DOCUMENT RESUME

ED 318 641 SE 051 395

AUTHOR Zielinski, Edward J.; Smith, Bruce G.
TITLE An Evaluation of the Program To Improve Elementary Science (PIES).
PUB DATE 90
NOTE 47p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (63rd, Atlanta, GA, April 8-11, 1990).
PUB TYPE Reports - Evaluative/Feasibility (142) -- Tests/Evaluation Instruments (160) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Educational Improvement; Elementary Education; *Elementary School Science; *Evaluation Methods; *Inservice Teacher Education; Longitudinal Studies; *Program Evaluation; Science Education; *Science Teachers; Surveys; Teacher Attitudes; Teaching Methods

ABSTRACT

The purposes of this study were to determine (1) whether or not the participants of the program demonstrated significant gains in knowledge and attitudes as a result of the courses; (2) whether the gains persisted over time; and (3) if there was an associated increase in the participants' proclivity to do science which was also stable over time. Four instruments were used in this study. The PIES test was a 50 item, multiple choice instrument measuring knowledge and comprehension of basic science content and process. The second instrument used was the Science Attitude Scale for Inservice Elementary Teachers, a 26 item instrument. The third instrument, the Science Proclivity Test, was a 25 item instrument designed to assess teachers' inclination to do activity-oriented science lessons. The PIES Evaluation Project Knowledge Test was a 25 item, multiple choice instrument constructed from the first test. Significant gains were found in the PIES group of teachers compared to a control group and these gains appeared to be stable over the 5 years of the study. Appended are the Science Attitude Scale; the Science Proclivity Test; and the PIES Evaluation Project Knowledge Test. (CW)

AN EVALUATION OF THE PROGRAM TO IMPROVE ELEMENTARY SCIENCE (PIES)

PRESENTED BY

EDWARD J. ZIELINSKI
AND
BRUCE G. SMITH

CLARION UNIVERSITY
CLARION, PA 16214

PAPER PRESENTED AT THE ANNUAL MEETING OF THE
NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

ATLANTA, GEORGIA
APRIL 8, 1990

AN EVALUATION OF THE PROGRAM TO IMPROVE ELEMENTARY SCIENCE (PIES)

INTRODUCTION & LITERATURE REVIEW

Literature Review

A review of the literature concerning effective elementary science teaching shows that there is need for improvement. The problems facing science education in general and elementary science specifically are numerous. From *A Nation At Risk* (National Commission on Excellence in Education, 1983) to *Educating Americans for the 21st Century* (National Science Board, 1983), a call is sounding for the improvement of science at all levels. Specifically, a call to make students more active users of science as a process to understand and resolve the ever increasing technological problems of modern day society.

United States students are not doing as well in science as those in other countries. In the recent Second International Study of Science Education (Jacobson, 1987) students from Japan, Korea, Canada, Finland, Hungary, and Italy outdistanced US students in elementary science achievement. The current state of affairs in the US was described in *Educating Americans for the 21st Century* (National Science Board, 1983) as "The nation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the 21st century."

The Program to Improve Elementary Science (PIES) was designed to promote science teaching competence and instructional leadership in science among selected elementary teachers. The course was a three-credit, graduate-level course in science education with emphasis on activities that have application in elementary classrooms. The course instructed elementary teachers in the effective use of "hands-on" science by using free and inexpensive materials, many of them teacher constructed. Fourteen areas of science content and skills most often dealt with in elementary science programs such as magnetism, plants, animals, electricity, and simple machines were taught through the use of activities teachers could take directly back for use in their classrooms. Since the participants expressed less familiarity with physical science concepts, the physical and earth sciences were stressed.

The PIES courses were offered across the state at up to eighteen sites each year. Participants in the courses received three graduate credits, at no cost, from the host institution through tuition scholarships by the granting agency, the Pennsylvania Higher Education Assistance Agency (PSTA). The course follows a standard syllabus at all sites leaving open the latitude to build upon local strengths. Depending upon the location and the semester of offering, the courses were offered as a fifteen week class (meeting one evening a week) or as a three-week class (meeting every day for three consecutive weeks). Each program contained approximately 50 hours of instruction, weaving together science content and processes.

The program began with eight courses offered at eight sites the first year and has grown each successive year to as many as eighteen courses offered in a year.

Needs Assessment

The Program to Improve Elementary Science (PIES) was one arm of the statewide Pennsylvania Science Teacher Education Program (PA STEP). The PA STEP project had as its genesis the 1983 statewide Survey of Science In-service Needs conducted by the Pennsylvania Science Teachers Association. Under the direction of Dr. Ken Mechling, Past President of PSTA, 150 districts in Pennsylvania were randomly selected and surveyed to collect information from elementary and secondary school teachers to determine their science education in-service needs. The results of this survey (Mechling, 1983) were analyzed for the Perceived Needs Related to Science Content and Instructional Techniques.

The needs from the Perceived Needs-Content results were identified in this order; Physical Science, Life Science, Earth/Space Science, Computer Science, and Other (see Table 1). In keeping with the national research indicating the lack of physical science in the elementary school curriculum, it is noted that the teachers identified physical science as the greatest need. The PIES program was designed to be "physical science heavy" as a result of this information. Many of the life science responses indicated that the teachers were very interested in the environmental/conservation aspect of life science. As a result, PIES was designed to include environmental/conservation topics.

TABLE 1
ELEMENTARY NEEDS RELATED TO SCIENCE INFORMATION

Physical Science	Life Science	Earth/Space Science	Computer	Other
29%	26%	18%	9%	9%

The results from the Perceived In-service Needs-Instructional Techniques showed the following: Most of the elementary teachers who responded indicated that they would like in-service instruction to focus on materials (see Table 2). Obtaining free or inexpensive materials and relating materials to current or new units were the major concerns surrounding materials. Further results showed many of the elementary teachers surveyed indicated a need to obtain contacts for resource people. Another group of these teachers were interested in more "hands-on" approaches to teaching science (see Table 2). PIES was designed to involve teachers in the effective use of hands-on science by using free and inexpensive materials, many of them teacher-constructed.

TABLE 2

ELEMENTARY NEEDS RELATED TO IMPROVEMENT OF INSTRUCTIONAL TECHNIQUES

Use of Science Materials	Hands-On Experiences	Resource People	Computers	Evalution of Objectives
69%	18%	26%	6%	4%

The results from this elementary section of the State Needs Assessment were the basis of the Program for Improving Elementary Science.

A second program-related survey was conducted in 1986 to gain at least a rudimentary measure of the PIES program effectiveness. The Program for Improving Elementary Science (PIES) Retrospective Survey was conducted by staff during the spring of 1986 (Smith, 1988). To allow program participants adequate time to institute the PIES materials in their classrooms, only those PIES classes conducted in the summer of 1985 and earlier were surveyed, a total of twenty-two courses. From each of these courses eleven participants were randomly selected and an additional eight were randomly selected from the population at large to bring the total to 250 surveys distributed. A total of 56.4% of the surveys were returned representing twelve PIES sites.

Results from the Likert-type 5-item survey revealed that, as a result of the PIES program, participants perceived they were teaching more science, felt more confident about teaching science, and feel more competent in designing and presenting science experiences which involved their students. The survey results also showed teachers believed that their students were receiving more hands-on science experiences as a result of their participation in PIES.

An open-ended item from the survey, "What actions have you taken in your classroom as a result of participating in the PA STEP Program for Improving Elementary Science?" revealed participants taught more science, used PIES activities, enjoyed teaching science and were more confident among others (see Table 3).

TABLE 3

ACTIONS TAKEN BY TEACHERS AS A RESULT OF PIES RANKED BY % OF RESPONSE DURING PILOT STUDY

RESPONSE	
Teach more hands-on science	34.7%
Use PIES activities in class	16.9%
Taught more science	16.1%
More confident in teaching science	13.6%
Enjoy teaching science more	6.8%
Shared activities/ideas with other teachers	5.9%
Conducted an in-service program	2.5%
Set up school science fair	0.8%

The PIES Retrospective Survey was designed to give formative feedback to the project as the course continued to be offered across the state. A more formalized, statistically analyzed process of program evaluation was envisioned for the future. The Retrospective Survey was a mid-stream check to see if teacher needs were being met. It can be considered a pilot to the study which is the subject of this paper.

PURPOSE

The results from the PSTA Needs Assessment were a good indicator of the areas where teachers perceived they needed in-service help. The clamoring in the literature for the improvement of science education across the grade levels was an indication that this *was not* a localized problem. The time was ripe for a program such as PIES to begin. The question at hand, the purpose of this study, was how effective was this program as a model and how long-term were the effects?

Studies conducted by the PIES staff indicated the positive effects the PIES Program had on the participants on a site-by-site, year-by-year basis (Mechling, 1984, 1985, 1986, 1987). All of the reports indicated that the participants increased their knowledge of the selected science concepts and processes as well as their attitudes towards science and the teaching of science. Mechling (1984) reported the data from every site in the 1983-84 PIES program showed an increase in knowledge scores. In addition, he reported that of the four sites from which complete data was available at the time of the report, three showed a statistically significant gain at the .05 level and one at the .10 level of significance using a t-test. Mechling further reported that every class in the 1983-84 PIES program had an increase in the attitude variable. He reported that the combined data (from 107 teachers from four of eight sites from which complete data was available at the time of the report) showed a statistically significant gain at the .0001 level of significance using ANOVA. Investigations by Mechling (1985, 1986, 1987) all reported descriptive data (class and yearly means and anecdotal reports) which substantiated the claims of improvement in knowledge and attitudes of the participants. However, no attempts were made to use inferential statistics to further validate these claims.

The purpose of this investigation was four-fold; first, to determine whether or not the participants in the PIES courses demonstrated statistically significant gains in knowledge and attitudes as a result of the courses; also, did these hypothesized knowledge changes persist over time and was there an associated increase in the participants' proclivity to do science which was also stable over time? This purpose was fulfilled by answering the following nine research questions:

R1 *Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes?*

R2 *Did the instruction received by the participants of the PIES program result in a significant gain in attitudes towards science and the teaching of science?*

R3 *Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes when compared to a randomly selected highly motivated/science oriented control group?*

R4 *Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes when compared to a randomly selected control group?*

R5 *Did the instruction received by the participants of the PIES program result in a significant increase in their proclivity to do science when compared to a randomly selected highly motivated/science oriented control group?*

R6 *Did the instruction received by the participants of the PIES program result in a significant increase in their proclivity to do science when compared to a randomly selected average control group?*

R7 *Were there any differences in science knowledge over time?*

R8 *Were there any differences in science proclivity over time?*

R9 *What are the current problems and in-service needs of elementary teachers regarding the teaching of science?*

For the purposes of this investigation, the following definitions were used:

Average Control Group: This group consisted of elementary teachers who had the responsibility of teaching science but *had not* taken a PIES course or joined national or state professional organizations for science teachers.

Highly Motivated/Science Orientated Group: This group consisted of elementary teachers who had demonstrated their motivation and interest in science and science teaching by joining the Pennsylvania Science Teachers Association (PSTA) but who had not participated in a PIES course.

Proclivity To Do Science: Proclivity To Do Science was defined as the inclination or disposition to do student-centered/activity-oriented science lessons.

Research studies such as this are important bases of information for persons attempting to impact elementary science teaching through in-service training programs. The results from this study may be helpful to in-service practitioners when developing elementary science in-service programs which have a positive impact on the participants' knowledge of science and science processes, attitudes towards science and science teaching, and their disposition towards activity-oriented/student-centered science in the classroom. The information from this investigation may be especially useful if it can be demonstrated that these traits are long-lived.

METHODOLOGY

Course evaluation was an integral part of each of the courses. Each time the course was taught, the participants were pre- and post-tested. Many of these data were never used in inferential statistical analysis, thus, it is these data which were used in the first portion of this study. In addition, randomly selected participants from each of the sites and years, along with two different control groups, were mailed two additional evaluation instruments in the fall of 1988. The returns from these mailings were the data used in the longitudinal portion of this study. This design may be characterized as a modified one-group pretest-posttest design with the addition of two control groups for the delayed testing (Isaac & Michael, 1971). (See Figure 1.)

FIGURE 1

EXPERIMENTAL DESIGN

GROUP	PRETEST	TREATMENT	POSTTEST	DELAYED POSTTEST
1*	O_1O_2[1,2]	X	O_1O_2	O_3O_4[3,4]
2				O_3O_4
3				O_3O_4

*<u>Group 1</u> represents the individuals and intact classes of PIES participants.

<u>Group 2</u> represents the randomly selected PSTA control group.

<u>Group 3</u> represents the randomly selected control group.

O_1 was the <u>PIES Test</u>.

O_2 was the <u>Science Attitude Scale</u>.

O_3 was the <u>Science Proclivity Test</u>.

O_4 was the <u>PIES Evaluation Project Knowledge Test</u>.

Research questions 1 and 2 were addressed using extant data and t-tests. Research questions 3 through 7 were addressed using two-way ANOVA. All statistical operations were performed by computer.

SAMPLE

During the 1983-84 year, eight PIES courses were offered at eight different sites distributed geographically around the Commonwealth. A total of 220 elementary teachers participated in the program. The program grew in 1984-85 to eleven courses and sites with 272 teachers participating. The 1985-86 year showed continued growth of the PIES concept. Fourteen courses at 12 sites representing 347 teachers were offered. During the 1986-87 year, fourteen courses at 12 sites representing 368 teachers were taught. Each of these course offerings represented an intact group who's means were used as the unit of analysis for the first part of this investigation (research questions 1 &2). In addition, they represent the population from which a randomly selected sample was selected for the second portion of the study (research questions 3 - 7). Participants were randomly selected from each PIES class for each year and mailed the survey. One month later, persons who had not responded were sent a reminder to respond to the survey. Fifty surveys were mailed to elementary teachers who were members of the state science teachers organization but had not taken a PIES course. Fifty surveys were mailed to elementary teachers who had neither had a PIES course nor were members of the state science teachers organization. (See Table 4.)

TABLE 4
SURVEYS MAILED AND RETURNED FOR SAMPLE

YEAR	SURVEYS MAILED	SURVEYS RETURNED	USABLE RETURN RATE
1983/84	106	27	24.5%
1984/85			
1985/86	115	42	36.5%
1986/87			
1987/88	110	24	21.8%
1988/89			
Control, Motivated	50	21	42.0%
Control, Average	50	17	34.0%

The Demographic Data indicated the samples were mostly female and still in the teaching profession. All grade levels and subject areas were represented. All had been teaching at least 14 years and most had master's degrees. Public, private and parochial schools were all represented. The groups appeared very similar. (See Table 5.)

TABLE 5

PIES SURVEY RESPONDENTS DEMOGRAPHICS

	83/84-84/85	85/86-86/87	87/88-88/89	CONTROL, M	CONTROL, A
Male/Female	5/22	7/35	2/22	4/17	2/15
Teaching/Not Teaching	25/2	38/2	23/1	21/0	17/0
Subjects:					
All	12	27	17	12	14
Science	12	14	1	9	1
Math	3	4	2	4	1
Language Arts	7	8	1	2	2
Social Studies	0	3	0	0	1
Other	3	6	3	1	0
Grade Levels:					
K	1	1	2	2	1
1	4	8	6	5	3
2	7	3	8	3	2
3	9	6	7	7	3
4	12	10	5	5	7
5	8	10	3	8	1
6	6	7	3	6	2
Other	6	5	2	4	0
Public/Private/Parochial	23/2/2	36/1/5	17/5/2	16/1/4	16/0/1
# of Years Teaching, Mean	15.8	1[illegible].1	14.2	14.5	20.8
Average Class Size	23.9	25.0	23.5	23.8	25.9
Average # Students/Year	95.4	52.3	71.4	95.4	33.2
Highest Degree: (BS/MEd/PhD)	12/15/0	13/27/0	9/15/0	8/13/0	8/9/0

At first, the population and the sample may appear to be one. The persons who attended PIES were motivated volunteers, the persons belonging to professional organizations were motivated volunteers, and the persons returning the surveys were motivated volunteers. However, evidence suggests this is not the case. The PIES sample and the motivated control group are different in some aspects pertaining to the degree of motivation towards professionalism as indicated by their membership in professional organizations. All of the motivated group were members of a professional organization at the beginning of the study and only 9% dropped out of the state science organizations during the course of this study. In contrast, approximately one-fourth of the PIES participants were members of a science teaching-oriented professional organization. Although both groups were motivated this suggests there were differences in their motivation.

Another difference in volunteers and professionalism can be found in Table 25 which suggests the motivated control is twice as likely to work with administrators on science curriculum. This evidence suggests the PIES sample and the motivated control group sample were similar but not the same population prior to this investigation.

INSTRUMENTATION

Four instruments were used in this study. *The PIES Test* was developed by the PIES instructors. It was a multiple choice free-answer instrument measuring knowledge and comprehension of basic science content and processes. The 50 item test included questions from life, physical and earth sciences and questions measuring participants' ability to utilize science processes such as classification, data analysis, and identification of variables. Test-retest reliability was measured using a class of 24 pre-service elementary science methods students over a two-week period and found to be r=.67.

The Science Attitude Scale for In-service Elementary Teachers II is a 26-item, Likert-type instrument designed to assess teacher attitudes toward science and teaching it in their own classrooms. The attitude scale was developed by Shrigley & Johnson (1974). (Appendix A.)

The Science Proclivity Test was a 25-item forced choice instrument developed by the investigators with the assistance of the PIES staff and instructors. The first 14 items were designed to measure the inclination or disposition of elementary teachers to do student-centered/activity-oriented science lessons. The remainder of the items were to be used in the needs assessment. Only the first 14 items were used in the data analysis. The internal consistency of the 14 item subtest was calculated using Kuder-Richardson - 20 procedures and found to be r= .78. (Appendix B.)

The PIES Evaluation Project Knowledge Test was a 25 item multiple choice instrument sampled from the original PIES Test. The questions were selected such that each of the content and process areas of the original instrument were represented. The internal consistency was calculated using Kuder-Richardson - 20 procedures and found to be r=. 89. (Appendix C.)

RESULTS

The results of this investigation will be addressed in the order of each of the research questions.

R1 ***Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes?*** The results from the t-tests conducted on the extant data indicated that a significant difference occurred for every year the PIES courses were conducted. (see Table 6). In every case the t value exceeded the value needed for the 95% confidence level.

TABLE 6

STATISTICS FOR INTACT GROUPS BY ACADEMIC YEAR ON THE PIES TEST

GROUP	N	PRETEST MEANS	SD	POSTTEST MEANS	SD	t	p
83-84	4	30.72	3.58	37.5	4.3	-2.42	<.05
84-85	8	31.47	4.41	37.25	3.53	-2.89	<.01
85-86	10	30.38	1.98	35.26	2.21	5.2	.0002
86-87	10	29.19	2.75	35.02	3.7	-3.98	.001

R2 *Did the instruction received by the participants of the PIES program result in a significant gain in attitudes towards science and the teaching of science?*

The results from the t-tests conducted on the extant data indicated that a significant difference on the attitude variable occurred for every year the PIES courses were conducted (see Table 7). In every case the significance exceeded the 95% confidence level.

TABLE 7

STATISTICS FOR INTACT GROUPS BY ACADEMIC YEAR ON THE SCIENCE ATTITUDE SCALE

GROUP	N	PRETEST MEANS	SD	POSTTEST MEANS	SD	t	p
83-84[1]	4	114.28	2.73	119.05	5.46	-3.03	<.05
84-85[2]	6	.71	.18	1.09	.24	-3.04	<.01
85-86[2]	10	.65	.34	.98	.32	-2.22	<.05
86-87[2]	10	.60	.17	.95	.19	-4.23	<.001

[1] Sum scores of the items reported.

[2] The classes were scored differently in the literature. The scores ranged from -2 to 2 with 0 indicating a neutral response. The average of the items was reported.

R3 *Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes when compared to a randomly selected highly motivated science oriented control group?*

No significant differences were found when the mean scores for the groups who had taken a PIES course were compared with the highly-motivated control group (see Tables 8 and 9).

TABLE 8
DESCRIPTIVE STATISTICS FOR INTACT GROUPS BY CALENDAR YEAR ON PIES KNOWLEDGE TEST

GROUP	N	MEAN	SD
Control, Motivated	22	20.77	1.88
Control, Average	15	17.60	3.18
83-84	27	20.44	4.56
85-86	41	20.80	2.60
87-88	23	20.30	2.12

TABLE 9
CONDENSED ANOVA OF INTACT GROUP MEANS BY CALENDAR YEAR ON PIES EVALUATION PROJECT KNOWLEDGE TEST WHEN COMPARED TO THE MOTIVATED CONTROL GROUP MEAN*

GROUP	SS	DF	MS	F	P
83-84	1.31	1	1.31	.10	ns
85-86	.015	1	.015	.003	ns
87-88	2.47	1	2.47	.614	ns

*Within group variances not shown

R4 *Did the instruction received by the participants of the PIES program result in a significant gain in knowledge of the selected science concepts and processes when compared to a randomly selected average control group?*

- Statistically significant differences exceeding the .05 level were found for every group when compared to the average control group on the knowledge of science and science processes variable (see Tables 8 and 10).

TABLE 10

CONDENSED ANOVA OF INTACT GROUP MEANS BY CALENDAR YEAR ON PIES EVALUATION PROJECT KNOWLEDGE TEST WHEN COMPARED TO THE AVERAGE CONTROL GROUP MEAN*

GROUP	SS	df	MS	F	P
83-84	78.02	1	78.02	4.57	.04
85-86	112.80	1	112.80	14.78	.0006
87-88	66.40	1	66.40	9.94	.0035

*Within group variances not shown

R5 ***Did the instruction received by the participants of the PIES program result in a significant increase in their proclivity to do science when compared to a randomly selected highly motivated science oriented control group.?*** No significant differences were found when the mean scores for the groups who had taken a PIES course were compared with the highly motivated control group on the proclivity to do science variable (see Tables 11 and 12).

TABLE 11

DESCRIPTIVE STATISTICS FOR INTACT GROUPS BY CALENDAR YEAR ON SCIENCE PROCLIVITY TEST

GROUP	N	MEAN	SD
Control, Motivated	22	34.59	12.46
Control Average	15	25.27	6.96
83-84	27	38.48	10.53
85-86	41	36.39	11.92
87-88	23	33.0	8.51

TABLE 12

CONDENSED ANOVA OF INTACT GROUP MEANS BY CALENDAR YEAR ON SCIENCE PROCLIVITY TEST WHEN COMPARED TO THE MOTIVATED CONTROL GROUP MEAN*

GROUP	SS	df	MS	F	P
83-84	183.49	1	183.49	1.404	.24
85-86	46.35	1	46.35	.316	.58
87-88	28.46	1	28.46	.252	.62

*Within group variances not shown

R6 *Did the instruction received by the participants of the PIES program result in a significant increase in their proclivity to do do science when compared to a randomly selected average control group?* Statistically significant differences exceeding the .05 level were found for every group when compared to the average control group on the proclivity to do science variable (see Tables 11 and 13).

TABLE 13

CONDENSED ANOVA OF INTACT GROUP MEANS BY CALENDAR YEAR ON SCIENCE PROCLIVITY TEST WHEN COMPARED TO THE AVERAGE CONTROL GROUP MEAN*

GROUP	SS	df	MS	F	P
83-84	1683.95	1	1683.95	18.9	.0002
85-86	1358.86	1	1358.86	11.54	.0016
87-88	542.96	1	542.96	8.59	.0059

*Within group variances not shown

R7 *Are there any differences in knowledge over time?*

Analysis of variance did not indicate any significant differences between the PIES groups on the knowledge variable regardless of when they took the course. (See Table 14.)

TABLE 14
ANOVA BETWEEN INTACT GROUP MEANS BY CALENDAR YEAR ON PIES EVALUATION PROJECT KNOWLEDGE TEST

GROUP	SS	df	MS	F	P
Effect	4.31	2	2.155	.208	.8128
Within	909.978	88	10.341		

R8 *Are there any differences in proclivity over time?*

Analysis of variance did not indicate any significant differences between the PIES groups on the proclivity variable regardless of when they took the course. (See Table 15.)

TABLE 15
ANOVA OF INTACT GROUP MEANS BY CALENDAR YEAR ON PIES SCIENCE PROCLIVITY TEST

GROUP	SS	df	MS	F	P
Effect	377.35	2	188.68	1.634	.1992
Within	10158.5	88	115.44		

R9 *What are the current problems and in-service needs of elementary teachers regarding the teaching of science?*

The data in Table 16 suggests the primary assistance elementary teachers need to become better science teachers is equipment and supplies followed by more time dedicated to the teaching of science. New science activities and more background information in science were tied for third.

The teachers indicated gathering and preparing materials with which to teach science as the task most difficult to accomplish. (See Table 17.)

The data in Table 18 indicated physical science is still the subject area the participants were the most uncomfortable with or had the greatest difficulty teaching.

TABLE 16
WHAT DO YOU NEED ASSISTANCE WITH TO BECOME A BETTER SCIENCE TEACHER? (TOP FIVE RESPONSES)

More science equipment/materials	79	35.0%
More time for science	58	25.7%
New science activities	36	15.9%
Background information	32	14.2%
More in-service education	21	9.3%

TABLE 17
WHAT TASKS DO YOU FIND MOST DIFFICULT TO ACCOMPLISH WHILE TEACHING SCIENCE?

Gathering/preparing materials	35	50.0%
Making time to prepare for lessons	11	15.7%
Conducting demonstrations/activities	10	14.3%
Classroom management	9	12.8%
Evaluation of students	5	7.1%

TABLE 18
WHICH SCIENCE AREA ARE YOU MOST UNCOMFORTABLE WITH OR HAVE THE MOST DIFFICULTY TEACHING?

Physical Science	55	59.8%
Earth/Space Science	29	31.5%
Life Science	8	8.7%

DISCUSSION

The ultimate success of any in-service program is the long term effect it has upon the participants. This investigation measured the effects of PIES on the knowledge and proclivity to do science and found long term significant effects on each variable.

Perhaps it may be more enlightening to examine the effect of each item contributing to the overall variance on the proclivity to do science variable as they compare to the control groups.

TABLE 19
NUMBER OF STUDENT-CENTERED ACTIVITY-ORIENTED SCIENCE LESSONS PER WEEK (ITEM 1)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0	0.0	9.8	8.3	6.7	9.1
B. 1 or 2	37.0	41.5	66.7	80.0	40.9
C. 3 or 4	33.3	24.4	8.3	13.3	31.8
D. 4 or 5	7.4	7.3	12.5	0.0	9.1
E. >5	22.2	14.6	4.2	0.0	9.1

The data in Table 19 indicates that the participants in the PIES Program teach more student-centered, activity-oriented science lessons than persons who have not had PIES. None of the average control elementary teachers reported that they taught more than 4 student-centered, activity-oriented science lessons per week. However, more than 16% of the PIES participants reported they taught five or more student-centered, activity-oriented science lessons per week. These data compare favorably with the reports of the highly motivated control group. The PIES Program has been successful at increasing the number of student-centered, activity-oriented science lessons taught per week by the participating teachers.

TABLE 20
THE NUMBER OF NEW SCIENCE LESSONS ADDED TO MY CURRICULUM LAST YEAR (ITEM 2)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-5	18.5	26.8	45.8	86.7	27.3
B. 6-10	37.0	29.3	16.7	6.7	45.5
C. 11-15	29.6	14.6	12.5	6.7	9.1
D. 16-20	3.7	12.2	12.5	0.0	9.1
E. >20	11.1	14.6	12.5	0.0	4.6

The data in Table 20 indicates that the participants in the PIES Program added more science lessons to their curriculum in the last year than persons who did not. None of the average control elementary teachers reported that they added more than 15 science lessons in the last year. However, more than 14% of the PIES participants reported they added 16 or more science lessons with at least 11% reporting they added more than 20. These data exceed the reports of the highly motivated control group. The PIES Program has been successful for increasing the numbers of science lessons in some participating teachers' curriculum.

TABLE 21
THE NUMBER OF TEACHERS THAT WERE ASSISTED WITH THE DEVELOPMENT OF SCIENCE LESSONS (ITEM 3)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-2	40.7	56.1	66.7	100.0	54.6
B. 3-5	33.3	26.8	25.0	0.0	31.8
C. 6-9	0.0	9.8	0.0	0.0	0.0
D. 10-15	3.7	2.4	4.2	0.0	4.6
E. >15	22.2	2.4	4.2	0.0	4.6

The average control group reported they assisted two or less teachers with the development of science lessons (Table 21). These data contrast sharply with the responses of the PIES participants. Twenty-five percent or more reported they assisted with the development of science lessons with 3 - 5 teachers, 2% or more assisted 10 - 15 teachers, and more than 2% assisted more than 15 teachers. These results indicate the PIES program has impacts on teachers and science teaching far beyond its immediate sphere of influence. The participants are motivated to share their knowledge with other teachers by assisting them with the development of science lessons.

TABLE 22
THE NUMBER OF NEW "HANDS-ON" SCIENCE ACTIVITIES I ACQUIRED FOR MY CLASSES IN THE LAST YEAR (ITEM 4)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-5	29.6	26.8	29.2	73.3	22.7
B. 6-10	48.2	31.7	25.0	26.7	31.8
C. 11-15	11.1	14.6	8.3	0.0	18.2
D. 16-20	0.0	4.9	16.7	0.0	9.1
E. >20	11.1	22.0	20.8	0.0	13.6

None of the average control group teachers reported they added more than 10 new "hands-on" science lessons in the preceding year (Table 22). The PIES participants however, added more. At least 11% added 20, twice the amount of the average control. In two of three cases they added more than the motivated control group. The only case which did not add more than the motivated group were the participants of the PIES courses five years ago. It is possible that these teachers have begun to saturate their curriculum with new science lessons by now and there is less opportunity to add more and the emphasis may be changing to modification of existing lessons or replacement of lessons with "better" ones.

TABLE 23

MEMBERSHIP IN PROFESSIONAL SCIENCE TEACHERS' ORGANIZATIONS (ITEM 5)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0	48.2	78.1	75.0	100.0	9.1
B. 1	14.8	17.1	16.7	0.0	54.6
C. 2	18.5	4.9	8.3	0.0	27.3
D. 3	14.8	0.0	0.0	0.0	4.6
E. >3	3.7	0.0	0.0	0.0	4.6

One index of a teacher's commitment to the teaching of science and their desire for continued upgrading of their knowledge and skills may be membership in professional organizations. None of the average control teachers belonged to any science teachers' professional organizations (Table 23). All but 9% (which dropped out during the investigation) of the motivated control teachers belonged to one or more science teachers' professional organization. Approximately twenty-five percent of the teachers who participated in a PIES program are members of at least one science teachers' professional organization. These data may indicate that PIES participants are motivated to join professional organizations in science to continuously upgrade their knowledge and skills, or they were already members.

TABLE 24

PERCENT OF SCIENCE LESSONS COMPRISED OF PROCESS SKILLS (ITEM 6)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-20	11.1	26.8	29.2	53.3	27.3
B. 21-40	29.6	12.2	25.0	13.3	18.2
C. 41-60	18.5	22.0	33.3	13.3	22.7
D. 61-80	22.2	24.4	0.0	6.7	18.2
E. 81-100	18.5	14.6	12.5	13.3	4.6

From these data it is apparent that PIES participants and the motivated control group use more science process skills while teaching science than does the average control group (Table 24). Fifty-three percent of the average control group reported using science process skills 20% of the time or less. Less than 30% of any of the other groups reported 20% or less time spent on the science process skills. Over 12% of the PIES participants reported using science processes to teach science more than 80% of their science teaching time.

TABLE 25
WORKING WITH ADMINISTRATORS ON SCIENCE CURRICULUM (ITEM 7)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0	51.9	48.8	79.2	66.7	40.9
B. 1 or 2	18.5	14.6	8.3	20.0	13.6
C. 3 or 4	11.1	14.6	0.0	6.7	4.6
D. 5 or 6	3.7	4.9	0.0	6.7	0.0
E. >6	14.8	17.1	12.5	0.0	36.4

School administrators provide the local leadership for curriculum decisions. More than 12% of the PIES participants indicated they have worked on science curricula with administrators for a week or more (Table 25). None of the average control teachers reported this level of activity. Less than 14% of the normal control teachers reported they have worked on science curricula with administrators for more than two days. This is in contrast to the PIES participants of which 29% of two groups indicated more than two days and 12.5% of the other group indicated more than six days. The PIES program participants appear to be more active in science curriculum planning with administrators than the average control group. Their level of activity is approaching the activity of the motivated control group. These data indicate PIES teachers and administrators are jointly working to improve the condition of science education within the effected districts.

TABLE 26
SCIENCE LEARNING CENTERS (ITEM 8)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0	33.3	24.4	16.7	40.0	31.8
B. 1-2	18.5	29.3	33.3	46.7	31.8
C. 3-4	29.6	19.5	25.0	6.7	13.6
D. 5-6	11.1	14.6	8.3	0.0	0.0
E. >6	3.7	12.2	12.5	6.7	18.2

Using learning centers as one vehicle for the teaching of science was a concept developed during the PIES program. The development of these centers takes considerable time and effort. Although the quality of these learning centers was not assessed, the fact that the PIES participants were more willing to expend the necessary time and effort to construct learning centers may be an indicator of their desire to teach more science. Over 86% of the average control group constructed two or less science learning centers within the last year while more than 44% of the PIES participants constructed more than two (Table 26). These percentages exceed those of the motivated control group. The PIES program appears to be successful for motivating participants to build science learning centers for use in their classrooms.

TABLE 27
NUMBER OF INSTRUCTIONAL TECHNIQUES USED WHEN TEACHING SCIENCE (ITEM 9)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 1 or 2	3.7	12.2	0.0	6.7	4.6
B. 3 or 4	11.1	4.9	16.7	20.0	9.1
C. 4 or 5	3.7	14.6	37.5	40.0	40.9
D. 6 or 7	18.5	26.8	16.7	13.3	13.6
E. 8	63.0	41.5	29.2	20.0	27.3

Good science teachers use many different instructional techniques. The data in Table 27 indicates that PIES participants like the highly motivated control group used more instructional techniques to teach science than did the average control group. (See Appendix B, Item 9 for a listing of techniques.) These data indicated that the instruction and modeling which occurred during the PIES Program was successfully transferred into the participants' classrooms.

TABLE 28
VERBAL DESCRIPTION OF 'MY' SCIENCE TEACHING (ITEM 10)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
Enthusiastic	63.0	51.2	54.2	13.3	50.0
Interesting	33.3	39.0	45.8	40.0	36.4
Boring	0.0	4.9	0.0	6.7	0.0
Fearful	0.0	2.4	0.0	13.3	4.6
Anxious	3.7	0.0	0.0	20.0	4.6

The data contained in Table 28 indicated more than 50% of the PIES program participants and the motivated control group describe their science teaching as 'enthusiastic' while less than 14% of the average control group characterized themselves in this way. In contrast, 20% of the average control group characterized themselves as 'anxious' while less than 4% of the PIES participants and less than 5% of the motivated control group used 'anxious' as a description of their science teaching. PIES program participants, like their highly motivated counterparts, are more likely to characterize their science teaching as 'enthusiastic' or 'interesting' and less likely to describe it as 'boring', 'fearful', or 'anxious' than the average control group of teachers.

TABLE 29

PERCENT OF HANDS-ON ACTIVITIES DURING SCIENCE LESSONS (ITEM 11)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-20	25.9	19.5	16.7	46.7	13.6
B. 21-40	25.9	24.4	41.7	13.3	36.4
C. 41-60	18.5	26.8	16.7	26.7	13.6
D. 61-80	3.7	17.1	12.5	6.7	27.3
E. 81-100	25.9	12.2	12.5	6.7	4.6

Participants in the PIES program and the motivated control group used more hands-on activities during their science teaching than did the average control group (Table 29). More than 46% of the average control group reported doing hands-on science for less than 20% of the science lesson. Less than 26% of the PIES participants used hands-on science for less than 20% of the science lesson. Less than 14% of the average control group reported using hands-on science more than 60% of the science lesson while more than 25% of the PIES participants made this claim. These data indicate that the PIES Program was successful for increasing the amount of hands-on science used during the science lessons.

TABLE 30

NUMBER OF HANDS-ON SCIENCE LESSONS DEVELOPED WITHIN THE LAST YEAR (ITEM 12)

Response	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-5	44.4	43.9	45.8	86.7	31.8
B. 6-10	37.0	24.4	29.2	6.7	40.9
C. 11-15	7.4	12.2	12.5	6.7	13.6
D. 16-20	0.0	7.3	8.3	0.0	9.1
E. >20	11.1	12.2	4.2	0.0	0.0

The participants in the PIES program continue to develop more hands-on science lessons than either of the two control groups (Table 30). Neither of the control groups reported persons developing more than 20 new hands-on science lessons in the last year while over 11% of the 83/84 participants, 12% of the 85/86 participants, and 4% of the 87/88 participants did. The decline in the 87/88 participants' data is perhaps due to the short time period which had elapsed from the taking of the PIES course and the receipt of the questionnaire.

TABLE 31
AVERAGE MINUTES PER WEEK OF HANDS-ON SCIENCE (ITEM 13)

Response (Minutes)	83/84	85/86	87/88	Average Control %	Motivated Control %
A. 0-15	25.9	24.4	20.8	33.3	18.2
B. 16-30	18.5	17.1	54.2	46.7	13.6
C. 31-45	14.8	19.5	20.8	6.7	27.3
D. 46-60	7.4	7.3	0.0	6.7	22.7
E. >60	33.3	31.7	4.2	6.7	13.6

Eighty percent of the average control group reported teaching hands-on science lessons less than 30 minutes per week (Table 31). This amount is very different from the 83/84 and 85/86 PIES groups in which over 55% reported more than 30 minutes and over 31% reported over one hour. Over one hour of hands-on science teaching was more than the motivated control group reported. The 87/88 PIES group reported teaching more hands- on science than the average control group but less than the other two PIES groups and the motivated control groups. Perhaps they did not have time to implement the PIES objectives into their classrooms prior to this survey.

TABLE 32
SCIENCE IN-SERVICE PROGRAMS CONDUCTED FOR OTHER TEACHERS (ITEM 14)

Response (Days)	83/84	85/86	87/88	Average Control %	Motivated Control %
0	51.9	78.1	70.8	93.3	68.2
1 or 2	29.6	19.5	25.0	6.7	9.1
3 or 4	3.7	2.4	4.2	0.0	4.6
5 or 6	11.1	0.0	0.0	0.0	4.6
>6	3.7	0.0	0.0	0.0	9.1

The data in Table 32 indicate that PIES participants are more likely to conduct science in-service programs than the teachers in the average control group. Over 93% of the average control group reported they had conducted no science in-service programs while over 19% of the PIES participants had conducted at least one. PIES participants assisted other teachers with the development of science lessons (Table 15), but perhaps their assistance was informal in nature.

The successes of programs like PIES can be measured in many different ways. In this study, the effectiveness of the PIES program was evaluated in terms of the short and long term gains in knowledge and attitudes of the participants and how their knowledge and attitudes compared with two different control groups. In addition, the participants' proclivity to do science was evaluated.

PIES has been an effective model to impact the knowledge and attitudes of the participants. In every case the knowledge and attitudes of the participants in the PIES courses significantly increased during the course. When the knowledge and proclivity variables were compared to a highly motivated science-oriented control group, up to five years after the course was completed, no significant differences were found. However, when the knowledge and proclivity variables were compared with the average control group up to five years after taking the courses a significant difference was found in every instance.

The failure to find significant differences between any of the PIES groups and the significant differences found between PIES groups and the average control group implies that the knowledge gained and the proclivity to do science obtained is stable for at least five years. PIES has been an effective model for increasing knowledge and proclivity to do science.

The results from the needs assessment portion of the study indicated the following from participating teachers:

1. *Elementary teachers desire more equipment and materials with which to teach science.*
2. *Elementary teachers need more time dedicated to the teaching of science.*
3. *Gathering and preparing materials is the most difficult task facing elementary teachers.*
4. *Physical science followed by earth/space science are still the areas elementary teachers are most uncomfortable teaching.*

Perhaps time is the major concern. Dedicated time for preparation and teaching of science would address two of their needs. More and better focused in-service education would address the other two.

These results have impact for designers of in-service programs designing similar outcomes for their participants. Pre-service elementary science methods and content instructors should note the needs and difficulties in-service teachers are having and attempt intervention prior to these new teachers having negative experiences which may affect all of their future science teaching.

The difficulty elementary teachers perceive they have in the physical sciences may be multifaceted. The first aspect may be the general mathematics and science phobias reported in the literature. In addition, it may be true that the teachers do not understand the concepts or are suffering from the many misconceptions involved in the physical sciences which block their understanding. Pre-service education programs may generally fail in the preparation of teachers in this area. Research needs to be initiated to identify the cause of the problems in physical science teaching at the elementary level. Following problem identification, remediation and prescriptive programs can be developed.

REFERENCES

Jacobson, Willard J. et. al., The Second IEA Science Study --U.S., New York; Teachers College, Columbia University, 1987.

Mechling, Ken, Pennsylvania Assessment of Needs in Science Education, Report to Pennsylvania Science Teachers Association (Unpublished), July 1, 1983.

National Commission on Excellence in Education, A Nation at Risk, Washington, DC, April 1983.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983). Educating Americans for the 21st Century. Washington, DC. The National Science Board, p.v.

Shrigley, Robert and Johnson, Theodore, "The Attitude of In-Service Elementary Teachers Toward Science", School Science and Mathematics, Vol 74.

Smith, Bruce G., "A Retrospective Survey of the Program for Improving Elementary Science, Report to PA STEP, (Unpublished), 1986.

Appendix A

SCIENCE ATTITUDE SCALE FOR IN-SERVICE ELEMENTARY TEACHER II

ROBERT L. SHRIGLEY AND THEODORE JOHNSON
THE PENNSYLVANIA STATE UNIVERSITY
UNIVERSITY PARK, PA 16802

Directions: This is not a test. You are to indicate your feelings toward the subject of science and the teaching of science. You may react to the statements in one of five ways:

A - Strongly Agree
B - Agree
C - Undecided
D - Disagree
E - Strongly Disagree

Please mark your choice on the answer sheet.

Statements:

1. As a teacher, I am afraid that science demonstrations will not work.
2. I enjoy discussing science topics with fellow teachers.
3. If I had time, I would like to attend an elementary science workshop during the summer.
4. If I were to enroll in a college science course, I would enjoy the laboratory periods of the course.
5. I am afraid that I do not have enough background to teach science adequately.
6. If I were to return to college for additional graduate work, I would enroll in at least one science course.
7. I enjoy manipulating science equipment.
8. I believe science is too difficult for me to learn.
9. I would like to have a desk barometer that measures air pressure.
10. I would like to work with the science consultant on my science program.
11. Most science equipment confuses me.
12. I enjoy constructing simple equipment.
13. I would not enjoy working in a science laboratory for a summer.
14. I enjoy science courses.
15. I would enjoy participating in a science in-service program in my school district.
16. I eagerly anticipate the teaching of science to elementary school children.
17. Science is my favorite subject.

18. If I were to enroll in any college science course, I would likely be bored.

19. I prefer teaching science over any other subject of elementary school.

20. I would not like to keep a hamster in my classroom.

21. In a departmental situation or similar situation, I would like to be responsible for teaching all of the science.

22. I am apprehensive about anything that is associated with science.

23. I would read an issue of the professional journal, Science and Children, if it were in the teacher's room.

24. I would be interested in working in an experimental science curriculum project.

25. If given a choice in professional improvement, I would choose any area but science.

26. I would prefer to be a team leader in any curriculum area but science.

Appendix B

Test B

SCIENCE PROCLIVITY TEST
PIES EVALUATION PROJECT
PENNSYLVANIA SCIENCE TEACHER EDUCATION PROGRAM (PA STEP)

DIRECTIONS: For each of the questions below, "Blacken in" the correct answer on the enclosed answer sheet. **Please use a number 2 pencil only!**

1. I teach approximately ______ student-centered, activity-oriented science lessons per week.
   A. 0
   B. 1 or 2
   C 3 or 4
   D. 4 or 5
   E. more than 5

2. The number of new science lessons I added to my curriculum last year was ____
   A. 0-5.
   B. 6-10.
   C. 11-15.
   D. 16-20.
   E. more than 20.

3. The number of teachers I assisted with the development of science lessons was ____
   A. 0-2.
   B. 3-5.
   C 6-9.
   D. 10-15.
   E. more than 15.

4. The number of science new "hands-on" activities I acquired for my classes in the last year was ____
   A. 0-5.
   B. 6-10.
   C. 11-15.
   D. 16-20.
   E. more than 20.

5. I am a member of ____ professional science teachers' organizations.
   A. 0
   B. 1
   C 2
   D. 3
   E. more than 3

6. Science process skills e.g. observing, inferring, classifying, designing investigations, etc. comprise about ___% of my science lessons.
   A. 0-20
   B. 21-40
   C 41-60.
   D. 61-80
   E. 81-100

7. I have worked with administrators on science curriculum for ______.
   A. 0 days.
   B. 1 or 2 days.
   C. 3 or 4 days.
   D. 5 or 6 days.
   E. more than a week.

8. Last year, I constructed ___ science learning centers.
   A. 0
   B. 1-2
   C. 3-4
   D. 5-6
   E. more than 6

9. Last year, I used ____(number)___ of the following techniques when teaching science.

student centered	*problem solving*
discovery	*presentation*
inquiry	*integration with other subjects.*
process skills	*hands-on activities*

   A. 1 or 2
   B. 3 or 4
   C. 4 or 5
   D. 6 or 7
   E. 8

10. The word which best describes my science teaching is _____.
   A. enthusiastic
   B. interesting
   C. boring
   D. fearful
   E. anxious

11. Hands-on science activities comprise about ___% of my science lessons.
   A. 0-20
   B. 21-40
   C. 41-60.
   D. 61-80
   E. 81-100

12. How many new hands-on science lessons have you developed for your curriculum within the last year?
   A. 0-5
   B. 6-10
   C. 11-15
   D. 16-20
   E. more than 20

13. Approximately how many minutes per week (average) do you spend doing hands-on science lessons with your students?
   A. 0-15 min.
   B. 16-30 min.
   C. 31-45 min.
   D. 46-60 min.
   E. more than 60 min.

14. I have conducted science inservice programs for other teachers approximately _____.
   A. 0 days.
   B. 1 or 2 days.
   C. 3 or 4 days.
   D. 5 or 6 days.
   E. more than a week.

15. The leadership for my school's science program comes from
   A. the principal.
   B. the department chairperson.
   C. another teacher.
   D. someone outside my school.
   E. myself.

16. When I think about the administration's attitudes about my science program, I think...
   A. I have very strong support.
   B. I have strong support.
   C. I have adequate support.
   D. I have very little support.
   E. I have no support.

17. The person (principal, supervisor, etc.) who evaluates my teaching has observed a science lesson in my classroom ____ times last year.
   A. none
   B. one
   C. two
   D. three
   E. more than three.

18. When it comes to the budget for science items...
   A. I have very strong support.
   B. I have strong support.
   C. I have adequate support.
   D. I have very little support
   E. I have no support.

19. What subject do you perceive your administration feels is the most important?
   A. Science
   B. Language Arts
   C. Social Studies
   D. Art and Music
   E. Mathematics

20. My principal seems to want me to emphasize
    A. process skills.
    B. basic skills.
    C. content mastery.
    D. preparation for a standardized test.
    E. something other than the above listed items.

21. How would you rate your interest in microcomputer science laboratory interfacing (the use of microcomputers to collect, refine and display science investigation data)?
    A. Very Interested
    B. Moderately Interested
    C. Neutral
    D. Moderately Disinterested
    E. Very Disinterested

22. How would you rate your experience level in the area of microcomputer science laboratory interfacing?
    A. Very Experienced
    B. Moderately Experienced
    C. Little Experience
    D. No Experience

23. What role does the microcomputer currently play in your <u>science instruction</u>?
    A. Major role in science instruction
    B. Moderate role in science instruction
    C. Minor role in science instruction
    D. Not used in science instruction

***If you have not had a PIES Course omit questions 24 and 25.**

24. As I think back to the PA STEP-PIES course I completed I would rate its value toward improving my science teaching as:
    A. Excellent
    B. Good
    C. Average
    D. Fair
    E. Poor

25. Compared to all other college and university courses which I have taken I would rate the PA STEP-PIES course as:
    A. the best
    B. one of the best
    C. in the top 1/3
    D. in the middle 1/3
    E. in the bottom 1/3

APPENDIX C

Test A

PIES EVALUATION PROJECT
PENNSYLVANIA SCIENCE TEACHER EDUCATION PROGRAM

DIRECTIONS: For each of the questions below, blacken in the correct answer on the enclosed answer sheet. **Please use a number 2 pencil only!**

Questions 1 - 5; The following story is broken into numbered segments. Each of the numbered statements refers to one of the science process skills lettered A, B, C, D, & E. For each of the numbered statements, blacken in the letter of correct science process skill onto the answer sheet.

(1) John and Mary were walking in the forest looking at the leaves on the trees. Mary noticed the leaves possessed a wide variety of shapes.

(2) John said to Mary, I think these trees are different species. Mary began to assemble leaves from each of the trees into a pile. She counted the number of points on each

(3) leaf and placed it into a pile according to the shape and number of points on each of the leaves.

(4) John drew a sketch of each type of leaf and wrote down the number of leaves in each of the piles.

(5) "I believe we need to determine the size of the area we just observed" John said.

A. Recording data
B. Measuring
C. Inferring
D. Observing
E. Classifying

Questions 6 - 10; The story continues. Each of the numbered statements below refers to one of the science process skills lettered A, B, C, D, & E. For each of the numbered statements, blacken in the letter of correct science process skill onto the answer sheet.

(6) Mary said, "I think that if we move to another part of the forest we will see the same kinds of leaves on the trees ."

(7) We need to insure that all of the conditions of the first investigation are repeated exactly in the second experiment..

(8) Mary said she thought they could find out if forests everywhere were similar. All they need to do is write a procedure which controls the variables necessary to determine whether there is support for the hypothesis that all forests are the same.

(9) They went to another part of the forest, constructed a hypothesis, designed and conducted an investigation to demonstrate whether or not the hypothesis was acceptable.

(10) John said, "Let's write a report so everyone can learn about the trees in this forest."

A. Experimenting
B. Controlling variables
C. Predicting
D. Communicating
E. Designing experiments

11-20 Please choose the best answer and "blacken it in" on the answer sheet. Please use a number 2 pencil only!

11. A simple machine can be used to

A. store energy
B. gain work from the operation of a small force
C. change the direction of a force.
D. increase energy put into it.

12. A drinking glass containing water and ice is placed on a table in a warm room. After a time during which the glass remains untouched, droplets of moisture can be seen on the <u>outside</u> surface of the glass below the water line. The most likely explanation for the appearance of moisture on the outside of the glass is

A. the water has come out through the glass, something like osmosis in plants.
B. the ice in the water has cooled the glass below the dewpoint of the surrounding air.
C. the water from inside the glass has moved over the edge of the glass by capillary action.
D. transpiration has occurred due to uneven cooling and heating.

13. When you see a brown-eyed person, his/her eye color is caused by

A. reflection of light from the iris of the eye.
B. refraction of light by the lens of the eye.
C. emission of blue light by the iris.
D. difraction of light through the pupil of the eye.

14. A boy some distance up the railroad track from a workman holds his ear to the rail and listens to the workman drive spikes. He notes that he hears the sound of each blow twice and correctly decides it is because

A. part of the wave is reflected between the rails.
B. longitudinal and transverse waves have different speeds.
C. the speed of sound is greater in air than in a solid.
D. the speed of sound is greater in a solid than in air.

15. Of the following, the ultimate source of all food in a freshwater pond is/are the

A. microscopic green plants.
B. minnows, aquatic insects and mollusks.
C. large fish.
D. bacteria and fungi.

16. Water (150 g.) at 80 degrees Celsius is added to 150 g. of water at 20 degrees Celsius resulting in a beaker containing 300 g. of water. The best predicted temperature of the 300 g. of water would be

A. 100 degrees Celsius.
B. 60 degrees Celsius.
C. 50 degrees Celsius.
D. 40 degrees Celsius.

17. Air expired from human lungs usually contains

A. approximately the same amount of nitrogen as is present in inhaled air.
B. practically no oxygen.
C. less carbon dioxide than is present in inhaled air.
D. less water vapor than is present in inhaled air.

18. During the summer (approximately June 21 to September 21) in Pennsylvania, the noon shadow of a flag pole in a school yard will

A. be shortest half way through the summer period.
B. be longest half way through the summer period.
C. lengthen as the summer goes on.
D. shorten as the summer goes on.

19. An acidic substance can be distinguished from a basic substance by bringing the substance into contact with

A. filter paper.
B. vinegar.
C. iodine.
D. litmus paper.

20. Which of the following has the largest mass?

A. 1 kg. of feathers.
B. 1 lb. of feathers.
C. 1 lb. of gold.
D. 100 g. of gold.

21. Which of the following is an example of a chemical change?

A. Rust on a bike.
B. An Alka-Seltzer tablet in H_2O.
C. Fermentation of fruit juice.
D. All of the above.

22. A student is given a graduated cylinder containing 200 ml. of water. The student is also given a 4 cm^3 sphere of aluminum and an equal size sphere of lead. The student gently lowers the aluminum sphere into the flask and observes the water level to be 204 ml. How much additional rise will occur in the water level when the lead sphere is lowered into the cylinder?

A. 4 ml.
B. 6 ml.
C. 8 ml.
D. 16 ml.

23. Which of the following best describes an inquiry or discovery investigation?

A. The teacher discusses the results that should be obtained by performing a certain investigation.
B. The teacher describes the step by step procedure that should be followed in performing the investigation.
C. The student performing the experiment does not know the outcome of the investigation until it is completed.
D. The student used the library to determine results obtained by others who performed the same investigation.

24. A child is given a closed shoe box containing an unknown object. He/She is directed to manipulate the box, using their senses to acquire some information about the object. They are further instructed to try to draw a picture of what they think the object is. This lesson is best designed to develop skill in

A. measuring and observing.
B. observing and data collecting.
C. observing and inferring.
D. data collecting and measuring.

25. Which of the following diagrams show the expected path of light rays passing from air into and through a convex (glass) lens?