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ABSTRACT

The Institute in Physical Science was developed to address the need for updated information and training in physics, chemistry, and technology among teachers of physical science. Five major objectives addressed were to: (1) improve physical science teachers' understanding of fundamental concepts in physics and chemistry; (2) provide physical science teachers with training in the use of the essential elements to teach introductory physics and chemistry concepts included in the physical science course; (3) update teacher's knowledge of recent research findings in physics, chemistry, and science education; (4) inform teachers of the recent research development and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community; and (5) develop "Physical Science Factsheets" for teachers to use when teaching physical science. The report includes a description of the operation of the project and an evaluation of its effectiveness. Eleven teachers enrolled in the spring program, while 25 teachers were enrolled in the summer program. Courses included Concepts in Chemistry; Concepts in Physics; and Frontiers in Physical Science. Program evaluation data show the participants reported to have achieved, in their opinion, each of its four objectives. (MVL)

INSTITUTE IN PHYSICAL SCIENCE

A Category I Spring and Summer Inservice Program for
Secondary Teachers of Physical Science in the
Austin Metropolitan Community
Austin, Texas

Final Performance Report

Prepared by

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Submitted to the

Texas Higher Education Coordinating Board

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INTRODUCTION

The past four years are best described as a period of research, recommendation, and reform regarding precollege education. More than ?00 local, state, and national task forces have studied the schooling process and issued reports criticizing the state of precollege education. Particularly hard hit have been precollege programs in science and mathematics. That achievement in these subjects has undergone a sharp decline in the past 20 years has been well documented at local, state, and national levels. Although the complexity of the problem is widely acknowledged, the finger of blame has come to rest all too often on the declining quality of teachers. Academically talented teachers are seldom attracted to teaching, the reports show, and those who do become teachers are among the first to leave the profession. Moreover, studies of elementary and secondary curricula have shown that too many students study too little science. This finding has led many states to increase the time spent on science instruction in the elementary schools and raise the requirements in science for high school graduation. Increased graduation requirements along with more stringent course expectations for students have exacerbated the problem of the declining quality of science teachers.

The crisis in science education in Texas mirrors that of the nation. In its report titled Study of the Availability of Teachers for Texas Public Schools (1984), the Texas Education Agency documented the extent of the teacher supply/demand crisis in secondary science education. For several years teachers certified to teach science have been among the greatest in demand yet shortest in supply. For example, the applications to openings ratio for science teachers at the beginning of the 1983-84 school year was next to the lowest, exceeded only by mathematics. The shortage of applicants to fill teaching vacancies in science in the 1983-84 school year resulted in the hiring of 1 out of 5 teachers who were less than qualified to teach science.

Schools and school districts have been placed in a bind. Increased course and graduation requirements in science necessitate the hiring of more and better qualified science teachers. Unable to find qualified or certified science teachers some school districts have resorted to "making do in the classroom". In their report titled "Making Do in the Classroom: A Report on the Misassignment of Teachers"(1985), the Council for Basic Education and the American Federation of Teachers provided state by state documentation to show that assigning teachers to teach subjects for which they have little academic preparation is completely legal. Faced with the task of offering more sections of existing science courses, school districts have exercised their legal authority and have assigned teachers to teach science courses for which they have limited academic preparation. Unfortunately, only a few states maintain records to document the extent to which teachers are misassigned.

Out-of-field teaching can and does occur in Texas. A school district need only issue to any certified teacher an Emergency Permit (<12 semester hours preparation) or a Temporary Classroom Assignment Permit (≥12 semester hours preparation). No records are maintained by the Texas Education Agency as to the extent to which school districts issue either Emergency or Temporary Classroom Assignment Permits. The misassignment of teachers is legal and a common practice.

Improved instruction in traditional basic science skills will not prepare today's students to face the world of tomorrow. Changing world and national economies have made obsolete the learning of only basic vocabulary and minimal problem solving skills in science and mathematics. Low skilled industrial jobs, traditionally available in great numbers to high school graduates, long ago shifted from the United States to Japan and more recently on to Korea Korean factory workers are well trained in the basic problem solving skills needed in science and mathematics, moreover they are willing to work long hours for low pay in the hope of improving their standard of living. The shift in technology and its invested capital to Japan and now on to Korea poses serious threats in the coming years to the high standard of living traditionally enjoyed by all Americans.

To protect and sustain the economic security and high standard of living traditionally enjoyed by all its citizens America's schools must graduate students who can reason and perform complex, non-routine tasks related to science and mathematics. People who are equipped to reason and think independently will be best prepared to function in, what has come to be called, a knowledge based economy, where the productivity of goods and services will be driven by highly advanced and sophisticated technology. To produce citizens of this high caliber the current educational system does not need to be repaired, in the words of the Carnegie Corporation's Task Force on Teaching as a Profession; instead "... it must be rebuilt to match the drastic change needed in our economy if we are to prepare our children for productive lives in the 21st century" (1986, p 14).

Mandates for dramatic improvement in the quality of pre-college science instruction require that improved continuing educational opportunities be made available to teachers of all science subjects, but particularly teachers of general education science courses which are taken most frequently by all students, regardless of ability or educational goals, to meet graduation requirements. Inservice programs must be provided for teachers to become acquainted with the rapid changes taking place in the subjects they teach, the interactions and mutually supportive roles played by science and technology, and the emerging issues in technology. Professional programs designed to accomplish these goals require collaboration among universities, business, and schools.

The Institute in Physical Science was developed to address the need for updated information and training in physics, chemistry, and technology among teachers of physical science throughout the Austin metropolitan community, particularly less than qualified teachers. The program was funded by the Texas Higher Education Coordinating Board for the Spring, Summer, and month of September, 1987. The project was conducted at the Science Education Center, University of Texas at Austin. Total expenditures for the project amounted to $28,884, 30% below the projected and approved budget total of $41,572. Five major objectives were addressed by the project:

1. To improve physical science teachers' understanding of fundamental concepts in physics and chemistry;
2. To provide physical science teachers with training in the use of the essential elements to teach introductory physics and chemistry concepts included in the physical science course;
3. To update teachers' knowledge of recent research findings in physics, chemistry, and science education;
4. To inform teachers of the recent research, development, and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community, and
5. To develop "Physical Science Factsheets" for teachers to use when teaching physical science.

The following sections of the report include a description of the operation of the Institute in Physical Science project and an evaluation of the project's effectiveness

PROJECT OPERATION

The operation of the Institute in Physical Science project is described in the following sections, which adhere to the approximate timeline for the project.

Planning and Recruiting

During the months of November and December, 1986, program plans were finalized, resource materials ordered, and experienced teachers of physical science recruited to enroll in the "Frontiers in Physical Science" course offered during the Spring Semester, 1987. Eleven experienced teachers of physical science were recruited for enrollment in the Frontiers course, representing the Austin, Del Valle, Pflugerville, and Round Rock Independent School Districts.

Concurrent with the Spring Program, plans were finalized for the Summer, 1987, Program Three courses were planned and scheduled—Concepts in Chemistry, Concepts in Physics, and Frontiers in Physical Science—and instructors were identified. With the unfortunate death of Dr John S. Trout, Associate Professor of Mathematics and Physical Science at St. Edward's University, a replacement instructor was identified for the "Concepts in Physics" course. Mr. Ted Zoch, Associate Professor of Natural Science at Concordia, was recommended to the Texas Higher Education Coordinating Board and approved to replace Dr. Trout as instructor of the "Concepts in Physics" course. Ms. Marianne Reese, Director of Secondary Instruction at the Del Valle ISD and instructor for Concepts in Chemistry course offered in the Summer Institute in Science, 1986, was recruited as instructor for the "Concepts in Chemistry" course.

Brochures were designed, reproduced, and mailed to key administrators in each of the nine public school districts and three private schools targeted to participate in the Institute in Physical Science (A copy of the brochure describing the Institute in Physical Science Program is included in Appendix A). Approximately 350 brochures were mailed—to key administrators, to the principal in each high school located in the twelve targeted, participating schools or school districts, and to teachers of physical science for whom addresses were on file. Principals were requested to distribute brochures to members of their science faculty who might be interested in attending the Summer Program.

Textbooks, laboratory equipment, and supplies were inventoried and replacements ordered Guest speakers were identified for the "Frontiers in Physical Science" course. Course schedules and room assignments were completed. Funds for the Institute in Physical Science to replenish laboratory equipment and supplies ($750) was requested from and granted by Dr. Mario Benitez, Chairman of the Department of Curriculum and Instruction, University of Texas at Austin

Participant Selection and Notification

Experienced teac ~s of physical science completed an application form and submitted the transcripts required for enrollment in the University and participation in the Frontiers in Physical Science course. Eleven teachers, all certified, were enrolled in the Frontiers course. Ten teachers held secondary teaching certificates and one teacher held elementary certification

Persons interested in participating in the Institute in Physical Science completed an application form included with the brochure and returned it to the Project Director. A total of 26 application forms were completed and returned. During the last week of April participants were selected. The following criteria were used to select participants

1. Applicants holding non-science certification assigned to teach one or more classes of physical science.
2. Applicants holding science certification but lacking preparation in physics, chemistry, and/or physical science and were assigned to teach one or more classes of physical science.

3. Applicants holding certification or endorsement in physical science who were assigned to teach physical science but who wanted to update their content knowledge and teaching skills in physical science.
4. Applicants newly certified to teach science who wanted to improve their content knowledge and teaching skills in physical science.

To be considered for participation in the Institute in Physical Science applicants were required to submit along with the completed application a letter from a school administrator or district official supporting the applicant's participation in the Institute in Physical Science and granting permission for the applicant to lead a workshop for other physical science teachers in the district/school during the start of the school year, 1987-88. Acceptance letters were mailed to 26 applicants, along with a University registration form.

Participant Characteristics

Eleven experienced teachers of physical science enrolled in the Frontiers in Physical Science course offered in the Spring, 1987. Tuition, fees, textbooks, and supplies were paid for the 11 teachers using funds provided by an EESA, Title II grant awarded by the Texas Higher Education Coordinating Board. All teachers held secondary teaching certificates. Six teachers held single subject field certificates, and five held composite science certification (Sci Comp). Of the teachers holding single subject certificates (SS), two were certified in non-science fields (Non-Sci), one was certified in science (SS-Sci) but not physical science, and three were certified in physical science (SS-PS). All but one teacher were teaching one or more physical science (P Sci) classes while enrolled in the Frontiers course. Ten teachers were teaching a total of thirty-nine (39) classes of physical science; five teachers each taught five physical science classes. Seven teachers taught in high schools located in the Austin ISD (City), and four teachers taught in high schools located in suburban Austin (Suburb). The entry characteristics of teachers enrolled in the Frontiers in Physical Science course during the Spring, 1987, are found in Table 1.

Table 1
Entry Characteristics of Spring Participants (#)

Certification Type				Teaching Assignment		# Phys Sci Classes					School Location	
Non-Sci	SS-Sci	SS-PS	Sci Comp	Sci	P Sci	1	2	3	4	5	City	Suburb
2	1	3	5	1	10	1	1	1	2	5	7	4

A total of 25 teachers were enrolled in the Institute in Physical Science, Summer Program. Tuition, fees, textbooks, and supplies were paid for the 25 teachers attending the institute using funds provided by an EESA, Title II grant awarded by the Texas Higher Education Coordinating Board. Of the 25 teachers enrolled in the Institute, 19 held secondary teaching certificates, 5 held elementary certificates, and 1 was completing a certification program while teaching. The elementary teachers (5) were endorsed to teach all subjects taught in the elementary grades. Four secondary held single subject, non-science certificates; six held single subject, science certificates (but not physical science); and four held single subject, physical science certificates. Five teachers were certified as composite science. Data on the level and type of certification held by participants are found in Table 2.

Table 2
Entry Characteristics of Summer Participants
Level and Type of Teaching Certificate

Level of Certificate			Type of Certificate					
Non-Cert	Elem	Sec	All Sub	Non-Sci	SS-Sci	SS-PS	Comp Sci	None
1	5	19	5	4	6	4	5	1

Four participants had not taught during the year prior to attending the Institute in Physical Science, Summer Program. Twenty-one teachers taught science during the 1986-87 school year Of those teaching science, fourteen teachers taught one or more classes of physical science, and seven teachers taught science classes but not physical science. The fourteen physical science teachers taught a total of forty-two classes, with most teachers teaching three sections. Institute participants represented city (6 teachers), suburban (11 teachers), rural (5), and private (1) schools. Data on teaching assignments and school location are presented in Table 3.

Table 3
Entry Characteristics of Summer Participants
Teaching Assignments and School Location

Teaching Assignment				# Classes Taught					School Location			
None	Non-Sci	Sci	P Sci	1	2	3	4	5	City	Suburb	Rural	Private
4	0	7	14	1	4	5	2	2	6	11	5	1

Three courses were offered to teachers attending the Institute in Physical Science, Summer, 1987. Sixteen teachers were enrolled in "Concepts in Chemistry", seventeen in the "Concepts in Physics", and fifteen in "Frontiers in Physical Science". Nine teachers were enrolled in one course only, nine teachers in two courses, and seven teachers in all three courses. The greatest number of teachers were enrolled in all three courses (n=7, 28%). Table 4 contains enrollment preferences for the Chemistry (Chm), Physics (Phy), and Frontiers (Front) courses.

Table 4
Enrollment Preference

	Chm	Phy	Front	Chm+Phy	Chm+Front	Phy+Front	Chm+Phy+Front
Count	3	3	3	4	2	3	7
%	12	12	12	16	8	12	28

Spring and summer participants in the Institute in Physical Science varied greatly in their teaching experience. Among experienced physical science teachers enrolled in the Spring program, one teacher had completed only one year of teaching; another teacher had completed 33 years. All totalled, 11 experienced teachers accounted for 132 years of classroom teaching, for an average tenure in the classroom of 12 years. Summer participants varied in teaching experience from 0 to 16 years. The 25 summer teachers accounted for a total of 129 years in the classroom, for an average of 5.16 years of teaching experience. Table 5 contains descriptive data concerning the teaching experience of spring and summer participants.

Table 5
Teaching Experience of Spring and Summer Participants

Group	Count	Minimum	Maximum	Total	Average	Deviation
Spring	11	1	33	132	12.00	10.60
Summer	25	0	16	129	5.16	5.01

Teachers enrolled in the Summer Program were asked their major reason(s) for attending the Institute in Physical Science. Although teachers were free to check more than one reason, most teachers attended the Institute in Physical Science to improve the methods they use to teach physical science (26.5%) and to obtain instructional materials (25.0). Additional reasons cited included "interest in physical science" (16.2%), "other" (14.7%), to complete "certification requirements" (10.3%), and to obtain "physical science endorsement" (7.4%). Teachers enrolled in the physics and frontiers courses more frequently cited "improve physical science teaching methods" (25.0% and 23.2%, respectively) as a reason for attending the Institute in Physical Science than did teachers enrolled in the chemistry course (6.7%). Table 6 contains data on the reasons offered by teachers for attending the Institute in Physical Science.

Table 6
Reasons Cited for Attendance (%)

	Courses			
Reasons	Chm	Phy	Front	Average
Certification Requirements	6.7	10.4	10.7	10.3
Physical Science Endorsement	6.7	8.3	7.1	7.4
Interest in Physical Science	15.6	16.7	10.7	16.2
Obtain Instructional Materials	24.4	22.9	21.4	25.0
Improve Physical Science Teaching Methods	6.7	25.0	23.2	26.5
Other	20.0	16.7	8.9	14.7

Few teachers attending the Institute in Physical Science, Summer Program, had ever participated in an extended inservice program designed specifically for teachers of physical science. Only 3 out of 16 teachers enrolled in the Chemistry course had prior inservice experience, as had but 3 out of 18 teachers enrolled in the Physics course and 4 out of 15 teachers enrolled in the Frontiers course. Teachers enrolled in Chemistry had more recently participated in a summer inservice program for physical science teachers (3.3 years ago) than had teachers enrolled in either the Frontiers (4.5 years ago) or Physics (5.4 years ago) courses. Financial aid was provided for the three teachers enrolled in Chemistry to attend a past institute. Two of three teachers enrolled in Physics and two of four teachers enrolled in Frontiers courses had also received financial in the past to attend a summer program designed specifically for teachers of physical science. Table 7 contains data on participants' record of attendance at a physical science teacher institute prior to attending the Institute in Physical Science.

Table 7
Prior Attendance at a Teacher Institute

	Courses		
Attendance	Chemistry	Physics	Frontiers
No	13	15	11
Yes	3	3	4
Last Attended (yrs)			
Range	1-10	1-10	1-10
Average	3.3	5.4	4.5
Financial Support			
Yes	3	2	2
No	0	1	2

Teachers expressed many needs prior to attending the Summer Program of the Institute in Physical Science. Regardless of the course in which they were enrolled, teachers reported that they would like but receive little or no assistance in their district in learning new teaching methods, stimulating critical thinking, acquiring instructional materials, getting science career information, and illustrating technical applications of concepts taught in physical science. The need for information on technical applications was expressed by most teachers enrolled in the Institute in Physical Science. By contrast, few teachers indicated they need help maintaining discipline, planning small group work, or establishing instructional objectives. Table 8 contains information about the needs of the teachers prior to attending the Institute in Physical Science

Program Operation

The Institute in Physical Science consisted of a Spring, 1987, Program offered to experienced physical science teachers and a Summer, 1987, Program offered to less experienced physical science teachers in each of the targeted, participating schools/districts. The operation of each program is described separately in the sections that follow.

Spring Program. The Institute in Physical Science Program began in the Spring, 1987, with the enrollment of eleven experienced physical science teachers in the Frontiers in Physical Science course. The eleven teachers represented the Austin (7), Round Rock (2), Del Valle (1), and Pflugerville (1) Independent School Districts. Teachers met each Monday evening, 4:30 to 7:00 pm. Presentations were made to teachers by representatives of the University and business community—three University researchers each from the departments of Physics and Chemistry and six representatives of the Austin-area "nigh-tech" comm~~ity.

Each teacher selected one of the twelve topics from which to develop instructional materials suitable for use in the teaching of high school physical science. Instructional materials were developed to include content, activities/investigation, evaluation, and careers sections.

Teachers prepared and submitted instructional materials for all topics except three, Physics of Pollution, Fabricating a Semiconductor Capacitor, and Fluid Dynamics: Transitions to Turbulence. These presentations were either inappropriate for use in physical science classrooms or were presented too late in the semester to permit development of lessons. Nine packets of

Table 8
Needs of Teachers Prior to Attending Institute in Physical Science

	Courses								
	Chemistry			Physics			Frontiers		
	1	2	3	1	2	3	1	2	3
Establishing Objectives	11	3	2	12	3	3	8	3	4
Planning Lessons	11	5	0	15	3	0	12	2	1
Learning New Teaching Methods	1	10	5	2	9	7	1	6	8
Teaching Lessons	10	5	1	13	3	2	13	2	0
Developing Tests	9	6	1	12	5	1	11	3	1
Stimulating Critical Thinking	3	10	3	5	7	5	4	8	3
Acquiring Instructional Materials	0	9	7	1	9	8	1	6	8
Obtaining Subject Information	6	4	6	8	3	7	5	3	7
Implementing Discovery/Inquiry	7	7	2	8	6	4	6	7	2
Using Hands-On Materials	7	6	2	8	5	4	7	4	4
Getting Science Career Information	6	9	1	8	10	0	6	8	1
Illustrating Technical Applications	1	14	1	4	13	1	3	10	2
Locating Equipment/Materials	3	9	4	2	10	6	4	6	5
Maintaining Equipment	7	7	2	7	7	4	8	5	2
Planning Small Group Work	12	3	1	13	4	1	14	0	1
Maintaining Discipline	12	4	0	15	2	1	11	3	1
Articulating Instruction Across Grades	8	8	0	10	8	0	7	7	1
Stimulating Interest in Physical Science	7	7	2	9	6	3	6	8	1

Note: 1 = Usually do not need assistance
2 = Would like assistance but receive little or none
3 = Would like assistance and receive adequate assistance

materials were prepared, revised during the month of May, and printed for use and revision by teachers attending the Institute in Physical Science, Summer Program. Topics presented to teachers enrolled in the Frontiers in Physical Science course during the Spring, 1987, semester include:

1. Surface Catalysis (Chemistry)
2. Protein Crystallography (Chemistry)
3. Photo-Electro Chemistry: Solar Energy Converters (Chemistry)
4. Surface Mount Technology: A Perspective (IBM)
5. Remotely Piloted Vehicle: Science NOT Technology (Lockheed, Austin)
6. Propagation of Sound in the Sea (Tracor)
7. Physics of Pollution (Physics)
8. Product Planning at AMD (Advanced Micro Devices)
9. Scanning/Tunneling Microscopy (Physics)
10. Composite Structures to Solve An Electronics Interconnection Problem (Texas Instruments)

11. Fabricating a Semiconductor Capacitor (Motorola)
12. Fluid Dynamics: Transitions to Turbulence (Physics)

Summer Program. The Summer Program began with a Welcoming Banquet, held in the College of Education on Sunday evening, June 7, 1987, from 4:00 - 6:30 pm. Participants registered, obtained name tags, and became acquainted with one another. At 4:30 pm participants were welcomed by the Project Director, Dr. Frank E. Crawley, and introduced to faculty and staff Next, a brief overview was given of the characteristics of the teachers attending the Summer Program, of the day-to-day operation of the program, and of problems concerning parking on campus. Brief meetings were held with each of the three course instructors, during which time participants were told about the course and given a course outline and textbooks. Teachers were also taken on a tour of the Science Education Center and shown the rooms in which they would be meeting for each course. Following the tour participants, instructors, and project staff were treated to a catered dinner consisting of Texas barbecue provided by Bill Miller's Barbecue.

Classes met for five weeks, June 8-July 10, 1987. Concepts in Chemistry and Concepts in Physics courses met Monday, Wednesday, and Friday from 8:30 to 11:30 am (Physics) and 1:30 to 4:30 pm (Chemistry). The Frontiers in Physical Science course met on Tuesday and Thursday, 8:30 am to 2:00 pm. Summer teachers who were enrolled in the Frontiers course attended presentations held in the laboratories of University chemists and physicists and at the facility of the representatives of Austin area "high-tech" manufacturers. Topics for presentations were revised for the summer offering of the Frontiers course, as a result of information received from spring participants and a scheduling problem that arose with one of the spring presenters. Participants heard presentations titled:

1. Surface Catalysis (Chemistry)
2. Protein Crystallography (Chemistry)
3. The Texas Tokamak (Physics)
4. Automated Manufacturing at IBM (IBM)
5. Scanning/Tunneling Microscopy (Physics)
6. Propagation of Sound in the Sea (Tracor)
7. Remotely Piloted Vehicle: Science NOT Technology (Lockheed, Austin)
8. Seed to Semiconductor (Motorola)
9. Composite Structures to Solve An Electronics Interconnection Problem (Texas Instruments)
10. Super Physics: Conductivity, Colliders, and Strings (Physics)
11. Neural Networks: A Model for the Storage and Retrieval of Information (Chemistry)
12. Semiconductor Wafer Fabrication (Advanced Micro Devices)

Teachers prepared and revised materials for each of the twelve topics presented in the Frontiers in Physical Science course. Instructional materials were not prepared for the Motorola presentation, since the topic was much the same as that made by the representative of Advanced Micro Devices, or for the topic "Super Physics: Conductivity, Colliders, and Strings". This topic was judged to be highly informative and enlightning but too theoretical for the design of meaningful activities/investigations to be included in the instructional materials made available to physical science students. By the end of the Summer Program, ten sets of materials (along with one additional set from the Spring Program) were revised and submitted for revision and typing

During the five week program the Research Assistant, Mr. George F. Spiegel, designed and produced a logo to use on a T-shirt for Institute in Physical Science participants. A sample T-shirt was prepared and put on display in the Science Education Center office. Approximately 35 orders were taken for T-shirts, at a cost of $8.00 each. T-shirts arrived and were distributed to

Tom's Tabooley. Dr. James P. Barufaldi, Director of the Science Education Center, was the guest speaker. Dr. Barufaldi's presentation focused on the physical science teachers' role in improving the outcomes of science instruction for all students, regardless of their career or educational goals. Upon completion of Dr. Barufaldi's presentation, the Project Director made several closing remarks, presentations, and announcements. Participants were reminded about the Teacher Workshops they had planned, prepared for, and were to present at the beginning of the Fall, 1987, semester to other teachers of physical science in their schools. The helpful assistance of course instructors and project staff was recognized and applauded. At the conclusion of the Closing Banquet, teachers were given a Certificate of Program Completion (designed by Mr. George F. Spiegel) and an Advanced Academic Training certificate issued by the Texas Education Agency.

PROJECT EVALUATION

During the last class meeting in each course participants completed five instruments designed to quantify the success of the Program. These instruments included the following:

1. Content Test - A test given at the beginning and end of the Concepts in Chemistry and Concepts in Physics courses and at the end of the Frontiers in Physical Science course to measure participants' gain in knowledge of the concepts presented in each course in which they were enrolled.
2. General Questionnaire - A questionnaire (2 pages, 6 items) developed to collect information about teachers' needs prior to attending the Summer Institute in Science and the extent to which their needs were met by the instructors of each course.
3. Program Evaluation - A Likert-type instrument (1 page, 19 items) developed to measure participants' attitudes concerning the general operation and requirements of the Institute.
4. Course/Instructor Evaluation - A modified version of the standard Course/Instructor Survey used throughout the University (1 page, 23 items) designed to provide instructors with information concerning the participants' evaluation of the effectiveness of the course and the instructor.
5. Activities and Investigations Questionnaire - A questionnaire (6 pages, 42 items) developed to measure the extent to which participants intend to use the activities and investigations produced in the courses in which they were enrolled, their attitude toward use of the instructional materials, and the social pressures on teachers to use the materials.

The resulting data collected using each of these instruments are presented in the following sections (A copy of each instrument, except the content tests, is included in the Appendices). The concluding section of the Final Performance Report addresses the question of project effectiveness, i.e., the extent to which the Institute in Physical Science accomplished its objectives.

Knowledge Gain

Instructors developed and administered a content test at the beginning and end of the course Test questions were developed to measure knowledge of each of the course's objectives. Instructors were free to develop any type of test, as long as the test questions were representative of the content to be covered and the objectives of the course.

teachers on Wednesday, July 8. It was agreed at this time that all participants, instructors, and staff would wear Institute in Physical Science T-shirts to the Closing Banquet.

On Friday, July 10, the Closing Banquet was held for participants in the Institute in Physical Science. The noonday luncheon meeting consisted of a soup, salad, and sandwich buffet catered by

Most teachers entered the Institute in Physical Science lacking background training or courses in the subjects they studied. This was particularly true of teachers registered for the Frontiers in Physical Science course, which included presentations by three distinguished University researchers in chemistry and three in physics about their most recent research accomplishments as well as presentations by representatives of six Austin area "high tech" firms about most recent product research and development activities related to physical science.

Pretests were administered during the first class meeting to teachers enrolled in the Concepts in Chemistry and the Concepts in Physics courses, but a pretest was not administered to teachers enrolled in the Frontiers in Physical Science course. Information included in the presentations was judged to be unfamiliar to teachers and was not contained in any of the textbooks included on the list of textbooks approved for local adoption by school districts throughout the State of Texas.

Pretest scores were lowest for participants enrolled in the Physics course. The content knowledge of teachers enrolled in the chemistry and physics courses increased significantly from pre- to posttest ($p \leq .05$). In addition to improved content knowledge, the variability among teachers' in their knowledge of physics was reduced between pre- and posttests. Teachers improved their understanding of chemistry from pre- to posttest, although instruction appears to have been differentially effective, as is evidenced by an increase in the standard deviation from beginning to end of course. On the average, teachers enrolled in the Frontiers in Physical Science course mastered better than 60% of the course content, consisting of recent research and development activities of University and "high tech" scientists. Table 9 contains the descriptive data for teachers enrolled in Physics, Chemistry, and Frontiers courses and results of correlated sample t tests for significance of the difference in teachers' pre/post knowledge of physics and chemistry.

Table 9
Tests of Teachers' Content Knowledge

		M		SD			
Course	n	Pre	Post	Pre	Post	t	p
Chemistry	16	63.31	75.44	11.95	14.75	3.39	.0041
Physics	18	52.44	73.88	15.82	10.40	6.92	.0001
Frontiers	15	—	62.53	—	10.76	—	—

Note. Maximum score range 0 to 100.

Teachers' Needs

Teachers entered the Institute in Physical Science, Summer Program, with many needs related to the teaching of physical science. What is obvious from teachers' responses is that they attended the Institute in Physical for renewal. Justification for this conclusion is based on the observation that all teachers, regardless of the course for which they were registered, wanted to learn new teaching methods, find out how to stimulate critical thinking among students, acquire instructional materials, obtain information about science careers, and gain ideas concerning technical applications of concepts taught in physical science. The need for information on technical applications was expressed by most teachers enrolled in the Institute in Physical Science. More traditional teacher needs were not expressed, e.g., how to maintain discipline, plan small group work, or establish instructional objectives.

At the end of each course teachers were asked to indicate which needs were adequately met by their instructor, using a General Questionnaire. The instructor of the chemistry course did a particularly effective job, as evidenced by teachers responses, in providing them with instructional materials, chemistry information, hands on teaching materials, science career information, and information on technical applications of chemistry concepts. Moreover, the chemistry instructor provided information about locating equipment/materials and stimulating student interest in physical science. Not provided to teachers, however, was information on how to stimulate critical thinking when teaching the introduction to chemistry course in physical science.

The instructor for the Concepts in Physics course was effective in several areas. Teachers noted that the instructor was particularly effective in helping them establish instructional objectives, learn new teaching methods, develop tests, and stimulate critical thinking. In addition, teachers indicated that the instructor had met their need for instructional materials, additional physics information, information on how to implement discovery/inquiry teaching methods, hands on materials, science career information, and ways to illustrate technical applications of physics concepts. Strengths were also noted in the area of locating equipment/materials and stimulating student interest in physical science. Needs not adequately met by the physics instructor included maintaining science equipment and appropriate student discipline.

The instructor of the Frontiers in Physical Science course was particularly effective in meeting specific needs of physical science teachers. Needs met by the instructor included establishing instructional objectives, acquiring instructional materials, obtaining additional subject matter information, getting hands on materials, identifying science career information, and learning of ways to illustrate technical applications of physical science concepts. In addition, teachers thought the instructor met their need to locate equipment/materials and stimulate student interest in physical science. Table 10 contains data on the extent to which teachers' needs were adequately met by the course instructors.

Program Evaluation

Participants were asked to indicate their feelings about returning to college and to evaluate specific features of the Institute in Physical Science. Generally speaking, teachers were not anxious about returning to school for additional training or about obtaining the training at the University of Texas at Austin. Participants expressed agreement that the Welcoming Banquet helped to clarify Institute expectations. The duration of the Institute and the time spent in class each day were acceptable to participants, although teachers enrolled in the Frontiers course were less certain about the length of time they spent in class. Teachers tended to strongly agree that the resource guides prepared in each course would be useful to them when teaching the following school year and that the textbooks and materials were well chosen for each course. Teacher-conducted workshops are an effective means for sharing activities and investigations with other teachers, according to Institute participants. There was strong agreement among teachers that they would use the course materials, activities, and investigations when teaching the following year. Teachers enrolled in the Frontiers in Physical Science course strongly agreed that they would use the materials developed in the course during the following school year.

There tended to be strong agreement among participants that the Institute in Physical Science Program had been successful. Teachers strongly agreed that the program was well organized and that staff members were helpful. Teachers enrolled in the Frontiers in Physical Science course registered strong agreement with the goals of the Frontiers course, namely to update teachers knowledge of recent research findings in chemistry, physics, and science education (Objective 3), to inform teachers of research and development activities in science and technology (Objective 4), and to develop materials suitable for use when teaching students about "frontiers in physical

Table 10
Instructors Attention to Needs of Participants

	Courses					
	Chemistry		Physics		Frontiers	
	Yes	No	Yes	No	Yes	No
Establishing Objectives	8	3	12	2	10	2
Planning Lessons	5	5	9	4	6	5
Learning New Teaching Methods	8	6	10	6	7	6
Teaching Lessons	4	5	7	5	3	6
Developing Tests	9	3	10	6	7	5
Stimulating Critical Thinking	5	10	10	7	9	5
Acquiring Instructional Materials	12	2	15	2	11	2
Obtaining Subject Information	13	1	16	1	13	0
Implementing Discovery/Inquiry	8	4	11	5	8	4
Using Hands-On Materials	13	0	16	1	11	2
Getting Science Career Information	15	0	15	2	14	0
Illustrating Technical Applications	12	2	13	2	13	0
Locating Equipment/Materials	10	4	12	5	13	1
Maintaining Equipment	6	7	4	11	4	9
Planning Small Group Work	5	6	6	8	4	8
Maintaining Discipline	2	9	3	10	0	13
Articulating Instruction Across Grades	4	5	5	8	6	6
Stimulating Interest in Physical Science	10	2	14	2	13	1

<u>Note</u>. Not all participants responded to all items, and some participants indicated a need was both met and not met.

science" (Objective 5). Furthermore, participants agreed that the Institute accomplished its five goals:

1. To improve physical science teachers' understanding of fundamental concepts in physics and chemistry;
2. To provide physical science teachers with training in the use of the essential elements to teach introductory physics and chemistry concepts included in the physical science course;
3. To update teachers' knowledge of recent research findings in physics, chemistry, and science education;
4. To inform teachers of the recent research, development, and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community; and
5. To develop "Physical Science Factsheets" for teachers to use when teaching physical science.

Overall, teachers strongly agreed that the Institute in Physical Science was a success, that they would encourage teachers to apply for the Institute Program to be held in the Summer, 1988, and that they would like their name to be added to the mailing list to be considered for future training programs held at the Science Education Center. Results of the program evaluation are found in Table 11.

Course/Instructor Evaluation

Participants in each course were asked to complete a Course/Instructor Evaluation, a modified version of the Course/Instructor Survey used by students throughout the University to evaluate courses and instructors. Only minor changes were made in the wording of items to be consistent with the nature of the courses offered in the Institute in Physical Science. On occasion an item was deleted when it was thought to be inappropriate for the three courses offered. Additional items were added to better address the purpose of the Institute courses.

Results of the Course/Instructor Evaluation were overwhelmingly favorable, although there were minor variations in opinion expressed by teachers about individual courses and instructors. Participants thought that instructors were well prepared, class time was well spent, they were free to ask questions, the instructor was intellectually stimulating, and the instructor revealed enthusiasm for teaching the course. In addition, activities and discussions clarified concepts taught in the three courses.

Tests appear to have met with mixed reactions from teachers enrolled in the three courses. Teachers enrolled in the Chemistry course thought test questions were clear and covered topics included in the chemistry course. There was less certain agreement among teachers in the Frontiers course concerning the clarity and appropriateness of test questions. Test questions in the physics course tended not to be clear and to cover topics not included in the course.

All participants, regardless of the course, thought that instructors were interested in making participants better physical science teachers. In addition, teachers believed that they had learned much information applicable to teaching physical science, that the texts and references were well chosen, and that class activities were appropriate to their needs. Furthermore, teachers found the course(s) to be interesting, enjoyed attending class, and believed that they would be satisfied with their final course grade. Teachers agreed that they would use the information gained in the courses when teaching physical science.

After participating in the Institute courses teachers expressed an increased interest in teaching physical science. The number of topics covered and the pace of the Physics and Frontiers courses needed to be reduced, according to teachers. Regardless of pace and topic coverage, teachers indicated that they would recommend the courses to other teachers interested in physical science and that they wanted their name included on a mailing list to be considered for future programs offered at the Science Education Center. The results of the Course/Instructor Evaluation are presented in Table 12.

Activities and Investigations Questionnaire

One of the major outcomes of the Institute in Physical Science was to provide teachers attending the program with activities and investigations covering the content of the course in which they were enrolled. Each of the activities and investigations stressed the development of one or more science concepts through active use of the essential elements. Instructors provided teachers enrolled in their course with written materials suitable for use with students they would be teaching at the start of the new school year. In the chemistry and physics courses the materials

Table 11
Participants' Evaluation of Institute in Physical Science

Item	Courses		
	Chemistry	Physics	Frontiers
Before attending the Institute in Physical Science, I was anxious about going back to school.	2.40	2.24	2.73
I was anxious about attending a summer program held at UT-Austin.	2.13	2.12	2.60
The Welcoming Banquet helped to clarify Institute expectations, procedures, and requirements.	4.00	4.00	3.93
Five weeks is an appropriate length of time for the Institute.	3.73	3.41	3.93
The length of time for each class meeting was acceptable			
- Three hours per class meeting for chemistry/physics	3.86	3.94	4.00
- Five and a half hours per class meeting for Frontiers in Physical Science	2.83	3.21	3.08
The resource guides assembled for chemistry/physics will be useful for teaching physical science.	4.20	4.47	4.40
The textbooks and materials used in each course were well chosen.	4.33	4.47	4.13
Teacher-conducted workshops are an effective means for spreading the word to other teachers about Institute activities/investigations.	4.13	4.12	4.20
I intend to use the course materials, activities, and investigations when teaching physical science.	4.27	4 41	4.60
The Institute in Physical Science was well organized.	4.40	4.47	4.40
Members of the Institute staff were helpful.	4.60	4.77	4 60
The Institute in Physical Science accomplished its goals:			
- to improve teachers' understanding of fundamental concepts in physical science	4.27	4.24	4.20
- to provide teachers with training in the use of the Essential Elements to teach introductory chemistry and physics concepts included in physical science.	3.93	4.00	3 87
- to update teachers' knowledge of recent research findings in chemistry, physics, and science education.	3.80	3.94	4 40
- to inform teachers of recent research, development, and manufacturing activities of major science and technology manufacturers located in the Austin metropolitan community.	3.86	4.12	4 60
- to develop materials suitable for use when teaching students about "frontiers in physical science".	3.79	3.82	4.27
Overall, the Institute in Physical Science was a success.	4.47	4.47	4.67
I will encourage teachers to apply for the Institute in Physical Science program to be held in 1988.	4.33	4.53	4.67
I would like my name to be added to the mailing list to be considered for future teacher training programs held at the Science Education Center.	4.92	4.93	4 92

Note: 1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

Table 12
Participants' Evaluation of Courses and Instructors

Item	Courses		
	Chemistry	Physics	Frontiers
The instructor was well prepared for class.	4.94	3.88	4.73
Class instruction was time well spent.	4.81	4.00	3.73
The instructor made me feel free to ask questions and express my ideas.	4.75	4.35	4.80
The instructor was intellectually stimulating.	4.75	4.18	4.53
The instructor revealed enthusiasm for teaching the course.	4.94	4.41	4.87
Activities and discussions clarified concepts for me.	4.44	3.65	3.53
The instructor gave adequate instructions for activities, investigations, and assignments.	4.44	3.82	3.73
Test questions were clear.	4.69	2.53	3.07
Tests questions covered topics included in the course.	4.88	2.71	3.07
The texts and references used in the course were appropriate.	4.56	4.47	3.80
Class activities were appropriate to my needs.	4.38	3.77	4.07
The instructor seemed interested in making me a better teacher of physical science.	4.88	4.18	4.60
I learned much material applicable to teaching physical science.	4.44	4.59	4.00
I will probably be satisfied with my grade in this course.	4.56	4.18	3.87
I found this course to be interesting.	4.81	4.24	4.73
I enjoyed attending class.	4.69	3.94	4.67
I will recommend this course to other teachers interested in a physical science course.	4.69	3.82	4.53
I will use the information covered in this course when I teach science.	4.44	4.35	4.07
This course has increased my interest in teaching physical science.	4.31	4.35	4.13
The pace of the course was about right.	4.25	2.77	3.14
The number of topics covered was sufficient.	4.50	3.47	3.27

Note. 1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

stressed investigative experiences and included the purpose, equipment, essential elements, and procedures to be followed for each activity/investigation and contained summary and extension questions. Instructional materials developed in the Frontiers in Physical Science course stressed new information supplemented with activities and investigations appropriate for use when introducing the materials. Information included recent research and development activities taking place in the Austin community, particularly among chemists and physicists at UT-Austin and among researchers in the six "high tech" manufacturers located in Austin. Although it would be impossible to visit each teacher during the following school year to see the instructional materials in use, information was sought regarding teachers' intention to use the activities and investigations with students during the new school year. Social psychology offers a theoretical basis for linking teachers' use of the instructional materials with their intention to do so, their attitude toward using the materials, and the social pressures that exist.

The Theory of Reasoned Action was developed by social psychologists to better understand and predict human behavior. Developed by Ajzen and Fishbein (1975) the theory has been found to be extremely successful in explaining diverse human behaviors such as drinking, dieting, choosing a career, planning a family, voting, and purchasing a product (1980). In education, the Theory of Reasoned Action has been used to gain information about the intent of grade 8 students to enroll in a high school science course (Coe, 1986). According to the theory, the best predictor of someone's behavior is the person's intention to perform the behavior. Intention to engage in a specific behavior has been shown to be determined by two variables, one personal and the other social. Attitude toward the behavior, the personal component, represents the extent to which a person believes that performing a behavior will lead to desirable consequences. Subjective norm, the social component, is a measure of the extent to which an individual believes that important "others" think the behavior should be performed. Intention, attitude, and subjective norm are the three variables, according to the Theory of Reasoned Action, needed to predict and understand behavior.

An Activities and Investigations Questionnaire was constructed following the method described by Ajzen and Fishbein (1980). During the last class meeting information was collected from teachers in each course concerning their intention to use 50% of the activities and investigations developed and used in the Institute courses, with the students they would teach during the following school year. In addition, teachers completed items that assessed their attitude toward the behavior (i.e., using 50% of the activities and investigations developed and used in the Institute in Physical Science courses with the students teachers would teach during the following school year). Also, teachers indicated whether most people important to them thought they should perform the behavior (i.e., use 50% of the activities and investigations developed and used in the Institute in Physical Science courses with the students they would teach during the following school year).

Intentions to perform the behavior, attitudes toward the behavior, and subjective norm data were obtained from each participant enrolled in each course [Note: Of the 25 participants 9 were enrolled in 1 course only, 9 were enrolled in 2 courses, and 7 were enrolled in all three courses]. Teachers' intentions to use the activities and investigations were quite similar, regardless of the course in which they were enrolled, although teachers enrolled in the Physics course reported slightly stronger intention scores than teachers enrolled in the Chemistry or Frontiers courses. The greatest variation in the group scores occurred on teachers' attitude toward use of the activities and investigations. Scores ranged from a low of 6.67 to a high of 8.81 (possible score range = -12 to 12). Subjective norm, the extent to which teachers perceived pressures from people important to them to use the activities and investigations, were somewhat higher for teachers enrolled in the Chemistry course. Table 13 contains descriptive data on intention, attitude, and subjective norm for participants enrolled in each of the three courses.

The means for the three outcomes (intention, attitude, and subjective norm) were analyzed separately for teachers enrolled in the Chemistry, Physics, and Frontiers courses, using analysis of variance techniques. No differences were found in the intention and subjective norm scores; differences in attitude attributable to the course in which teachers were enrolled approached but did not reach significance. Table 14 contains the results of significance tests

According to the Theory of Reasoned Action, intention to perform a behavior is determined by attitude toward the behavior and subjective norm. Teachers' intention to use the activities and

Table 13
Descriptive Data on Outcomes by Course

	Course					
	Chemistry		Physics		Frontiers	
Outcome	Mean	SD	Mean	SD	Mean	SD
Intention	0.44	2.19	1.06	1.92	0.60	1.68
Attitude	8.81	1.52	7.00	3.78	6.67	2.61
Subjective Norm	2.19	0.91	2.06	1.09	1.87	1.06

Note: Score range = -3 to 3 for Intention and Subjective Norm and -12 to 12 for Attitude, in integer steps.

Table 14
Results of Separate ANOVAs for Three Outcomes

Outcome	Effect	SS	df	MS	F	p
Intention	Course	3.44	2	1.72	0.54	.6381
	Error	170.48	45	3.79		
Attitude	Course	42.23	2	21.12	2.66	.0812
	Error	357.77	45	7.95		
Subjective	Course	0.81	2	0.40	0.38	.6831
Norm	Error	47.11	45	1.05		

investigations with the students they would teach during the following school year is related to teachers' attitudes toward use of the materials and their beliefs that persons important to them want them to do so. An intercorrelation matrix was computed for teachers enrolled in each of the three courses to determine the degree of association among the three outcomes—intention, attitude, and subjective norm.

Regardless of the class in which teachers were enrolled, their intention to use the activities and investigations was unrelated to what they perceived that people important to them wanted them to do, although the relation approached significance among teachers enrolled in the Concepts in Chemistry course. Teachers' personal beliefs concerning the value of using the activities and investigations, their attitude, proved to be a significant predictor of intention to use the activities and investigations for teachers enrolled in the Physics and Frontiers courses but not in Chemistry Personal beliefs, not the desires of other people, appear to be associated with teachers' intention to use the activities and investigations with the students they will teach during the 1987-88 school year. Table 15 contains data from teachers enrolled in each of the three courses summarizing the correlation between intention and attitude and intention and subjective norm.

The extent to which intention can be predicted from attitude and subjective norm data was tested using multiple regression techniques. According to the Theory of Reasoned Action behavioral intention is the best predictor of behavior, and attitude toward the behavior and subjective norm are the best predictors of intention. Attitude and Subjective Norm were both found to aid significantly in the prediction of behavioral intention (i.e., intention to use the activities and

Table 15
Outcome Intercorrelations by Course

Outcome Correlation		Course		
		Chemistry	Physics	Frontiers
Intention/Attitude	r	-.22	.76	.65
	p	.4245	.0004	.0086
Intention/ Subjective Norm	r	-.48	-.09	.13
	p	.0608	.7268	.6489

investigations with students enrolled in physical science) for teachers enrolled in the Physics and Frontiers courses but not for teachers enrolled in the Chemistry course. Data on the regression of intention on attitude and subjective norm are presented in Table 16.

Table 16
Regression of Intention on Attitude and Subjective Norm

Course	Source	df	SS	MS	F	p
Chemistry	Regression	2	21.83	10.92	2.83	.0953
	Residual	13	50.11	3.85		
Physics	Regression	2	34.74	17.37	10.05	.0020
	Residual	14	24.20	1.73		
Frontiers	Regression	2	17.82	8.91	4.91	.0277
	Residual	12	21.79	1.82		

The independent contributions of attitude and subjective norm to the prediction of behavioral intention were determined by examining the relative magnitudes of the coefficients of regression in each regression equation. The behavioral intention of teachers enrolled in Chemistry is best predicted from knowledge of subjective norm, i.e., the extent to which teachers are motivated to comply with the wishes of influential persons whom they perceive want them to use the activities and investigations. In contrast, for teachers enrolled in the Physics and Frontiers courses behavioral intention is best predicted from knowledge of their attitude toward use of the activities and investigations, not the subjective norm. Personal beliefs rather than the perceived desires of others exert the greater influence on behavioral intention. Data on the independent contributions of attitude and subjective norm to the prediction of behavioral intention are found in Table 17.

PROJECT EFFECTIVENESS

The Institute in Physical Science brought to the campus of the University of Texas at Austin 11 experienced teachers of physical science for the Spring, 1987, Program and 25 teachers of physical science for the Summer, 1987, Program. Participants represented private and public schools; city, suburban, and rural schools; and certified and non-certified, elementary and secondary school teachers from school districts primarily located in the central Texas region. Although "interest in the subject" was a major reason cited by teachers for attending the Institute in Physical Science, Summer Program, the primary need was to obtain instructional materials for

Table 17
Regression Coefficient Table by Course

Course	Outcome	Beta	t	p
Chemistry	Attitude	-.28	1.18	.2594
	Subjective Norm	-.51	2.19	.0472
Physics	Attitude	.76	4.45	.0005
	Subjective Norm	-.115	0 67	.5139
Frontiers	Attitude	.73	3.08	.0096
	Subjective Norm	-.18	0.75	.4655

teaching physical science. For three fourths of the teachers the Institute in Physical Science was the first summer or academic year institute designed specifically for teachers of science that they had ever attended.

Teachers entered the Institute in Physical Science with a variety of needs. They reported that they would like but receive little or no assistance in their district in learning new teaching methods, stimulating critical thinking, acquiring instructional materials, getting science career information, and illustrating technical applications of concepts taught in physical science. Most teachers' needs were adequately met by the instructor for the course(s) in which they were enrolled. Moreover, teachers registered significant gains in their knowledge of science. The program, courses, and instructors received extremely favorable evaluations from the teachers attending the Institute in Physical Science.

Evidence indicates that the Institute in Physical Science was successful in meeting its objectives. The objectives of the program were:

1. To improve physical science teachers' understanding of fundamental concepts in physics and chemistry;
2. To provide physical science teachers with training in the use of the essential elements to teach introductory physics and chemistry concepts included in the physical science course;
3. To update teachers' knowledge of recent research findings in physics, chemistry, and science education;
4. To inform teachers of the recent research, development, and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community; and
5. To develop "Physical Science Factsheets" for teachers to use when teaching physical science.

Program evaluation data show that participants reported the Institute in Physical Science to have achieved, in their opinion, each of its five objectives (see Table 11).

Content knowledge data reveal that all participating teachers significantly <u>improved their understanding of fundamental concepts in physics and chemistry</u> (Objective 1). Teachers enrolled in the Concepts in Chemistry and Concepts in Physics courses reached an average level of mastery of basic concepts in chemistry and physics exceeding the 70% level. Moreover, teachers enrolled in the Frontiers in Physical Science course reached an average level of mastery exceeding 60%, on information related to <u>recent research findings in physics, chemistry, and science education</u>

(Objective 3) and recent research, development, and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community (Objective 4)

Evidence indicates that physical science teachers were trained in the use of the essential elements to teach introductory chemistry and physics concepts included in the physical science course (Objective 2) and that the instructional materials developed for use in their classrooms will be used during the 1987-88 school year. Self report data contained on the Program Evaluation completed by all participants show that teachers were provided with training in the use of the essential elements to teach basic concepts in the subject field(s) of study. Only 1 of 25 responses given by teachers indicated disagreement that the program had been successful in providing teachers with training in the use of the essential elements to teach physical science Furthermore, all teachers reported that they intended to make use of the activities and investigations, which utilize the essential elements, when teaching physical science.

As a result of the efforts of teachers enrolled in the Institute in Physical Science, Spring and Summer Programs, eleven sets of instructional materials are ready for distribution to and use by teachers of physical science in the Austin community. The development of these materials directly addresses the need to develop "Physical Science Factsheets" for teachers to use when teaching physical science (Objective 5). The materials titled, "Frontiers in Physical Science: A Sourcebook of Materials for Teachers of Physical Science", are being bound and will be distributed to teachers enrolled in the Spring and Summer, 1987, "Frontiers" classes. Each set of instructional materials includes objectives, content, activities/investigation, evaluation, and career opportunity sections. Topics contained in the Sourcebook include:

1. Surface Catalysis and Surface Science (Chemistry)
2. Protein Crystallography (Chemistry)
3. Nuclear Fusion and the Texas Tokamak (Physics)
4. IBM, Computer Integrated Manufacturing, and Surface Mount Technology (IBM)
5. The Scanning Tunneling Microscope (Physics)
6. Propagation of Sound in the Sea (Tracor)
7. Remotely Piloted Vehicles (Lockheed, Austin Division)
8. Photoelectric Chemistry (Chemistry)
9. Composite Structures (Texas Instruments)
10. Neural Networks, The Brain, and Dream Sleep (Chemistry)
11. From Sand to Space—The AMD Voyage (Advanced Micro Devices)

The Institute in Physical Science proved to be a cost effective means of upgrading the quality of physical science education. The Program succeeded in improving teachers' knowledge of chemistry, physics, and recent research findings in physics, chemistry, and science education; training teachers in the use of the essential elements to teach physical science; informing teachers of the recent research, development, and manufacturing activities of major science/technology manufacturers located in the Austin metropolitan community; and developing "Physical Science Factsheets" for teachers to use when teaching physical science. Furthermore, the data overwhelming show that training provided in the Institute in Physical Science improved teachers' instructional skills and renewed their interest in and commitment to teaching physical science. With all 25 teachers expressing their intent to use the activities and investigations with their students, the Institute in Physical Science will have a pronounced positive impact on the quality of physical science instruction received by students in classrooms throughout the Austin metropolitan community.

Appendices

1. Institute in Physical Science Brochure
2. General Questionnaire
3. Program Evaluation
4. Course/Instructor Evaluation
5. Activities and Investigations Questionnaire

(Note: Copies of all questionnaires are avialable from the Project Director)