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ABSTRACT

A group of scientists and science educators at Washington State University (WSU) has developed and pilot tested an integrated physical science program designed for preservice elementary school teachers. Courses developed were: (1) fundamentals of astronomy and physics, (2) fundamentals of chemistry and earth sciences, and (3) methods for teaching elementary school science. During the project, courses were taught twice each so that student feedback could be integrated into final course materials. Assessment of student attitudes toward science showed that the cohort of participants was most positive about science and the teaching of science. This first project report provides background information; descriptions of each course; the project evaluation including the WSU science inventory test, a science attitude survey; tips on implementation and a discussion of dissemination activities. (CW)

**APPENDIX VII**

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|---|---|---|
| **NATIONAL SCIENCE FOUNDATION** Washington, D.C. 20550 | **FINAL PROJECT REPORT** NSF FORM 98A | |

*PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING*

**PART I—PROJECT IDENTIFICATION INFORMATION**

| 1. Institution and Address | 2. NSF Program | 3. NSF Award Number |
|---|---|---|
| Washington State University<br>Pullman, WA 99164-1030 | Methods & Materials Dev. | TEI-8470609 |
| | 4. Award Period From 1985 To 1988 | 5. Cumulative Award Amount $264,948.00 |

6. Project Title

A MODEL TO IMPROVE PRESERVICE ELEMENTARY SCIENCE TEACHER DEVELOPMENT

**PART II—SUMMARY OF COMPLETED PROJECT** *(FOR PUBLIC USE)*


A team of scientists and science educators at Washington State University developed and pilot-tested integrated physical science materials specifically focused for preservice elementary school teacher candidates.

Courses developed were: (1) fundamentals of astronomy and physics, (2) fundamentals of chemistry and earth sciences, and (3) methods for teaching elementary school science. During the project, courses were taught twice each so that student feedback could be integrated into final course materials. Assessment of student attitudes toward science showed that the cohort of participants was most positive about science and the teaching of science.

The course that combined astronomy and physics was approved by the University Senate to serve as a General University Requirement (GUR) in the field of physical sciences. This is a major accomplishment and one that will institutionalize one aspect of the project. The course that combined chemistry and earth sciences is in the process of being polished further. It will ultimately be recommended also for GUR status.

It is difficult to prepare a special physical science sequence for elementary school majors as there is such a breadth of topics and concepts to be covered. Further, it proved to be unrealistic to teach two semesters of the science teaching methods course. A massive over-crowding of courses that are expected for preservice elementary school teachers was one problem that was not solved.

Materials developed from the project can be adapted for use at other institutions of higher education.


**PART III—TECHNICAL INFORMATION** *(FOR PROGRAM MANAGEMENT USES)*

| 1. ITEM *(Check appropriate blocks)* | NONE | ATTACHED | PREVIOUSLY FURNISHED | TO BE FURNISHED SEPARATELY TO PROGRAM: Check (✓) | TO BE FURNISHED SEPARATELY TO PROGRAM: Approx. Date |
|---|---|---|---|---|---|
| a. Abstracts of Theses | | x | | | |
| b. Publication Citations | | x | | | |
| c. Data on Scientific Collaborators | | | x | | |
| d. Information on Inventions | x | | | | |
| e. Technical Description of Project and Results | | x | | | |
| f. Other *(specify)* Five volumes of coursework | | x | | | |

| 2. Principal Investigator/Project Director Name *(Typed)* | 3. Principal Investigator/Project Director Signature | 4. Date |
|---|---|---|
| Dr. Julie H. Lutz | | 6-15-88 |

FINAL REPORT

Submitted to the National Science Foundation

# A MODEL TO IMPROVE PRESERVICE ELEMENTARY SCIENCE TEACHER DEVELOPMENT

Julie H. Lutz, Principal Investigator
Donald C. Orlich, Principal Investigator

NSF Grant No. TEI-8470609
WSU 145 01 12V 2460 0102
Washington State University
Pullman, Washington 99164-2930
June 15, 1988

# FINAL PROJECT REPORT

# A MODEL TO IMPROVE PRESERVICE ELEMENTARY EDUCATION SCIENCE TEACHER

NSF Grant No. TEI-8470609

Julie H. Lutz
and
Donald C. Orlich

Project Co-Directors

June 15, 1988

## Background

A team at Washington State University developed a prototype program of integrated physical sciences for prospective teachers to redress the obvious imbalance of content in elementary school science. At present, teachers, lacking training in the physical sciences, do not have the confidence to teach these subjects and are therefore more likely to stress more comfortable biological sciences concepts.

In the courses that we developed, prospective elementary school teachers acquired selected knowledge and skills to cover fundamental topics in astronomy, physics, chemistry and earth sciences and the skills to relate them to the everyday world of experience. Demonstrations and hands-on activities, using simple, readily available materials, were featured in the new courses. From interviews with the selected preservice teacher candidates, who took the courses, it is apparent that they developed the confidence to use these practical and tested techniques in their classrooms, thus exciting their students' interest in science. The courses were taught in conjunction with a teaching methods course that coordinated science content, processes, and teaching strategies.

Historically, at WSU, the number of elementary education graduates ranges between 125 and 150 per year. Yet, the number of elementary school teachers who major in "natural science" (a 33 semester credit hour major) accounts for only 5% of all elementary graduates. Our data show that elementary majors typically select only one four-semester credit course in one of the physical sciences to meet the General University Requirements in science. These majors tend to avoid physical sciences courses when possible.

The obvious lack of the prospective teacher's science background became the focus of a special Provost's "Commission on Teacher Education" study at WSU during 1983-84. The Commission report (1984) requested more science for elementary majors. Robert Nilan, Dean, College of Sciences and Arts; Mike Kallaher, Chair, Department of Mathematics; Donald C. Orlich, Professor of Education and Science Instruction; Glenn A. Crosby, Professor of Chemistry; and Calvin Long, Professor of Mathematics then began monthly discussions to focus on science and mathematics education.

The group addressed: (a) the fact that too few preservice teachers major in science, (b) the problem of too few science courses specifically designed for elementary majors, and (c) the needed commitment of scientists to design a new model that would provide increased physical sciences exposure for prospective elementary teachers.

From this small group, other scientists and science educators asked or were contacted about working collectively to help solve the three identified problems. From the expanded group, a conceptual model emerged that would maximize the faculty resources of the university for the improvement of teacher education. This project report represents the fruition of that model.

The Model

The model is designed explicitly to improve the physical sciences preparation of prospective elementary teachers and has three major components.

1. Physical scientists who have a commitment to elementary teacher education designed sequences that covered selected major science concepts proposed to be taught, or that might be taught, in elementary schools for grades K-6. The design required the restructuring of course content, not simply the rearrangement of currently available texts and lectures. Project personnel modeled teaching techniques in the content courses. The course is a one year sequence of (1) astronomy and physics and (2) chemistry and earth sciences.

Lecture techniques were adapted from those proposed by Mary Budd Rowe (1983), whereby lectures are subdivided by periods of discussion among the students. This model has been shown to be successful in encouraging students to verbalize concepts and in improving students' long term memory of conc· ·ts and pl·enomena.

A "hands-on" laboratory was prepared for each course. The laboratories incorporated many demonstrations and experiments that could be done with inexpensive, readily-available materials.

2. A concurrent and coordinated science methods course was taught that (a) attempted to articulate the science content with techniques of science instruction, (b) examined and critiqued various science curricula being used in the schools (based on nationally published texts and nontext materials), and (c) illustrated methods of evaluation in science. We found it difficult to articulate content and methods on a one-to-one basis.

3. Evaluation and research elements were integrated into the project and will be discussed later.

The above model provided close cooperation between WSU's physical scientists in Astronomy, Chemistry, Geology, and Physics with science educators from the Program in General Biology, and the department of Elementary and Secondary Education and Educational Administration and Supervision. The model has been successfully tested at WSU and can be installed nationally.

Significance of the Proposed Work Goals

The project achieved two goals. The first was to provide a preservice model that can be disseminated, adapted and implemented in not only land-grant universities, but in all universities having a similar administrative organization. The second was to begin a redress of the collectively identified science deficiencies in teacher preparation existing nationally as well as on our own campus.

Impact of the Work

Our review of published studies illustrated the need for easily adaptable and transportable courses for preservice elementary teachers. Our project illustrates the methods by which human resources may be utilized to accomplish the goals and how a multi-departmental effort to improve science education may be designed and implemented in teacher preparatory institutions. The ultimate impact of this project will be to provide quality science experiences for elementary school children, who, on an average, currently are being exposed to between 16 and 30 minutes of science per week!

Internal Planning and Development Team

During the fall semester of 1985 a group of scientists and science educators met to plan this project and to incorporate the plan into WSU's teacher education program. Faculty participants in the project were:

Toshio Akamine, Professor of Educational and Couseling Psychology

Paul Bender, Associate Professor of Physics

Ronald W. Brosemer, Professor of Chemistry

Glenn Crosby, Professor of Chemistry

Miles Dresser, Associate Professor of Physics

Jack Horne, Director, Science Learning and Instructional Center

Mike Kallaher, Chair, Department of Mathematics

Julie Lutz, Professor of Astronomy and Planetarium Director and Co-Director of this NSF project.

Kirk McMichael, Associate Professor of Chemistry

James Migaki, Associate Professor of Education

Donald Orlich, Professor of Education and Science Instruction and Co-Director of this NSF project.

Gary Webster, Professor of Geology

Maurice Windsor, Professor of Chemistry

The project secretaries were Judith A. Lyon and Charm Arneson. Student Graduate Assistants who aided were: Paul E. Adams, Gail McCurdy, Jim Goodwin, Keith Wells, Bonnie Jimison, James Dull, Thomas Wood, Christine Sordorff, James Vanderhusen, Kevin Jordan, Cathleen Brenner, Tom Gougeon, and Eric Weberg.

## Implementation Phases

The project had a three year time span and consisted of six distinct phases.

1. Phase one began during the Summer and Fall of 1985. The project was funded too late to recruit students for the fall term. Thus, materials for instructional development were collected and analyzed. Laboratory procedures were prepared for the physics and astronomy components and the accompanying science methods course. Plans to train teaching assistants were devised. Letters were sent to all elementary education majors and project personnel visited

classes to make students aware of the availability of the courses starting in spring semester.

2. Phase two began in Spring Semester 1986 with the actual prototype-testing of materials in the eight-week astronomy component followed by the eight-week physics part.

3. Phase three focused on formative evaluations and the consequent adjustments needed in the course components for earth sciences and chemistry that were initially taught the Fall Semester of 1986.

4. Phase four initiated an eight week block of physics and astronomy in Spring 1987, followed in the fall 1987 by chemistry and earth sciences.

5. Phase five, Summer 1987, constituted the preparation of the final set of materials and procedures by which the project was implemented during the 1987-88 academic year.

6. Phase six will be a culmination of dissemination efforts.

## Component Course Descriptions

There are five distinct disciplinary components to our model. These are: (1) physics, (2) chemistry, (3) earth sciences, (4) astronomy, and (5) science teaching methods. It should be noted that evaluation and research aspects are continuous in each of the five components.

Physics

The Physics block has three primary goals. The first goal is to provide prospective elementary teachers with some basic reasoning skills. The second goal is to instruct prospective teachers on a variety of physical concepts that are relevant to the intellectual growth of children. The third is to provide prospective elementary teachers with the necessary physical sciences background so that they may pursue other physical science topics with understanding.

It was our intent to provide the prospective teacher with sufficient subject content, laboratory exercises, and lecture demonstrations so that teachers will be able to translate these topics to their classes without anxiety, and at an appropriate level for understanding. This goal proved to be most difficult to accomplish, largely because the students have little experience in thinking about what happens in the physical world.

The sequence of topics in the physics list can be divided into six groups: (a) mechanics, (b) heat, (c) electricity and magnetism, (d) waves and optics, (e) atomic and nuclear theory, and (f) integrated historical concepts.

Chemistry

Virtually no chemistry is taught in the elementary schools, and it was the intent of this project to rectify the situation. Because of the novelty of the proposed course for elementary teachers, however, explanations of <u>why</u>

and a description of how the chemistry component should be taught are relevant. Teachers should be able to help children classify matter, recognize the properties of solids, liquids, and gases, and understand what a separation is.

The heart of chemistry is chemical reactivity. Prospective teachers need to understand reactivity and be able to run simple reactions themselves. There are many simple reactions that children can also do that are not dangerous, but are colorful and exciting.

Teachers should understand that atoms and molecules are constructs, theories manufactured by the human mind. Some atomic and molecular theory would be necessary so that the science of chemistry would make sense to prospective teachers and allow them to organize their knowledge efficiently.

Teachers need to be able to develop their ability to relate common chemicals and their properties to everyday materials (cleaners, plastics, fuels, oils, waxes) and experience.

Teachers need to acquire a basic understanding of chemistry so that they can help the child relate to the physical environment. Exposure to relevant chemistry that integrates principles is a must.

The chemistry laboratory dwells on content, but the experiments are designed around simple apparatus so that the prospective teachers would learn how to work with inexpensive, easily acquired, equipment. Whenever possible, household products were employed in the lab. Further development of this aspect will continue as the goal proved to be more difficult to attain than originally planned.

Earth Science

Earth Science is founded on the fundamental principles of physics and chemistry and the interpretations of observations of naturally occurring processes on the Earth. Utilizing the principles presented in the physics and chemistry parts of this sequence, the Earth Science section covered topics that were basic to an overall knowledge of the Earth's materials and formation and the processes which continually affect the Earth. Emphasis is placed on presenting modern concepts and theories along with well established descriptions.

Elementary teachers usually present beginning Earth Science in the 3rd through 6th grades. However, an understanding of the fundamentals of Earth Science should help the elementary teacher at all levels since these fundamentals have applications in many disciplines and relate well to the other sciences. The basic concepts of the following topics formed the course organization.

Plate tectonics. The theory of plate tectonics has been verified in the past 25 years. The concept is fascinating to most students. The prospective applications to mineral occurrences, earthquake zones and volcanism are discussed in recognition of plate tectonics.

Earthquakes and volcanism. Modern communications have brought the public awareness of natural disasters to a level that demands a general basic knowledge of these events. The cause of earthquakes and volcanism and associated phenomena such as mudflows and rockslides is now understood to the extent that geologists are cautiously starting to predict when and where they will occur.

Geologic processes. Minerals and rocks, earth resources and the recognition of the complex relationships among environment, habitation and human exploitation of natural resources cannot be comprehended without a basic knowledge of Earth Science. The influence of Earth Science on the political and social structure of the world is not fully presented to as many students as possible at an early level. The concepts and theories of Earth Science are understandable by elementary students and should be presented to them so that they may apply them where applicable. However, this aspect of the project yet needs revision to be more useful to elementary teachers.

Astronomy

Astronomy is one of the most exciting, interesting and rapidly-changing subjects studied by elementary school children. Astronomy topics are found throughout the curriculum for elementary school science and this course was designed to address traditional topics, as well as new discoveries.

The Astronomy section reinforced concepts introduced in physics and chemistry. Astronomy is somewhat different from physics, chemistry and earth sciences since, for the most part, astronomers must rely upon observing and analyzing the radiation from planets, stars and galaxies rather than doing direct experiments.

The first part of the course is devoted to the phenomena that can be seen in the sky without the aid of telescopes. The earth's rotation and revolution, the seasons, eclipses and the motions of the moon and planets are discussed. As part of the laboratory, the students learned to identify bright stars and prominent constellations.

Other topics covered in the course include a brief history of astronomy; astronomical equipment and modern space astronomy; the planets, satellites and other bodies in the solar system. Basic properties of stars, stellar evolution, galaxies and the universe are mentioned only briefly.

## Project Evaluation

Course materials were judged systematically by the staff and students. Collectively, the team addressed a series of questions; each of which is discussed below.

### General Protocols

1. How effective were the project components toward promoting the overall concept of scientific literacy?

Based on team meetings and student interviews, it was concluded that the totality of project components did promote scientific literacy better than do college science courses that are oriented toward the majors in a discipline, or a "general" non-science student audience.

Further testimony to this aspect is that the fundamental of physical sciences courses that integrate astronomy and physics was approved by the Washington State Faculty Senate to be approved as a General University Requirement in the sciences. This is a measure of great magnitude.

All students who participated in the project were able to complete the courses successfully. Again, this indicates a measure of the program's efficacy.

All student participants were interviewed at the conclusion of each year of the project. There was unanimous agreement that the project was a "highlight" of each year for these volunteer students (all undergraduate teacher preservice).

2. How effective were the teaching strategies?

Student evaluations of the courses indicated that the combined set of teaching strategies was effective and that the professors did model appropriate techniques by which to teach science.

Each student participant micro-taught classes in the methods courses. These practice lessons were modeled to the specifications established by instructors. The micro-taught lessons gave evidence of behaviors endorsed by the project.

3. How appropriate were the physical characteristics, rationales, goals, objectives, and general formats?

Again, frequent faculty discussions and informal evaluations tended to support elements associated with the project. Perhaps, one major problem that occurred was that in every case, faculty members had prepared and planned to accomplish content far in excess of what could actually be delivered. Time is a critical factor in the life of a college student and the professor as well.

The team of chemistry professors found it very difficult to reduce the vast array of chemical concepts and principles into an exportable short course. That difficulty is illustrated by the fact that the team continues to develop the chemical short course that meets their own expectations. It is difficult to synthesize essential learning of a scientific discipline.

4. How appropriate were instructional designs, formats, contents, topics, sequencing, and inter -disciplinary integration?

In part, this question was addressed in number three above. However, an unanticipated major problem came with trying to integrate concepts with the methods course. Initially we tried to provide a parallel (one-to-one correspondence) with the science concepts. That attempt proved to be impossible. Science topics just do not lend themselves to easy translation to instructional techniques.

5. How effective was the integration of computer usage with materials development?

Our experiences showed the problem of time constraints associated with student programs was far more serious than was originally assumed. Some articulation was attained by using the Science Learning and Instructional Center by students. But, we found that the time demands on students was too great to integrate the predicted consequences in any meaningful manner. A greater problem was to identify appropriate computer software.

Overall, the team devoted a great deal of time coordinating activities with each other. The project director found that her time was being spent far in excess to what she had anticipated. It is a time-consuming and energy absorbing process to use instructional teams and to integrate science teaching with five different areas.

We would suggest that future NSF projects allocate even greater amounts of time to project personnel.

Impact on Teacher Training

1. How well were the preservice teachers' needs addressed by the materials?

Student interviews and evaluations showed that the materials and special treatment given to the participating students was highly regarded. Students' summed up this aspect of the project as being "most exciting." They used the materials and understood science and scientific epistemology.

2. To what extent was the overall design effective for preservice training?

The design proved to be effective. However, the restraints placed on elementary preservice students by education and certification requirements tended to have a negative impact. That is, there is a very large emphasis on reading and language arts in the teacher training programs. That emphasis leaves little time for expanding science instruction. In one sense, there are "turf" problems that we simply underestimated at the development stage.

Of course, the use of professors only was a very strong point as far as students were concerned. The students remarked that they had never had a course sequence that had major professors entirely, rather than teaching assistants.

3. How readily is the model exportable to other institutions?

In our opinion, the model may be adapted to fit the circumstances of any land grant or research university having faculty flexibility and administrative commitment.

Student Accomplishments

Each course had prepared specific tests and some are included in the respective reports. We found it challenging to prepare criterion referenced tests and appropriate laboratory exams that tested at levels above "knowledge."

While there was a distribution of student grades; all students in the project were successful. This illustrates project efficacy.

Student Attitudes. We used two published attitude scales: "Test on Understanding Science" (TOUS) and the "Shrigley Attitude Toward Teaching Science" scale. We also constructed a 22 item "WSU Science Attitude Scale." The results are discussed briefly below.

Test on Understanding Science. The TOUS has three areas or themes: (1) understanding the scientific enterprise, (2) understanding scientists, and (3) understanding methods and aims of science. Students who were enrolled in the project courses had only three areas significantly different on only three themes of 15 comparisons. That datum compares to 10 areas with significant differences for students enrolled in nonproject elementary science methods courses.

We interpret these findings to show that the group who volunteered for project courses had a better understanding of science than the typical elementary student.

Shrigley Attitude Toward Teaching Science. The Shrigley scale yielded some interesting results. Table 1 shows how various groups tested on the four main subscales of this attitude scale. It should be noted that the project students had a better attitude toward science at the end of the year than did the sample of elementary majors enrolled in the nonproject science teaching methods courses.

On the pretests, project students showed significant differences on three of the four scales when compared to nonproject students. That number dropped to one on the post-tests. But, observe how the standard deviations tended to decrease on all groups--indicating that there was a positive shift in attitude by all students after attending the science methods courses.

Table 1. Shrigley Science Attitude Scale--Subscales

| | Project Students | | | |
|---|---|---|---|---|
| | Pre | | Post | |
| Subscale | Mean | S. D. | Mean | S. D. |
| Antipathy | 4.3810 | 0.756 | 2.1908 | 0.836 |
| Science Content | 3.9048 | 0.666 | 3.3810 | 0.599 |
| Handling Science Equipment | 4.7143 | 0.559 | 3.9524 | 0.381 |
| Teaching Science | 4.4286 | 1.602 | 3.9429 | 0.443 |
| | Other Education Majors | | | |
| | Pre | | Post | |
| Antipathy | 3.2745 | 1.162 | 3.0392 | 1.006 |
| Science Content | 2.9118 | 0.858 | 2.8922 | 0.806 |
| Handling Science Equipment | 3.4510 | 0.707 | 3.7941 | 0.591 |
| Teaching Science | 4.2235 | 2.060 | 3.6471 | 1.207 |

WSU Inventory. The WSU Inventory was developed by project personnel under the leadership of Toshio Akamine, Professor of Counseling and Educational Psychology. The inventory had two main parts: (1) student feelings toward science and (2) conditions that needed improvement in science education.

Observe on Table 2 the rank-orders for 10 items relating to feelings about science. Our students ranked as their top feeling that there ought to be greater emphasis on science instruction in public schools. Further, the students feel that they are likely be become very good at teaching science and would especially enjoy teaching science.

Table 3 shows how the groups ranked needed improvements for science instruction. They ranked as number one, emphasizing critical thinking and problem solving methods in the school curriculum grades 1-8. In second place was the need for increased emphasis on experiments or hands-on activities in grades 1-8.

These general findings from the WSU Inventory suggest that when students complete their science methods courses, they have a very positive attitude about science teaching and the improvements they see as needed reflect more of how science educators feel than teachers in the field. No question, science educators do affect the attitudes of preservice teachers.

Figure 1 displays the WSU Inventory.

FIGURE 1. WSU SCIENCE INVENTORY

DIRECTIONS

The purpose for this survey is to obtain first-hand information concerning your feelings and opinions about science and science education. Your candid answers will help us evaluate and improve our approach to science instruction.

Please take a few minutes and answer all of the questions in this questionnaire. This is an anonymous survey, therefore, please feel free to respond frankly to each question.

Please answer each question by choosing one of the response options provided for the question, and placing a check mark in the space provided to indicate your answer. You may also write in additional comments to explain your answer further if you wish.

When you have finished, return the questionnaire to your instructor. Thank you.

PART I. BACKGROUND INFORMATION

Please place a check mark in the space provided to indicate your answer to each question.

1. SEX: 1 [ ] Male 2 [ ] Female

2. AGE: 1 [ ] 19 years or younger
2 [ ] 20 to 24 years
3 [ ] 25 years and older

PART II. FEELINGS ABOUT SCIENCE AND SCIENCE EDUCATION

Read each of the following statements carefully and indicate how you feel about it by choosing one response option that best represents your feeling.

Use the following code:
1 -- Strongly Disagree
2 -- Disagree
3 -- Undecided
4 -- Agree
5 -- Strongly Agree

3. Science has been one of my favorite subjects.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

4. My own background in science is fairly good.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

5. As a classroom teacher I would especially enjoy teaching science classes.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

6. I am likely to become very good at teaching science.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

7. There ought to be a much greater emphasis on science instruction in public schools.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

8. The course contents, teaching methods, and learning activities I have experienced in EDUC 304 (or EDUC 311/312) this semester have prepared me well for teaching science in the elementary school.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

9. The quality of science instruction I have received at the college or university level is excellent.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

10. The quality of science instruction I received while I was in the elementary school was excellent.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

11. The quality of science instruction I received while I was in the junior high school was excellent.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

12. The quality of science instruction I received while I was in the senior high scho . was excellent.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

PART III. IMPROVEMENTS NEEDED IN SCIENCE EDUCATION

Listed below are several categories of potential needs for improvement in the area of science education. Please indicate how critical the need is for each category.

Use the following code:
1 -- Not important
2 -- Of minor importance
3 -- Of some importance
4 -- Important
5 -- Very important

13. Improving a teacher's own knowledge of the science subject matter.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

14. Efforts on the part of the teacher to keep up with the up-to-date scientific information and developments.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

15. Increasing the amount of time allocated for science instruction in grades 1 through 8.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

16. Increased emphasis on the method of scientific inquiry in grades 1 through 8.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

17. Increased emphasis on the latest scientific knowledge and developments.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

Use the following code: 1 -- Not important
2 -- Of minor importance
3 -- Of some importance
4 -- Important
5 -- Very Important

18. Increased emphasis on experiments or hands-on activities in grades 1 through 8.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

19. Providing students in grades 1 through 8 with first-hand experience with scientists and scientific activities.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

20. Emphasizing critical thinking and problem solving methods in the school curriculum in grades 1 through 8.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

21. Decreasing the number of science courses at the university level for prospective elementary school teachers.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

22. Providing more diversity of science courses at the university level for prospective elementary school teachers.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

23. Decreasing the number of science teaching methods courses in the teacher education program.
1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

Please add any comments relating to science or science education.

TABLE 2. WSU INVENTORY COMBINED RESULTS ON FEELINGS

| Item | Rank | Mean* | Med. | S.D. |
|---|---|---|---|---|
| 3. Sc ence has been one of my favorite subjects. | (5) | 2.878 | 3.0 | 0.980 |
| 4. My own background in science is fairly good. | (4) | 3.098 | 3.0 | 1.068 |
| 5. As a classroom teach : I would especially enjoy teaching science classes. | (3) | 3.415 | 4.0 | 0.805 |
| 6. I am likely to become very good at teaching science. | (2) | 3.512 | 4.0 | 0.779 |
| 7. There ought to be a much greater emphasis on science instruction in public schools. | (1) | 4.146 | 4.0 | 0.615 |
| 8. The course contents, teaching methods, and learning activities I have experienced in EDUC 304/311/312 this semester have prepared me well for teaching science in the elementary school. | (8) | 2.634 | 2.0 | 1.178 |
| 9. The quality of science instruction I have received at the college or university level is excellent. | (6.5) | 2.854 | 3.0 | 0.981 |
| 10. The quality of science instruction I received while was in the elementary school was excellent. | (10) | 2.325 | 2.0 | 0.944 |
| 11. The quality of science instruction I received while I was in the junior high school was excellent. | (9) | 2.585 | 2.0 | 1.117 |
| 12. The quality of science instruction I received while I was in the senior high school was excellent. | (6.5) | 2.854 | 2.0 | 1.295 |

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*Coding

1 = Strongly Disagree
2 = Disagree
3 = Undecided
4 = Agree
5 = Strongly Agree

TABLE 3. WSU INVENTORY: NEEDED IMPROVEMENTS IN SCIENCE EDUCATION

| Item | Rank | Mean* | Med. | S.D. |
|---|---|---|---|---|
| 13. Improving a teacher's own knowledge of the science subject m tter. | (5) | 4.293 | 5.0 | 1.078 |
| 14. Efforts on the part of the teacher to keep up with the up-to-date scientific information and developments. | (4) | 4.366 | 5.0 | .827 |
| 15. Increasing the amount of time allocated for science instruction in grades 1 through 8. | (7) | 4.220 | 4.0 | 0.690 |
| 16. Increased emphasis on the method of scientific inquiry in grades 1 through 8. | (8) | 4.146 | 4.0 | 0.727 |
| 17. Increased emphasis on the latest scientific knowledge and developments. | (9) | 3.976 | 4.0 | 0.851 |
| 18. Increased emphasis on experiments or hands-on activities in grades 1 through 8. | (2) | 4.585 | 5.0 | 0.774 |
| 19. Providing students in grades 1 through 8 with first-hand experience with scientists and scientific activities. | (6) | 4.275 | 4.0 | 0.784 |
| 20. Emphasizing critical thinking and problem solving methods in the school curriculum in grades 1 through 8. | (1) | 4.610 | 5.0 | 0.494 |
| 21. Decreasing the number of science courses at the university level for prospective elementary school teachers. | ** | 1.789 | 1.0 | 1.166 |
| 22. Providing more diversity of science courses at the university level for prospective elementary school teachers. | (3) | 4.390 | 5.0 | 0.737 |
| 23. Decreasing the number of science teaching methods courses in the teacher education program. | ** | 1.641 | 1.0 | 1.013 |

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*Coding

1 = Not Important
2 = Of Minor Importance
3 = Of Some Importance
4 = Important
5 = Very Important

** Results not directly interpretable due to item construction.

# SHRIGLEY SCIENCE ATTITUDE SCALE

Below are 20 statements. Please read each statement then to the right circle your response code number by using the following code:

5 = I strongly agree
4 = I agree
3 = I have no opinion
2 = I disagree
1 = I strongly disagree

| | | | | | |
|---|---|---|---|---|---|
| 1. I daydream during science class. | 5 | 4 | 3 | 2 | 1 |
| 2. I would like to have chosen science as a minor in my elementary education program. | 5 | 4 | 3 | 2 | 1 |
| 3. I dread science classes. | 5 | 4 | 3 | 2 | 1 |
| 4. Science lab equipment confuses me. | 5 | 4 | 3 | 2 | 1 |
| 5. I enjoy manipulating science equipment. | 5 | 4 | 3 | 2 | 1 |
| 6. I am afraid young students will ask science questions I cannot answer. | 5 | 4 | 3 | 2 | 1 |
| 7. In science classes, I enjoy lab periods. | 5 | 4 | 3 | 2 | 1 |
| 8. Science is my favorite subject. | 5 | 4 | 3 | 2 | 1 |
| 9. If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school. | 5 | 4 | 3 | 2 | 1 |
| 10. My science classes have been boring. | 5 | 4 | 3 | 2 | 1 |
| 11. I would enjoy helping children construct science equipment. | 5 | 4 | 3 | 2 | 1 |
| 12. When I become a teacher, I fear that science demonstrations will not work in class. | 5 | 4 | 3 | 2 | 1 |
| 13. I enjoy college science courses. | 5 | 4 | 3 | 2 | 1 |
| 14. I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it. | 5 | 4 | 3 | 2 | 1 |
| 15. I would be interested working in an experimental elementary science curriculum project. | 5 | 4 | 3 | 2 | 1 |
| 16. I enjoy discussing science topics with my friends. | 5 | 4 | 3 | 2 | 1 |
| 17. Science is very difficult for me to understand. | 5 | 4 | 3 | 2 | 1 |
| 18. I expect to be able to excite students about science. | 5 | 4 | 3 | 2 | 1 |
| 19. I frequently use science ideas or facts in my personal life. | 5 | 4 | 3 | 2 | 1 |
| 20. I believe that I have the same scientific curiosity as a young child. | 5 | 4 | 3 | 2 | 1 |

Staff Perceptions

Frequent meetings of the project staff were held to determine progress and to solve problems. First, the content of the courses was deemed to be in constant need of review so that appropriate content would be presented in the short time span. This area required more discussion among the project staff than any other item. Even at the conclusion of the project, the chemistry team feels frustrated that they yet have too much content and want to pilot test another version of their efforts.

To be adopted elsewhere, the strategies and format of the project could be duplicated.

Media use would probably be enhanced, but due to time constraints of getting through the lecture/laboratory material, greater use of media might be used as enrichment only.

Laboratories and lab set-ups were perceived as adequate. However, the initial development of laboratories proved to be very time consuming.

The methods course print items tended to be adequate. However, there is the need for the elementary education faculty to reevaluate their adopted "infusion" model. It was apparent that topics that elementary faculty stated they had already taught via infusion in other courses had not been assimilated by the students. It would be better for elementary majors to have one generic methods course prior to taking any others. This generic course would provide entry level knowledge about objectives, sequencing instruction, hierarchies of learning, lesson planning, questioning, and discussion leading. These were notoriously lacking by all students and had to be taught concurrently in the science methods course so that inquiry strategies would make sense.

We consistently had a problem collecting, coding and retrieving evaluation data. We recommend that in future projects, the NSF encourage a 0.5 time person or research assistant who would be solely responsible for collecting and interpreting evaluation and research data. Perhaps, it would be appropriate to support a 0.5 time faculty member for the entire duration of any such project.

Tips On Implementation: A Short Manual

The WSU project team pilot-tested sets of materials with the goal of preparing a one-year physical sciences course for elementary school preservice teachers. Accompanying that goal, the team prepared an innovative science teaching methods course. Now comes the major question, "How can others in similar institutions of higher education adopt and adapt the project materials?" Our experience from this project yields 10 specific tips.

1. There must be a genuine commitment by scientists and science educators to collaborate. Collaboration means just that--working together, compromising, and supporting each other. Faculty must agree on the nature and limitations of a physical science course that has a limited focus--elementary teacher training.

We recognize that universities are "loosely coupled." That is, assembly line and production metaphors cannot be applied to higher education issues. Loose coupling implies that individual professors work at their own paces and on problems of their own choosing. These issues are basic tenets of academic freedom and professionalism. Deans or chairs simply cannot order faculty members "to collaborate" on a science education project. Our experience shows that when interested individuals share a common perspective, then a collaborative effort is possible.

2. Innovations occur because of an accumulation of results that build on the past. We did not discard science courses and rebuild new ones. Instead, we adapted materials from courses that were in existence and built novel elements in them to accommodate our targeted clientele.

To this end, our project evolved through seven phases: (1) mutual problem identification, (2) agreement on seeking possible solutions, (3) idea generation and consensus on a proposal for improvement, (4) trial periods, (5) refinements of products, (6) implementation, and (7) dissemination.

3. We had a manageable project. The quality of the change was more important than the size. We did not try to improve or change all of elementary science education. We identified one part of a problem that could be solved. When this problem is solved, we might attack the broader problem of elementary science education, per se.

4. Our project was labor intensive. We did not rely on high technology. Sophisticated technology is now emerging. However, if any high tech component breaks down, the innovation is "in trouble." Yes, we acknowledge video disks, computer interactive systems, and the like. But, the current state-of-the-art is far too expensive for universities to adopt them. This condition will undoubtedly change in the future, but for the next few years institutions of higher education seeking to innovate in the field of elementary science education will yet have to rely primarily on the human resources not technological ones.

5. The implementation of an instructional innovation is directly related to immediate administrator support. The Dean of Sciences and the respective chairs in the academic departments supported this project to a full extent. That support is obvious, when one considers that a major General University Requirement in physical sciences came directly from this project.

At this point, it is not clear what will happen in the Department of Elementary and Secondary Education for future collaboration with the sciences.

Further, there is a need for respective administrators to provide personnel (FTE) to instruct in the project. We were fortunate in having research faculty members who desired to help improve elementary science education. Such an attitude is a necessary prerequisite for implementation in other research universities.

6. We found it rather easy to innovate in the area of curriculum and instruction. There were few changes needed in the organization or administration of the departments. Elaborate organizational structures were not needed to propel this project to success. However, the project Co-Director spent much time arranging and rearranging schedules and coordinating activities.

7. There was a critical mass of advocates who supported this project. A major project cannot be a one person show. This aspect illustrates the power of "ownership" to yield successful projects. All the

professors who played a role in this project were involved in the planning and, in most cases, the writing of the NSF proposal that ultimately supported their collective efforts.

There was no "strong arming" of anyone. There was group agreement on goals and purposes of the project. Any groups desiring to adopt this program must spend quality time determining if they are truly in agreement on philosophy and goals of elementary science education.

The project team spent hours on curriculum design, on team work to solve problems, and on work to provide a high quality set of courses.

8. It costs money to innovate. The amount of faculty and staff time that it took to plan, design, pilot test and revise the courses was far in excess of what the NSF grant supported. Problem solving and collaborative curriculum design requires an inordinate amount of interaction to achieve thoughtful discussion and action.

9. The implementation of an innovation is basically a political process. The sciences and educational groups had to seek internal support for the project. The respective faculties will determine the ultimate fate of the project elements at WSU--and at other institutions as well.

10. The project leader is critical to the success of the project. It was the leader who called team meetings, arranged for problem solving agendas, aided in forward planning, prepared schedules, directed the organizational

elements, and maintained liaison with respective department chairs, deans and associate deans.

To repeat, curriculum changes are complex processes requiring faculty energy. Instructional changes require a "pay off" to those involved and to the students.

It took our team about three years to produce and partially implement this project. It may take two more years to implement the project fully. Those involved in a project must be committed to it for at least three to five years. Such a commitment is essential for success.

In conclusion, effective implementation of this small change in the preparation of prospective elementary school teachers is really contingent on supportive local conditions, not perceived national crises.

## Dissemination

Dissemination of project activities reflected many formats. Below is a listing of all papers, presentations and informal sessions given about the project at local, state, regional or national meetings. Additionally, other papers for appropriate science education journals will be completed and submitted later in 1988.

"Astronomy and Space Sciences for Elementary Teachers." A discussion at Voyager 2 Educators Conference, Jet Propulsion Laboratory, Pasadena, January 24, 1986, J. H. Lutz.

"A Project to Improve Preservice Elementary Science." Presentation at Principal Investigators' Meeting, NSF, Science and Engineering Education Section, San Jose, Calif., March 23 and 24, 1986, J. H. Lutz.

"Quality Science Education: Leading and Administering Curriculum Change." Invited presentation, OMSI, Portland, Oregon, May 15, 1986, D. C. Orlich.

"Astronomy Content and Methods Courses for Elementary Education Majors," the 98th Annual Scientific Meeting of the Astronomical Society of the Pacific, July 14-17, 1986, Boulder, Colorado, J. H. Lutz and D. C. Orlich.

"Physical Sciences for Elementary Teaching Majors." Paper presented at the American Association of Physics Teachers, Washington, D. C., October 25, 1986, M. J. Dresser.

"A Model for Science Education Improvement." Washington Science Teachers Association, Annual Meeting, Tacoma, November 1, 1986, D. C. Orlich and J. C. Horne.

"Chemistry Applications for Educators." Presentation at Washington Science Teachers Association, State Convention, Tacoma, November 1, 1986, G. A. Crosby.

"Design Problems: Elementary Science Education." Paper presented at the National Science Teachers Association, Regional Convention, Las Vegas, Nevada, November 23, 1986, J. H. Lutz and D. C. Orlich.

"The Creation of Preservice Teacher Physical Science Sequence: A Progress Report," National Science Teachers Association, Refereed Paper, Regional Convention, Anchorage, December 6, 1986, D. C. Orlich and J. H. Lutz.

"A Project to Improve Elementary School Science Teaching," Discussant and abstract, NSF Meeting of Project Directors, Science and Engineering Education Section, Washington , D. C., March 27, 1987, D. C. Orlich.

"Developing an Ideal Science Methods Course." Presentation at the National Science Teachers Association, Annual Convention, Washington, D. C., March 27, 1987, J. M. Migaki.

"Redefining a Physical Science Sequence for Preservice Elementary School Teachers." Presentation at the National Science Teachers Association, Annual Convention, Washington, D.C., March 27, 1987, J. H. Lutz.

Refereed Paper, "Designing Physical Science Experiences for Preservice Elementary Teachers." Association for the Education of Teachers in Science, National Conference, Washington, D. C., March 28, 1987, D. C. Orlich, J. H. Lutz and J. M. Migaki.

Refereed paper, "Process and Attitudinal Changes of Participants in an Elementary School Preservice Science Project." National Science Teachers Association, National Conference, Washington, D. C., March 29, 1987, D. C. Orlich, J. H. Lutz and J. M. Migaki.

"Integrating Physical Science in Methods Courses," Panel Presentation, Science for Handicapped Conference, Lawrence hall of Science, Berkeley, Calif., June 25, 1987, J. C. Horne.

"A College Course in Astronomy and Physics for Elementary Education Majors: What Worked and What Flopped in the Laboratories." Presentation at Astronomical Society of the Pacific, Pomona, Calif., July 15, 1987, J. H. Lutz.

"Instructional Strategies: A Research-Based Analysis," Invited presentation, Battelle Pacific Northwest Laboratories, Richland, WA, August 7, 1987, D. C. Orlich.

In-Service Workshop for 4th, 5th, and 6th Grade Teachers, District 81, Spokane, 2-day Workshop, August 1987, G. A. Crosby.

"Policy-Making for Science Education." Invited presentation, Central Kitsap Board of Directors, Silverdale, WA, September 2, 1987, D. C. Orlich.

"Physical Science Teacher Education and Women." Testimony given before the Congressional Task Force on Women, Minorities and the Handicapped in Science and Technology, Albuquerque, New Mexico, September 22, 1987, J. H. Lutz.

"Chemistry Activities for the Elementary Classroom," Washington Science Teachers' Association, Fall Conference, Washington State University, October 1987, G. A. Crosby.

Preservice Materials Display, Washington Science Teachers Association, State Convention, Pullman, November 30-31, 1987, J. C. Horne, J. H. Lutz and D. C. Orlich.

"Cosmic Fun and Learning," a 2 hour workshop presented at the Washington Science Teacher's Association, State Convention, Pullman, Washington, November 30-31, 1987, J. H. Lutz.

"A Model for Preservice Physical Science Education." Presentation at Advisory Meeting, Curriculum Research and Development Group, University of Hawaii, Honolulu, January 1988, D. C. Orlich.

"A Cooperative Design to Improve Preservice Teacher Science Education." Presentation at Arizona Alliance for Mathematics, Science and Technology Education, Luncheon, Tucson, February 22, 1988, D. C. Orlich.

One-day Teachers Workshop (junior/senior high), sponsored by the local American Chemical Society Section, Greensboro, N.C., March 1988, G. A. Crosby.

"Problems of Articulating Preservice and Inservice Education for Elementary Schools Teachers." Informal presentation, Association for the Education of Teachers in Science, NSTA, St. Louis, Missouri, April 7, 1988, D. C. Orlich.

"Introductory College Science Courses," Conference Participants, Washington, D. C., June 5-8, 1988, R. Brosemer, G. A. Crosby, J. C. Horne, and K. McMichael.

"Physical Sciences Courses for Elementary Education Majors: The Role of Astronomy." Presentation, American Astronomical Society Meeting, Kansas City, Kansas, June 7, 1988, J. H. Lutz.

Donald C. Orlich, Julie H. Lutz and James M. Migaki (1988). "The Creation of a Teacher Physical Science Sequence--A Progress Report." Washington Science Teachers' Journal, 28(2), 6-11.

Dissemination of the project's activities were also made on the local, regional, and state media. For example, Radio Station, KING of Seattle, tape recorded a 15 minute session in 1985 with D. C. Orlich concerning science education and how this project could improve teaching. Several articles were published in the Hilltopics, the WSU monthly Alumni newspaper that goes to over 65,000 persons. The Spokane newspaper, The Spokesman Review carried a laudatory editorial about the project on November 12, 1985. Numerous local releases were carried in the Pullman Herald and The Daily News and the Lewiston Tribune. These releases covered the span of the project. The WSU News Bureau personnel took great interest in the project and maintained systematic contact with all project personnel.

As project personnel participated in state, regional or national conventions, requests for materials followed. From the NSTA conventions many different requests for information about the program or materials were made. Of course, we anticipate that the NSF will forward the five volumes attached for dissemination to ERIC's Resources in Education.

Requests for information came from national and international sites. A listing of written requests is provided in Appendix A.

Courses Prepared and Delivered

1. EL/SE 311, 3 credits, Teaching Elementary Physical Sciences. Instructors: D. C. Orlich and J. M. Migaki.

2. EL/SE 312, 3 credits, Teaching Elementary Physical Science II. Instructor: J. M. Migaki.

3. (Astr 250) Phy Sci 250, 4 credits, Physical Sciences for Elementary Teachers. J. H. Lutz, M. J. Dresser and P. Bender.

4. (Astr 251) Phy Sci 251, 4 credits, Physical Sciences for Elementary Teachers, R. W. Brosemer, G. A. Crosby, K. McMichael, and G. Webster.

To expedite course delivery, the astronomy prefix (Astr) was used as a course designation until Spring of 1988.

Student recruitment. As the grant for this project was approved in the summer of 1985, it was too late to initiate the classes during the fall semester 1985. However, during the summer of 1985 over 200 letters were mailed to all certified elementary teaching majors informing them about the NSF project, the anticipated courses and the revised schedule

These students were provided with a self-addressed envelope and a form by which we could follow-up. During the advising periods of the fall semester (August) and spring semester (December) all elementary faculty advisors were contacted and provided with information about the courses and the program. Informational materials were distributed to all advisors and were provided at the Cleveland Hall registration sites for elementary majors.

During the fall semester Co-Directors, Lutz and Orlich addressed the entry classes of Education 300 and Mathematics 200 to provide detailed information about the course schedules. Informal coffee and cookie social hours were scheduled in both Cleveland Hall (Education) and Sloan Hall (Mathematics and Astronomy) to meet students, answer questions, and to recruit. Presentations were also given in various mathematics classes required of elementary school majors.

Such recruitment mechanisms were used during each semester of the project's duration. In this manner students were identified, recruited, and registered for the project courses. It might be noted that many hours were devoted to recruiting students for the project as these courses were optional for their programs of study. The Division of Sciences did allow tentative GUR status for (Astr 250) Phy Sci 250 and 251 (Astr 251). Students could use up to two credits toward science GUR's. The Department of Elementary and Secondary Education allowed students enrolled in EL/SE 311 or 312 to waive the required EL/SE 305, three credits.

Science Learning and Instructional Center (SLIC). Project students had access to the SLIC center directed by J. C. Horne. This center is an integral component of the Division of Sciences and is a multimedia and computer aided instructional complex. While some computer work was done by our students, it was concluded that appropriate software for preservice elementary teachers were sparse. The materials used in our project were gleaned with care from those used in other science courses.

One major restraint to using computer aided instruction was the time that it takes. Considering the classes, laboratories, outside readings, and computer experiences; it became apparent that time was a major constraint to expanding the computer aided instruction component.

Masters. Two students used this project to complete a thesis and a paper. Their abstracts follow.


## Abstract

Gail S. McCurdy (1988). Pendulum Project. Unpublished masters paper. Pullman: Washington State University.

The investigated problem related to the impact on student achievement as a result of participating in laboratory activities or reading about a single topic. Using "Swingers" from the SAVI/SELPH program as the protocol, undergraduates enrolled in elementary science methods course were subjected to three different treatments about pendulums. The first treatment was a laboratory employing the guided discovery format. The second was reading only about the topic. The third treatment was a combination of the first two. The research design, using five random intact groups, is shown below.

Design of the Study

| | | Treatment | | | |
|---|---|---|---|---|---|
| Group | n | Pretest | Activity | Reading | Posttest |
| A | 23 | yes | no | no | no |
| B | 17 | yes | no | yes | yes |
| C | 19 | yes | yes | no | yes |
| D | 19 | yes | yes | yes | yes |
| E | 8 | no | yes | no | yes |

When the four group means on the pretest were compared, there were no statistically significant differences. Thus, those groups had essentially the same prior knowledge concerning pendulums.

Results of the posttest showed that while there was an increase of posttest scores over pretest means, there were at the .05 level no differences of significance when posttests were compared. Test scores indicated that students who did the laboratory activities without reading about the topic achieved equally well as those students who read about the topic. That finding has educational significance for hands-on science in the elementary school.

Abstract

Paul E. Adams (1986). Physics Laboratory for Elementary Teachers. Unpublished masters paper. Pullman: Washington State University.

The problem of the investigation was to provide background materials for a physics laboratory section oriented to prospective elementary school teachers.

The effectiveness of the materials was evaluated by using a sample of eight students whose science background was slightly stronger than is typical of elementary teachers, yet, exhibiting learning difficulties in physics.

Three laboratories in mechanics, written for the course, were used for the evaluation. Laboratory one dealt with velocity, acceleration, and the parameters of a pendulum's motion. Laboratory two covered the vector nature of force, Newton's second and third laws, and torque. Laboratory three was designed toward work, energy and mechanical advantage as applied to simple machines.

Each laboratory was evaluated by written tests and personal interviews of the students. The evaluations were summed up to provide an overall laboratory evaluation. It was found that the laboratory section of the course, with the exception of laboratory three, was reasonably successful in teaching physics content, developing use of physics concepts in reasoning through problems and physical situations, and reducing anxiety towards physics.

From this evaluation specific recommendations are made to improve, expand, and implement the physics laboratory. These are: testing at the end of the laboratory for comprehension, condensing the laboratories, revising the worksheets to structure student learning, making available a large amount of time for students to see the instructor, giving take-home activities, having a student-to-laboratory-instructor ratio of twelve, assigning two laboratory sections of twelve to each laboratory instructor, and maintaining close association between the laboratory and lecture.

## The Future

The combined efforts of scientists, science educators, administrators, and students will have a positive impact at WSU. The most obvious is the institutionalization of Physical Sciences for Elementary Teachers, Physical Sciences 250, a four credit course as a course fulfilling the General University Requirement in physical science. This means that the course has been recognized by university committees as meeting the goal of the Liberal Arts. Further, Teaching Elementary Science, EL/SE 304, three credits, is now just that--a science methods course. Prior to this project, elementary school majors took a course that combined mathematics, social science and science methods in one course. Needless to say, that combination left much to be desired in all areas.

In the summer of 1988, D. C. Orlich will submit a proposal to the President of WSU calling for planning a "Center for Science and Mathematics Teaching."

The team who collaborated on this NSF project view an opportunity for science and mathematics education at WSU that should lead to state and regional leadership in these dynamic and very necessary areas.

# APPENDIX A. Requests for Project Information

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