in which the substance of structure is found; a (o) where it is not found.

Table 1. Comparison of Structures and Substance
In a Seaweed and a Land Plant

Plant Type	Stomate	Lignin	Starch	Vascular System
Seaweed				
Land Plant				

PART C: CLAM STRUCTURE

Complete Table 2 below using Fig. 2, Diagram of Internal Organs of a Clam as a guide. (A complete example is in #1.)

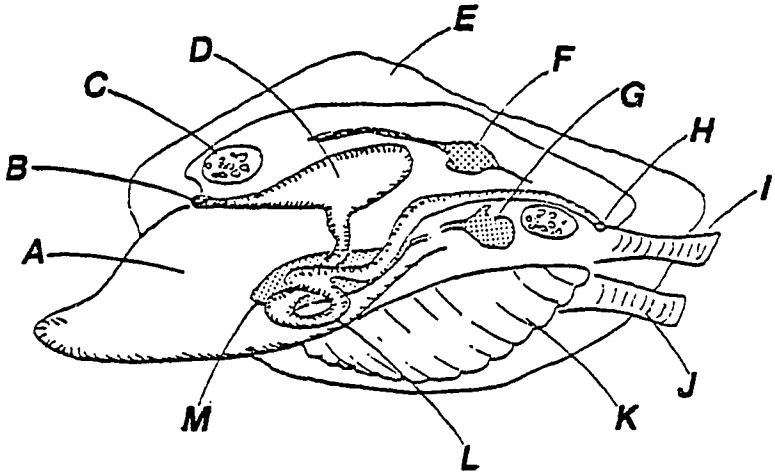


Fig. 2. Diagram of Internal Organs of a Clam

Table 2. Organs, Systems and Functions of a Clam

Number	System	System Function	Exemplary Organs	Name of Exemplary Organs
1	Skeletal	Protection and body support		Shell
2			A	
3		Defense		
4				Heart
5	Respiratory	O_2-CO_2 Exchanger	K	Gill
6	Reproductive		J	
7		Digests food		

PART D: SQUID STRUCTURE AND FUNCTION

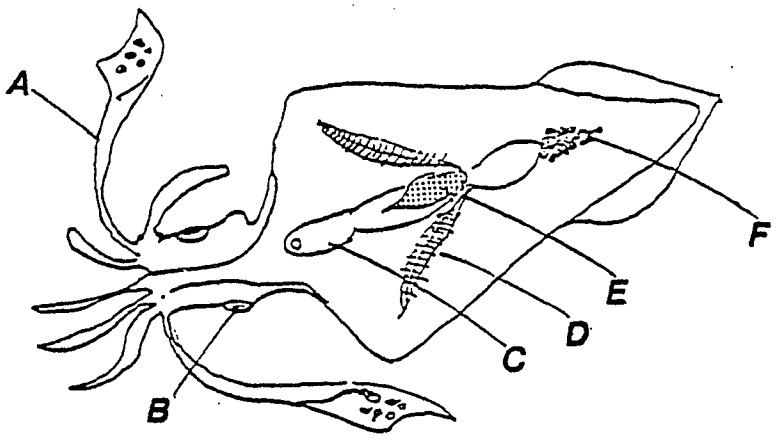


Fig. 3. Diagram of a Squid

Use the letters in Fig. 3 Diagram of a Squid to complete the following statements:

____1. The tentacles are exemplified by ____.

____2. Organs used to exchange O_2 and CO_2 are shown as ____.

____3. A tentacle is exemplified by ____.

____4. An organ used to exchange O_2 and CO_2 are shown as ____.

____5. A defensive organ is located at ____.

____6. An offensive organ is located ____.

PART E: FISH FORM AND FUNCTION

Below are body sketches of fish and tooth types. Use the symbols in parenthesis to describe each fish in Table 3.

Light Sensitive	Activity	Food Type	Food Capture
Nocturnal (N)	Sitter (S)	Plant (P)	Probes for Food (PR)
Diurnal (D)	Swimmer (SW)	Animal (A)	Lures Food (L)
			Captures Food in Open Ocean (C)

Teeth

FISH 1

FISH 2

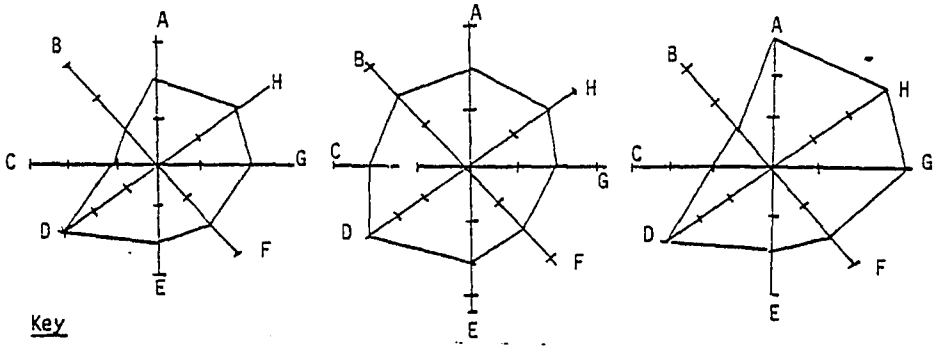
FISH 3

FISH 4

Table 3 Predicted Fish Description

	Light Sensivity	Food Type	Activity	Food Capture
FISH 1				
FISH 2				
FISH 3				
FISH 4				

PART F: FISHERIES MANAGEMENT



Key

A = Weight
B = Number rays in 1st dorsal fin
C = Number spines in 1st dorsal fin
D = Number scales lateral line
E = Fish & game constant
F = Caudal peduncle depth
G = Body depth
H = Total length

Fig. 4. Fish Polygraphs

Measurements have been taken on three (3) fish and put onto a polygraph. The information on all graphs is the same. The description of each measurement is shown on fish 1. Read the following statements. Place a (+) in the blank in front of correct statements and a (-) in front of all incorrect statements.

_____1. All three fish are probably of the same species because each has the same fish and game constant.

_____2. All three fish have the same number of scales on their lateral line.

_____3. Fish 1 and 2 are about the same size.

_____4. Fish 1 and 2 are probably the same species.

_____5. Body size is more important in determining fish species than any other factor.

_____6. Fish 1 and 3 could be of the same species.

_____7. If fish 1 and 3 are of the same species, fish 3 is older.

_____8. Fish 1 has more spines on its dorsal fin than fish 3.

APPENDIX B

PRELIMINARY ANALYSIS OF HMSS CONTENT MASTERY TEST SCORES

Table 10 Mean Pre- and Post-Workshop Scores on the HMSS Content Mastery Test for Teachers in the Massachusetts and Hawaii HMSS Workshop

Test	Number of Subjects	Mean (SD)	S.E.	Median	Mode	Kurtosis (Skewness)	Range (Min. to Max.)
A. Pre-Workshop Scores							
Massachusetts							
Subtest A. Physical Science	23	57.39 (14.71)	3.00	58.50	41	-0.57 (0.06)	57 (28 to 85)
Subtest B. Biological Science	24	72.03 (13.73)	2.80	75.0	77	-0.44 (-0.43)	53 (43 to 96)
Hawaii							
Subtest A. Physical Science	19	63.51 (14.05)	3.22	64.29	61	-0.29 (0.06)	53 (39 to 92)
Subtest B. Biological Science	20	71.35 (14.69)	3.28	73.51	60	-0.41 (-0.72)	50 (39 to 89)
B. Post-Workshop Scores							
Massachusetts							
Subtest A. Physical Science	23	68.26 (16.65)	3.47	65.75	63	-0.33 (-0.03)	65 (32 to 67)
Subtest B. Biological Science	23	83.74 (11.39)	2.37	84.00	83	0.34 (0.73)	42 (58 to 100)
Hawaii							
Subtest A. Physical Science	18	68.56 (14.21)	3.35	66.50	55	-0.41 (0.35)	52 (44 to 96)
Subtest B. Biological Science	20	79.93 (13.55)	3.03	79.50	93	-1.09 (-0.53)	41 (54 to 95)

Table 11 T-Test Comparison of Pre-Workshop and Post-Workshop Scores on the HMSS Content Mastery Test for Teachers in the Massachusetts and Hawaii HMSS Workshops

Test	Number of Subjects	Mean Score	S.D.	(Standard Error)	Pooled Variance Estimate T-Value	D.F.	Probability (One-tailed)
A. Massachusetts Workshop							
Subtest A. Physical Science Content							
Pre-Workshop Score	23	57.39	14.78	(3.08)	-5.48	22	0.000 ***
Post-Workshop Score		68.26	16.65	(3.47)			
Subtest B. Biological Science Content							
Pre-Workshop Score	23	73.08	13.11	(2.73)	-4.38	22	0.000 ***
Post-Workshop Score		83.74	11.39	(2.37)			
B. Hawaii Workshop							
Subtest A. Physical Science Content							
Pre-Workshop Score	18	63.11	14.34	(3.38)	-2.21	17	0.022*
Post-Workshop Score		68.55	14.21	(3.35)			
Subtest B. Biological Science Content							
Pre-Workshop Score	19	71.42	15.08	(3.46)	-3.25	18	0.002*
Post-Workshop Score		80.89	13.15	(3.02)			

*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 12 T-Test Comparison of Scores Between the Massachusetts and Hawaii HMSS Workshops

Test Site	Number of Subjects	Mean Score	S.D.	T-Value	Pooled Variance Estimate D.F.	Pooled Variance Estimate Probability (Two-tailed)
A. Pre-Workshop Scores						
Subtest A. Physical Science Content						
Massachusetts	23	57.39	14.78	-1.37	40	0.179
Hawaii	19	63.53	14.05			
Subtest B. Biological Science Content						
Massachusetts	24	72.08	13.7	0.17	42	0.865
Hawaii	20	71.35	14.7			
B. Post-Workshop Scores						
Subtest A. Physical Science Content						
Massachusetts	23	68.26	16.65	-0.06	39	0.953
Hawaii	18	68.56	14.21			
Subtest B. Biological Science Content						
Massachusetts	23	83.74	11.39	1.01	41	0.319
Hawaii	20	79.90	13.55			

Table 13 Mean Scores for the Combined Population Arranged by Years of Teaching Experience[a] and by Disciplinary Background on "Subtest A. Physical Science"

Years of Classroom Teaching Experience	Disciplinary Background: Physical Science (No. Teachers)	Biological Science (No. Teachers)	Nonscience Disciplines (No. Teachers)	(Row Totals)
A. Pre-Workshop Scores[b]				
0-6 years	64.00 (N=1)	55.20 (N=5)	46.60 (N=5)	52.09 (N=11)
7-10 years	74.17 (N=6)	54.00 (N=4)	63.50 (N=4)	65.36 (N=14)
More than 10 years	59.71 (N=7)	67.14 (N=7)	50.33 (N=3)	61.12 (N=17)
(Column Totals)	66.21 (N=14)	60.13 (N=16)	53.17 (N=12)	
B. Post-Workshop Scores[c]				(Row Totals)
0 to 6 years	90.00 (N=1)	63.60 (N=5)	49.80 (N=5)	59.73 (N=11)
7 to 10 years	77.33 (N=61)	60.75 (N=4)	76.00 (N=4)	72.21 (N=14)
More than 10 years	71.86 (N=71)	75.50 (N=6)	60.00 (N=3)	71.00 (N=16)
(Column Totals)	75.50 (N=14)	67.60 (N=15)	61.08 (N=12)	

[a] Grand mean for total years teaching experience is 9.8 years.

[b] Grand mean for pre-workshop scores on Subtest A is 60.17 (N = 42).

[c] Grand mean for post-workshop scores on Subtest A is 68.39 (N = 41).

Table 14 Mean Scores for the Combined Population Arranged by Teaching Experience[a] and by Disciplinary Background on "Subtest B. Biological Science"

Years of Classroom Teaching Experience	Disciplinary Background: Physical Science (No. Teachers)	Biological Science (No. Teachers)	Nonscience Disciplines (No. Teachers)	(Row Totals)
A. Pre-Workshop Scores[b]				
0-6 years	90.00 (N=1)	76.33 (N=6)	52.40 (N=5)	67.50 (N=12)
7-10 years	82.00 (N=6)	69.80 (N=5)	59.25 (N=4)	71.87 (N=15)
More than 10 years	72.50 (N=6)	81.88 (N=8)	59.67 (N=3)	74.65 (N=17)
(Column Totals)	78.23 (N=13)	76.95 (N=19)	56.50 (N=12)	
B. Post-Workshop Scores[c]				(Row Totals)
0 to 6 years	84.00 (N=1)	86.80 (N=5)	60.50 (N=4)	76.00 (N=10)
7 to 10 years	82.00 (N=6)	85.80 (N=5)	81.75 (N=4)	83.20 (N=15)
More than 10 years	81.86 (N=7)	88.83 (N=8)	78.00 (N=3)	84.22 (N=18)
(Column Totals)	82.07 (N=14)	87.33 (N=19)	73.00 (N=11)	

[a] Grand mean for total years teaching experience is 9.8 years.

[b] Grand mean for pre-workshop scores on Subtest B is 71.75 (N = 44).

[c] Grand mean for post-workshop scores on Subtest B is 81.95 (N = 43).

Table 15 Mean Scores for the Combined Population Arranged by Highest Degree in Science on "Subtest A. Physical Science"

Highest Level of Study	Number of Subjects	Mean[a]	S.D.	(Standard Error)	Min/Max	95% Confidence Interval for Mean
A. Pre-workshop Score Groups						
Nonscience Bachelor's Degree	9	57.22	17.58	5.86	28/84	43.7 to 70.7
Science Bachelor's Degree	18	60.67	13.35	3.15	41/92	54.0 to 67.3
Master's Degree	10	57.70	12.09	3.82	41/72	49.1 to 66.4
Master's Degree + 45 credits	5	68.60	18.96	8.48	39/85	45.0 to 99.2
Total	42	60.17	14.61	2.25	28/92	55.6 to 64.7
B. Post-workshop Score Groups						
Nonscience Bachelor's Degree	9	66.89	16.65	5.55	48/97	54.1 to 79.7
Science Bachelor's Degree	17	69.06	17.58	4.26	32/96	60.0 to 78.1
Master's Degree	10	67.70	11.08	3.50	50/82	59.8 to 75.6
Master's Degree + 45 credits	5	70.20	17.43	7.79	55/97	48.6 to 91.8
Total	41	68.39	15.44	2.41	32/97	63.5 to 73.3

[a]Median scores were not computed in the SPSS (Statistical Package for the Social Science) program used to compute this data.

Table 16 Mean Score for the Combined Population Arranged by Highest Degree In Science on "Subtest B. Biological Science" Content

Highest Level of Study	Number of Subjects	Mean[a]	S.D.	(Standard Error)	Min/Max	95% Confidence Interval for Mean
A. Pre-workshop Score Groups						
Nonscience Bachelor's Degree	9	58.89	13.76	4.59	39/77	48.3 to 69.5
Science Bachelor's Degree	20	75.35	14.17	3.17	49/96	68.7 to 82.0
Master's Degree	10	73.10	10.62	3.36	53/89	65.5 to 80.7
Master's Degree + 45 credits	5	77.80	6.10	2.73	71/85	70.2 to 85.4
Total	44	71.75	14.01	2.11	39/96	67.5 to 76.0
B. Post-workshop Score Groups						
Nonscience Bachelor's Degree	9	74.33	17.18	5.73	54/100	61.1 to 87.5
Science Bachelor's Degree	19	84.89	10.77	2.47	61/98	79.7 to 90.1
Master's Degree	10	81.50	10.56	3.34	58/95	73.9 to 89.1
Master's Degree + 45 credits	5	85.40	8.65	3.87	71/93	74.7 to 85.8
Total	43	81.95	12.44	1.90	54/100	78.1 to 85.8

[a]Median scores were not computed in the SPSS (Statistical Package for the Social Science) program used to compute this data.

Table 17 Mean Scores for Combined Population Arranged by Prior Marine Experience and by Sex of Teacher on "Subtest A. Physical Science"

Marine-Related Training and Experience	Sex of Teacher: Female (No. of Females)	Sex of Teacher: Male (No. of Males)	(Row Total)
A. Pre-Workshop Scores[a]			
None to little experience	52.27 (N=15)	59.00 (N=4)	53.68 (N=19)
Moderate to advanced experience	68.75 (N=8)	63.80 (N=15)	65.52 (N=23)
(Column Total)	58.00 (N=23)	62.79 (N=19)	
B. Post-Workshop Scores[b]			(Row Total)
None to little experience	62.21 (N=14)	68.00 (N=4)	63.50 (N=18)
Moderate to advanced experience	75.63 (N=8)	70.40 (N=15)	72.22 (N=23)
(Column Total)	67.09 (N=22)	69.89 (N=19)	

[a] Grand mean for pre-workshop scores on Subtest A is 60.17 (N = 42).

[b] Grand mean for post-workshop scores on Subtest A is 68.39 (N = 41).

Table 18 Mean Scores for the Combined Population Arranged by Level of Prior Marine Experience and by Sex of Teacher on "Subtest B. Biological Science"

Marine-Related Training and Experience	Sex of Teacher: Female (No. of Females)	Sex of Teacher: Male (No. of Males)	(Row Total)
A. Pre-Workshop Scores[a]			
None to little experience	67.47 (N=15)	62.25 (N=4)	66.37 (N=19)
Moderate to advanced experience	75.50 (N=8)	76.00 (N=17)	75.84 (N=25)
(Column Total)	70.26 (N=23)	73.38 (N=21)	
B. Post-Workshop Scores[b]			
Little Experience	80.07 (N=15)	72.25 (N=4)	78.42 (N=19)
Moderate experience	88.13 (N=8)	83.06 (N=16)	84.75 (N=24)
(Column Total)	82.87 (N=23)	80.90 (N=20)	

[a] Grand mean for pre-workshop scores on Subtest B is 71.75 (N = 44).

[b] Grand mean for post-workshop scores on Subtest B is 81.95 (N = 43).

Table 19 Mean Scores for the Combined Population Arranged by Age of Teachers on "Subtest A. Physical Science"

Age of Teachers in Years	Number of Subjects	Mean	S.D.	(Standard Error)	Min/Max	95% Confidence Interval for Mean
A. Pre-Workshop Score Groups						
Under 25	4	51.00	9.42	4.71	42/64	36.0 to 66.0
26 to 35	17	62.82	14.77	3.58	39/42	55.2 to 70.4
36 to 45	14	59.78	13.28	3.54	41/85	52.1 to 67.5
46 to 55	7	59.71	19.35	7.31	28/84	41.8 to 76.6
Total	42	60.17	14.61	2.25	28/92	55.6 to 64.7
B. Post-Workshop Score Groups						
Under 25	4	58.75	24.10	12.05	32/90	24.4 to 97.1
26 to 35	16	69.56	14.79	3.70	44/96	61.7 to 77.4
36 to 45	14	66.71	13.29	3.55	50/97	59.0 to 74.4
46 to 55	7	74.57	15.85	5.99	48/97	59.9 to 89.2
Total	41	68.39	15.44	2.41	32/97	63.5 to 73.3

Median scores were not computed in the SPSS (Statistical Package for the Social Science) program used to compute this data.

Table 20 Mean Scores for the Combined Population Arranged by Age of Teachers on "Subtest B. Biological Science"

Age of Teachers in Years	Number of Subjects	Mean[a]	S.D.	(Standard Error)	Min/Max	95% Confidence Interval for Mean
A. Pre-workshop Score Groups						
Under 25	4	62.75	18.48	9.24	49/90	33.3 to 92.2
26 to 35	19	72.84	14.83	3.40	39/89	65.7 to 81.0
36 to 45	14	74.57	9.41	2.51	59/89	69.1 to 80.0
46 to 55	7	68.28	17.16	6.49	43/96	52.4 to 84.2
Total	44	71.75	14.01	2.11	39/96	67.5 to 76.0
B. Post-workshop Score Groups						
Under 25	3	74.00	14.80	8.54	57/84	37.2 to 110.8
26 to 35	18	83.77	12.28	2.90	54/98	77.7 to 89.9
36 to 45	15	81.73	12.41	3.20	58/100	74.9 to 88.6
46 to 55	7	81.14	13.46	5.09	59/98	68.7 to 93.6
Total	43	81.95	12.44	1.90	54/100	78.1 to 85.8

[a] Median scores were not computed in the SPSS (Statistical Package for the Social Science) program used to compute this data.

APPENDIX C

COMPARISON OF TEACHER CHARACTERISTICS BETWEEN WORKSHOP GROUPS

Table 21 Comparison of the Disciplinary Background of Teachers in the Massachusetts and Hawaii HMSS Workshops

Count Row Pct Col Pct Tot Pct	Workshop Site Massachusetts	Hawaii	Row Total
Disciplinary Background			
Physical Science Background	7 50.0% 29.2% 14.9%	7 50.0% 30.4% 14.9%	14 29.8%
Biological Science Background	9 45.0% 37.5% 19.1%	11 55.0% 47.8% 23.4%	20 42.6%
Background	8 61.5% 33.3% 17.0%	5 38.5% 21.7% 10.6%	13 27.7%
Column Total	24 51.1%	23 48.9%	47 100%

Additional Statistics

Chi-square = .871 DF = 2

p = .647 MV = 0

Table 22A Comparison of Highest Degree Earned by Teachers in the Massachusetts and Hawaii HMSS Workshops

Count Row Pct Col Pct Tot Pct	Workshop Site Mass.	 Hawaii	Row Total
Bachelor's degree	7 36.8% 29.2% 14.9%	12 63.2% 52.2% 25.5%	19 40.4%
Master's degree	15 68.2% 62.5% 31.9%	7 31.8% 30.4% 14.9%	22 46.8%
Master's plus 45 or more credits	2 33.3% 8.3% 4.3%	4 66.7% 17.4% 8.5%	6 12.8%
Column Total	24 51.1%	23 48.9%	47 100%

Additional Statistics

Cell frequency too low for chi-square analysis.

Table 22B Comparison of Highest Degree Earned by Teachers in the Massachusetts and Hawaii Workshops

Count Row Pct Col Pct Tot Pct	Workshop Site Mass.	 Hawaii	Row Total
Bachelor's degree, (Nonscience)	5 50.0% 20.8% 10.6%	5 50.0% 21.7% 10.6%	10 21.3%
Bachelor's degree, major or minor in Science	10 47.6% 41.7% 21.3%	11 52.4% 47.8% 23.4%	21 44.7%
Master's degree in Science or Science Education	7 63.6% 29.2% 14.9%	4 36.4% 17.4% 8.5%	11 23.4%
Master's degree + 45 credits or more in Science	2 40.0% 8.3% 4.3%	3 60.0% 13.0% 6.4%	5 10.6%
Column Total	24 51.1%	23 48.9%	47 100%

Additional Statistics

Cell frequency too low for chi-square analysis

Table 23 T-Test Comparison of the Mean Years of Teaching Experience Between Groups of Teachers in the Massachusetts and Hawaii HMSS Workshops

Variables Associated with Classroom Teaching Experience	Number of Subjects	Mean Teaching Exper. (Yrs)	S.D.	Pooled Variance Estimate T Value	D.F.	Probability (Two-tailed)
A. Total Years Teaching Experience (All Areas)[a]						
Massachusetts	24	10.17	5.48	0.49	45	0.63
Hawaii	23	9.35	5.98			
B. (Estimated) Years Experience Teaching Marine Science Subjects[b]						
Massachusetts	24	2.84	0.58	1.10	39.4[c]	0.92
Hawaii	23	1.82	0.38			

[a] Grand mean for total years teaching experience is 9.8 years.

[b] F-value indicated that the variance about the means was significantly different at $p = .04$. Consequently a separate variance estimate was used instead of a pooled variance estimate for calculating the T-value.

[c] Data here is not exact because instruction given to teachers did not clearly indicate how to respond if they had taught one unit or one semester or some other block of time less than one year. It is believed that these values are therefore inflated. Consequently, Years Experience Teaching Marine Science Subjects was not used as a variable of the study.

Table 24 T-Test Comparison of Level of Prior Marine Experience Between Groups of Teachers in the Massachusetts and Hawaii HMSS Workshops

Variables Associated with Marine Training and Experience	Number of Subjects	Mean (credits)	S.D.	Pooled Variance Estimate T Value	D.F.	Probability (Two-tailed)
A. Level of Marine-Related[a] Experience (Research, Recreation, Nonschool Vocational)						
Massachusetts	24	(level) 0.792	1.06	-1.34	45	0.186
Hawaii	23	1.261	1.32			
B. Credits Acquired in Formal[b] Oceanography and Marine Science Courses						
Massachusetts	24	1.792	1.59	0.24	45	0.812
Hawaii	23	1.696	1.11			

[a] Level of Marine-Related Experience uses scale of (0) = none, (1) = little experience, (2) = moderate experience, (3) = advanced experience, and (4) = professional expert experience.

[b] Credits in marine science were not used as a variable in this study because of the low mean.

Table 25 Comparison of Sex of Teachers Participating in the Massachusetts and the Hawaii HMSS Workshops

Count Row Pct Col Pct Tot Pct	Workshop Site Massachusetts	Hawaii	Row Total
Sex			
Female	15 62.5% 62.5% 31.9%	9 37.5% 39.1% 19.1%	24 51.1%
Male	9 39.1% 37.5% 19.1%	14 60.9% 60.9% 29.8%	23 48.9%
Column Total	24 51.1%	23 48.9%	47 100%

Additional Statistics

Chi-square = 2.567 DF = 2 p = .190 MV = 0

Table 26 Comparison of Age of Teachers Participating in the Massachusetts and the Hawaii HMSS Workshops

Age (Years)

Count Row Pct Col Pct Tot Pct	Workshop Site Massachusetts	Hawaii	Row Total
Under 25	3 75.0% 12.5% 6.4%	1 25.0% 4.3% 2.1%	4 8.5%
26 to 35	7 33.3% 29.2% 14.9%	14 66.7% 60.9% 29.8%	21 44.7%
36 to 45	9 60.0% 37.5% 19.1%	6 40.0% 26.1% 12.8%	15 31.9%
46 to 55	5 71.4% 20.8% 10.6%	2 28.6% 8.7% 4.3%	7 14.9%
Column Total	24 51.1%	23 48.9%	

Additional Statistics

Cell frequency too low for chi-square analyses.

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