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ABSTRACT

This document presents a description of a science education program which provides experiences in the affective, cognitive, and psychomotor domains. The methods course has no required textbook and is an activity-oriented course, requiring students to become acquainted with three of the national elementary science projects: Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), and Science - A Process Approach (SAPA), as well as Science for the Seventies - Pennsylvania's Guide to Elementary School Science. The class learns through a series of mini-investigations using concrete manipulative experiences as a vehicle for the instructors to model desirable teaching strategies. Both formal and informal methods were used to assess the program. The formal assessment consisted of pre- and post-testing a group of students, using the Allison Attitude Scale. Evidence demonstrated a high degree of success in improving the attitudes of preservice teachers toward science. The paper also presents a brief report on science teaching in Pennsylvania public elementary schools during the 1971-72 school year. (Author/EB)

IMPROVING PRESERVICE TEACHERS' ATTITUDES TOWARD SCIENCE

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"I just do not have time to teach science." Is it an excuse or a reality? This often-repeated statement begins to sound like a handy excuse. In any case, it does appear to express the attitude of many elementary teachers toward the place of science instruction in the elementary curriculum. If time runs short, science is one of the subjects that is most often eliminated.

There are other indicators of what appears to be a prevailing negative attitude toward science on the part of elementary teachers. The statement "Science is my weak subject" expresses another dimension of the problem. Elementary teachers are required by the nature of the curriculum and school organization to be generalists in education. They are required to present lessons across the wide spectrum of the subjects and skills of the total elementary curriculum. Equal strength in all of these areas is an unrealistic goal, but competency in each area is desirable.

But competency in all areas may not be the general rule. In a local school district meeting, called to explain the soon-to-be established departmentalized organization to parents of the fifth and sixth graders, teachers were called upon to express their feelings toward the new plan. One teacher's comments make the existing condition clear. She said

> I'm going to like the departmentalized organization. I will be teaching reading and penmanship - both subjects have been my specialty for many years. I won't have to teach science, and I'm glad. For years I have not been teaching science to my classes, because I don't know how.

Was this an expression of relief at being released from an unwanted responsibility? A confession of incompetence? Or simply an excuse? Whatever it was, it expressed the lack of competency which existed.

A Report on Science Teaching in Pennsylvania

During the 1971-72 school year, the Pennsylvania Science Teachers Association, with the Pennsylvania Department of Education and Wilkes College, completed a survey entitled "Science Teaching in Pennsylvania Public Elementary Schools." (Belluci 1973) The results of the study showed Pennsylvania's elementary teachers and elementary principals to be in agreement on the important outcomes of teaching science in the elementary school. Both elementary teachers and elementary principals placed the following ten objectives of elementary science education in the identical order (Hierarchy of importance):

1. Develop critical thinking
2. Develop curiosity
3. Develop problem-solving skills
4. Develop attitudes about the environment
5. Develop concepts for interpreting the environment
6. Develop the use of science for the betterment of man
7. Teach knowledge about typical science area (e.g., plant life, animal life, weather)
8. Develop hobbies
9. Prepare for high school science
10. Develop scientists

The close agreement on this portion of the study serves to heighten the two groups' failure to agree on the obstacles to teaching science.

Obstacles to Teaching Science

Teachers and principals appear to hold the same purposes for teaching science to elementary school pupils. The same two groups could not agree when they were asked to rank order a series of statements characterizing factors which could be described as obstacles to the teaching of science. The results are shown in Table 1.

TABLE 1

Comparison of Teacher and Administrator Rankings of Obstacles to Effective Science Teaching

	Teacher Ranking	Administrator Ranking
Lack in-service facilities	1	3
Inadequate room facilities	2	5
Lack of supplies and equipment	3	8*
Insufficient funds to purchase equipment and supplies	4	11**
Lack of adequate consultants	5	4
Curriculum not sufficiently determined	6	9
Not enough time to teach science	7	7
Insufficient knowledge of science teaching methods	8	1**
Insufficient science knowledge	9	2**
Inability to improvise materials and equipment	10	10
School believes science less important than other areas	11	12
Lack of teacher interest	12	6**
Lack of community support	13	13

* .05

** .01

It can be inferred that teachers and administrators are clearly and significantly in disagreement where the difference in their statement rankings is statistically significant. It is interesting to note that those areas where significantly different opinions are expressed may well have been anticipated.

Two statements deal directly with the quantity of supplies and funds available to support a science program. This is an area where faculty and administration find it easy to disagree.

The remaining three areas:

Insufficient knowledge of science teaching methods

Insufficient science knowledge

Lack of teacher interest

all deal directly with the competence of the elementary teacher in the science area. The findings may be true and accurate, or there may be some reflection of the attitude of a generally male group of elementary principals toward a generally female group of elementary teachers. Whether there is a sex bias in this study is not significant here. The differences expressed in the study are real. Further, the negative attitude toward science by teachers and those preparing to teach in the elementary school, a predominately female group, has also been verified by the experiences of the authors.

Attitudes Toward Science

Preservice elementary education students avoid science courses unless they are required. Elective science

courses are met with comments such as:

"What, another science course? I've heard all that before!"

"Is it required?"

"Science courses are all the same."

Unfortunately, the next statement may be,

"I hate science!"

The attitude implied by these statements is similar to the attitude toward science reported by Margaret Mead and Rhoda Metreaux (Mead 1957). Those researchers reported that teenage girls reject science as a possible form of work for either themselves or their future husbands.

Is There A Vicious Cycle?

Elementary teachers with negative attitudes toward science do not usually teach science.

When these teachers do teach science, they present science as a series of facts to be memorized and vocabulary to be learned.

Students who complete this type science course may develop a negative attitude toward science.

This negative attitude is evidenced as the students fail to elect further science courses in high school or college.

Those students who enter an elementary preparation program take only those science courses which are required.

As these students graduate and enter full-time teaching positions, the cycle begins again.

The authors realize that there are elementary teachers who work conscientiously in the area of science. Unfortunately, there are only a few of these individuals in any given elementary school. The problem is real. Plans for reducing and/or eliminating the problem include departmentalization, special science teachers, and science supervisors. These approaches appear worthwhile and necessary, but they are viewed by the authors as short-term solutions to the immediate problem and do not represent a viable, long-range solution to the larger problem.

Providing science experiences for elementary students will help them become scientifically literate and will help produce a more positive attitude toward science. This should be one of the principal aims of the elementary school curriculum. To accomplish this goal will require all of the short-range plans already noted. Teacher attitudes need to be improved, through inservice and preservice programs. This combined effort should be more effective in breaking the vicious cycle and bringing about positive attitude changed toward science.

What Do Elementary Education Majors Say of Their Science Preparation?

Most elementary education majors say that they have had all of the science courses that they would like to take. These students indicate that few, if any, of their high school or college science courses were laboratory oriented. They claim that their science courses have been text-lecture courses. As a result, students may truly say that they have "heard all that stuff before."

Some students reported that their science instructors had performed some science demonstrations. Few, if any, instructors permitted or encouraged laboratory experiences where the students could gain confidence in the manipulation of materials. In short, of the three categories of objectives described by Bloom's Taxonomy (Bloom 1956) (i.e., cognitive, affective and psychomotor), most of our students claim that their prior science experiences emphasized only cognitive learning and excluded affective and psychomotor learning experiences.

A broader based science program providing experiences in the affective, cognitive, and psychomotor domains is a desirable goal. We are attempting to provide this type program. At Capitol Campus, the total elementary teacher preparation program is based on this broad foundation.

Elementary Teacher Preparation Program at Capitol Campus

In order to prepare elementary teachers for urban teaching positions, the faculty of Capitol Campus, The Pennsylvania State University designed a unique program. The Campus began in 1966, using the administrative facilities of the Olmsted Air Force Base deactivated by Secretary of Defense Robert McNamara. At the time of its formation, it was one of six institutions nationwide which were designed to serve students who had completed two years of college work at a community college or some other institution of higher learning. In other words, Capitol Campus is an upper division and graduate school of the Pennsylvania State University. Students are admitted as juniors, complete two years of work, and are graduated. Graduate programs were added as the size of the student

body increased and the demand from the central Pennsylvania area grew.

The University operates on a term system, with three ten-week terms in the academic year. There is an additional ten-week term in the summer. Students attending Capitol Campus usually complete eighteen units of work during their two years of study. Each unit of work is described as one-third of the student's full-time load per term. (One unit of work is roughly equivalent to four semester hours). The elementary education program follows these same general guidelines, but has several unique features of its own.

Basic Preparation Sequence

During a student's first year in the program, each is required to take three units of a course entitled Basic Preparation for Teaching (Basic Prep). The usual pattern is for the student to take one unit of this course during each of the three terms of the junior year. The courses include elements of general teaching methods, educational psychology, child growth and development, education theory, and the history and the background of education. Each course provides the opportunity for each student to participate in one of the public schools in the area, to try out their skills and to have first-hand experiences with teachers and students in urban situations.

Figure 1 is a graphic presentation of the normal course sequence of the elementary education program of Capitol Campus.

FIGURE 1

Graphic Presentation of the Normal Course Sequence
Elementary Education Program, Capitol Campus
The Pennsylvania State University, Middletown, Pennsylvania

JUNIOR YEAR

	FALL TERM			WINTER TERM			SPRING TERM		
	1 2 3 4 5 6 7 8 9 10			1 2 3 4 5 6 7 8 9 10			1 2 3 4 5 6 7 8 9 10		
ONE UNIT	BP 1* 3X Wk.	3 Wk. All Day	BP 1 3X Wk	BP II 3X Wk.	3 Wk. All Day	BPII 3XWk	BP III 3X Wk.	3 Wk. All Day	BP III 3X Wk
ONE UNIT	** Science 5X Wk.	No classes	Sci. 5X Wk	** Math 5X Wk.	No classes	Math 5X Wk	Social Studies 5X Wk.	No classes	Soc. St. 5X Wk.
ONE UNIT	** Reading 5X Wk.	No classes	Read. 5X Wk	** Fine Arts 5X Wk.	No classes	Fine Arts 5X Wk	Health & P.Ed. 5X Wk.	No classes	Health & P.Ed. 5X Wk.

SENIOR YEAR

	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
ONE UNIT	Communications	Student Teaching - Three Units -	Elective
ONE UNIT	Elective	All Day Field Experience	Elective
ONE UNIT	Elective	Urban School	Elective

* BP, Basic Preparation for Teaching Course
** Support Course - may be any one of the six courses required prior to student teaching

The Basic Preparation for Teaching Course increases in complexity and sophistication as the year progresses. The first term deals primarily with the individual child. Formal class work involves students in learning how children grow and how to identify their values and needs. In addition, both cognitive and affective lessons are prepared to meet identified student needs. The college student's knowledge of self and awareness of the world around that self is examined. The many roles of the elementary teacher are examined. And finally, information about school organization and how schools function is included to provide a transition into the first field experience in the public school. The second term participants work primarily with small groups of students, while the third term participants work primarily with large groups. The description of the field experiences below indicates more specifically the requirements of each term.

The Basic Preparation sequence is a particularly strong feature of the program at Capitol Campus. The preservice elementary education program is so designed to be a cooperative program, because both the education program faculty and the faculty and administration of the public schools recognize a shared responsibility in preparing teachers for service in the schools of the commonwealth.

Field Experience as a Part of the Program

The field experience component of the Basic Prep Course is generally three weeks long. As one can observe in Figure 1, page 9, these three weeks fall during the fifth through seventh weeks of the ten-week term. During this period the two support courses suspend formal meetings. Each support course has built-in requirements

for students to complete during their field participation.

An outline of the major field requirements is listed here for each of the Basic Prep field experiences.

Basic Prep I (WORK PRIMARILY WITH INDIVIDUAL CHILD)

Case Study	Home Visit
Cognitive Lesson	Community Resources List
Affective Lesson	Non-Prestige English Observation
Lesson With Game	Behavior Modification Proposal
Programmed Lesson	Classroom Observations
Non-School Activity	Building Observations

Basic Prep II (WORK PRIMARILY WITH SMALL GROUP)

Affective Unit	Classroom Observations
Small-group Management	Building Observations
Behavior Modification	Non-Prestige English Observation
Group Process Analysis	School System Observations
Non-School Activity	Institution Observations
Home Visits (2)	

Basic Prep III (WORK PRIMARILY WITH LARGE GROUP)

Unit Teaching	Neighborhood Walk
Test Construction	Non-School Activity
Large-Group Management	Home Visits (3)
Lesson With Game	Classroom Observations
Programmed Lesson	Use of Community Resources
Newsletter to Parents	Non-Prestige English Observation

These requirements provide the basis for the field experiences

of the junior year and lead directly to the full-time student teaching field experience of the senior year.

Support Courses

The support courses included in the teacher preparation program combine both methods and content. These courses meet five days a week, except during the three-week field experience period when formal class instruction is suspended. Six of the seven support courses are required prior to student teaching. The seventh, communication skills, may be taken any time prior to graduation. The support courses include: science, mathematics, reading, social studies, fine arts, health and physical education, and communications skills.

State Approved Program

Teacher Certification in the state of Pennsylvania is based on the completion of a state approved teacher preparation program and the recommendation of the approved institution. The elementary education program of Capitol Campus received a five-year state approval during the 1972-73 academic year.

As one can see, the basic program is unique. The support courses must be unique to meet the challenge of the program and to meet the needs recorded earlier in this paper. A description of the support course Science For Elementary Teachers follows.

Approaches to Teaching Science

Elementary teachers in Pennsylvania were asked to characterize the instructional strategies being used. Thirty-eight per cent of the teachers surveyed responded

that the science program in their classrooms has a textbook orientation. Thirty-five per cent responded that they were using an activity-oriented program. Twenty-two per cent utilized a combination of approaches. Five per cent used a demonstration-oriented program. (Belluci 1973).

The teachers who responded that their program was predominantly textbook-oriented, admitted that they had few, if any, activities as a part of the science program in their classrooms. These teachers indicated that equipment for activities was lacking.

The teachers who indicated that they were teaching an activity-oriented science program responded that they used no science textbooks as a part of that program. These teachers also felt the need for more science supplies and equipment than their schools have provided.

Modeling Techniques as a Methods Course

New teachers often use techniques and mannerisms learned from their favorite teachers in previous years. This has led to the statement, "Teachers teach as they were taught." The investigators have developed a science methods course for preservice teachers which serves as a model of teacher behavior appropriate for elementary science classes.

This methods course has no required textbook. It is an activity oriented course in which students manipulate materials and work out their own solutions. It is not a read-about, talk-about textbook oriented course. The investigators do not plan to be guilty of recommending

one approach to teaching and then avoiding that approach in their own teaching.

The methods course has a competency based module which requires students to become acquainted with three of the national elementary science projects Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), and Science - A Process Approach (SAPA) and Science For the Seventies - Pennsylvania's Guide to Elementary School Science. The class learns through a series of mini-investigations which use concrete manipulative experiences as a vehicle for the instructors to model desirable teaching strategies. In other words, the instructors make a conscious effort to provide a model for their students to emulate.

Fundamental to this process are six teaching strategies, which are spelled out in the Science For The Seventies -ITV - Handbook for Teachers, published by the Pennsylvania Department of Education in 1973. They are:

1. Teacher questions require students to arrive at an answer by examining and manipulating the materials they are using.

2. Students' responses are accepted when students use evidence from their lesson activities in observing and responding.

3. Student interpretations are considered acceptable, even though often they are partial or temporary conclusions, so long as the evidence and materials of

the lesson support the responses.

4. Reasonable time is provided during discussion for observation, thought, and reflection.

5. Teacher questions and behavior emphasize the use of the processes of observing, classifying, communicating, measuring, inferring, and predicting.

6. Teacher questions encourage wider student thought and suggestions for additional investigative behavior.

We encourage our preservice students to identify and pursue the kinds of questions that they will be able to answer by doing "something" with "things." The type of questions we ask are questions which can be answered by direct observations of "things" or "by how things interact." "Why" questions are rarely appropriate in an activity centered program. Students are presented situations from which they can learn that science is self-correcting. That is: they learn that any explanation is tentative and subject to change as new evidence is acquired. New evidence may cause a student to strengthen, revise, or reject an existing idea. Further, students develop skill in using the processes of science as a basic tool of investigation in science.

Teachers have much to learn about "wait-time" as it relates to the questioning technique. A teacher whose science program is textbook oriented, with a heavy emphasis on memorized facts could expect students to reply promptly and accurately to all questions. On the other hand, a

teacher using an activity approach which encourages exploration should permit a reasonable amount of time during discussions for students to think, to observe, and to reflect prior to responding. Researchers and teachers have found that by increasing "wait-time" to five seconds after each question is asked brings about the following changes:

1. More elementary students will participate in the discussion.

2. The quality of the responses given by the students is increased, and

3. That greater pupil to pupil discussion occurs. (Rowe 1974)

Does This Approach Make a Difference?

To verify the assumption that an attitudinal change would occur in students who enrolled in this pre-service science course, the investigators used both formal and informal means. The informal assessments consisted of interviews (both written and oral) with students at the beginning and end of the course. These interviews indicated that students gained confidence in their ability to teach science and that they had an increased desire to teach science. Some of the statements of students which indicate their approval of this approach are:

1. "At last a methods course in which the instructor practices what he preaches."

2. "It's nice to be able to experience some of these techniques before I'm expected to apply them."

3. "The three-week fulltime field experience was just great! I was able to try some of the things this class was teaching."

4. "I can do it! I was afraid of science before this course, but now I know I can do it!"

Many of the class members indicated that for the first time they enjoyed a science course and understood the concepts taught. Class members, who were observed during their three-week field experience, used concrete manipulative materials and experiences with elementary school children during their field placements. The college students felt this approach to teaching was far superior to any other method of teaching science they had observed or experienced.

The formal assessment consisted of pre- and post-testing the group, using the Allison Attitude Scale, an attitude inventory developed by Allen (1960) and adapted by Allison (1966). The instrument has a reliability coefficient of 0.94. Allen (1960) claimed both content and construct validity for his instrument. The correlation ($r = 0.81$) between the Allen and Allison instruments for the same group of high school seniors indicate little change in the instrument. Expert judges were also employed in establishing content and construct validity for the Allison Attitude Scale. The student group tested had an $N = 22$, a Mean of the Differences = 14.227, a Standard

Deviation = 19.432, a Sum of Squares = 12383 and a t-test = 2.748. The t-test score was significant at the .05 level.

Conclusions

The investigators feel that the course described is a step in the direction of improving elementary teachers' attitudes toward science. In fact, the evidence demonstrates a high degree of success in improving the attitudes of preservice teachers' attitude toward science. The next question to be researched is: "Will the participants in this study teach science according to the model provided by the instructors??

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