

SHAPING PRE-SERVICE TEACHERS' ATTITUDES: AN INQUIRY APPROACH TO COURSE REFORM

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The purpose of the study was to investigate the development of pre-service teachers' attitudes toward teaching science with inquiry methods as the result of their participation in the two-hour elementary science methods class. Southwestern Oklahoma State University is a partner in the Oklahoma Teacher Education Collaborative (OTEC) which is funded by the National Science Foundation's reform effort, Collaboratives for Excellence in Teacher Preparation (CETP). The reform effort focuses on the revision of the teacher preparation courses with emphasis on a systemic change in the method in which math, science, and education methods courses are taught across Oklahoma.

Nine Oklahoma universities, including the University of Tulsa, Oklahoma State University, the University of Central Oklahoma, Northeastern Oklahoma State University, Cameron University, Langston University, Tulsa Community College and Southwestern Oklahoma State University, have focused on revising the identified courses with inquiry-based instruction.

The Science Methods Course: *Teaching Science in the Elementary School*

The elementary science methods course, *SCI 4352: Teaching Science in the Elementary School* offered at Southwestern Oklahoma State University, has been revised with an inquiry approach to teaching science since the inception of the OTEC reform initiative. Revision of the science methods course was guided by the principles in *Science for All Americans* [1], *Benchmarks for Scientific Literacy* [2], and the *National Science Education Standards* [4]. The methods course is a two-hour per week lecture/lab course with two semester hours of credit.

One objective of the science methods course is to help pre-service teachers develop an individual understanding of scientific literacy. Without a clear meaning of scientific literacy, the pre-service teachers will not be prepared to assist their future students with attaining that goal. The interpretation of scientific literacy for the pre-service teachers to acquire is that science literacy is a combination of facts, terminology, concepts, history, and philosophy that a person needs to understand the everyday world [3]. It is paramount that pre-service students understand

that scientific literacy is not specialized knowledge of the experts, but more general and practical knowledge [6].

National Science Education Standards

The National Science Education Standards (NSES) [4] are interconnected with the practical and theoretical experiences provided in the methods course. With guidance from the assistant professors, chapter readings, inquiry-based activities, and interactive discussions of the Standards, the pre-service teachers began to formulate personal visions of science education. These activities assisted the students in understanding that the NSES, as essential elements, promote the learning and teaching of science as an inquiry process.

The Learning Cycle

The focus of teaching science as inquiry was the acquaintance with the learning cycle, the Five E Model [5]; i.e., engagement, exploration, explanation, elaboration, and evaluation. The learning cycle approach to teaching, compared to traditional approaches, promotes higher order thinking and problem solving. The learning cycle enables the pre-service teacher to be prepared to teach science as inquiry with students in kindergarten through sixth grade.

Scientific Attitudes

Science is based upon scientific values including integrity, diligence, curiosity, skepticism, and imagination. Scientists use curiosity when they question new theories. The science methods course provides pre-service teachers with strategies to direct curiosity in productive ways [2,4,6]. In addition, the course encourages pre-service teachers to be open to new ideas by emphasizing the importance of analyzing ideas contrary to their beliefs. In the scientific community, informed skepticism enables scientists to give new theories careful attention through a process of verification and refutation [2,4]. Experiences in the methods course help pre-service teachers perceive the social value of skepticism and the need for balance between skepticism and openness to new ideas [2,4,6].

The Survey

The assessment tool used to evaluate the pre-service teachers' attitudinal change and confidence levels of teaching science with inquiry methods was designed by the authors. The questionnaire included fourteen items, organized into three categories: Teaching Science as a

Process of Inquiry, Teaching Science in the Elementary School, and Hands-On/Laboratory Activities.

The Questionnaire for Pre-Service Teachers in the Science Methods Course

PART I.

TEACHING SCIENCE AS A PROCESS OF INQUIRY

1. Teaching science as a process of inquiry is contrary to the traditional way in which I was taught in public or private school.
2. The attitudes of successful scientists are characteristic to the scientific attitudes that successful teachers should model.
3. Open-ended questions asked during discussions promote divergent thinking and elicit diverse responses.
4. Increasing wait time has positive effects on the inquiry climate of the classroom.
5. Nonverbal reinforcement is more effective than repeated verbal praise after every student response.

PART II

TEACHING SCIENCE IN THE ELEMENTARY SCHOOL

1. I intend to use the Constructivist Learning Cycle often to teach science.
2. I can use the inquiry approach to teaching elementary science more easily.
3. The National Science Education Standards recommend that I teach inquiry-based science.
4. My plan to teach more hands-on/investigative science is valuable.
5. Principals of elementary schools think that I should teach science as a process of inquiry.

PART III

HANDS-ON / LABORATORY ACTIVITIES

1. My attitude toward teaching science in the elementary school is more positive.
2. Hands-on/laboratory investigations are important.
3. Working in collaborative groups during investigations encourages student-student interaction.

4. Using the stages of exploration, concept introduction, and concept application promote meaningful learning.

Data Collected

Using the indicated student response scale, data collected with a pre- and post-questionnaire during the 1998 and 1999 semesters suggest that the pre-service teachers are developing positive attitudes toward teaching science with inquiry methods. These data represent a small number of elementary education majors; however, the two classes were taught by assistant professors using an identical syllabus during the spring and fall semesters.

5 4 3 2 1

5 = STRONGLY AGREE
 4 = AGREE
 3 = SOMEWHAT AGREE
 2 = SLIGHTLY DISAGREE
 1 = DISAGREE

PART I

STUDENT RESPONSES: TEACHING SCIENCE AS A PROCESS OF INQUIRY

QUESTION	5	4	3	2	1	N	SET	MEAN	MED	SD
1	6	7	10	4	1	28	PRE	3.5	4	1.1
	9	7	7	2	1	26	POST	3.8	4	1.1
2	7	9	6	4	2	28	PRE	3.5	4	1.2
	17	6	1	2	0	26	POST	4.5	5	0.9
3	12	10	2	2	2	28	PRE	4.0	4	1.2
	19	6	1	0	0	26	POST	4.7	5	0.5
4	6	7	9	5	1	28	PRE	3.4	3	1.1
	17	5	3	0	1	26	POST	4.4	5	1.0
5	4	3	3	11	7	28	PRE	2.5	2	1.4
	7	10	5	2	2	26	POST	3.7	4	1.2

Mode in Boldface.

PART II
STUDENT ATTITUDES: TEACHING SCIENCE IN THE ELEMENTARY SCHOOL

QUESTION	5	4	3	2	1	N	SET	MEAN	MED	SD
1	2	9	17	0	0	28	PRE	3.5	3	0.6
	11	11	4	0	0	26	POST	4.3	4	0.7
2	5	12	8	3	0	28	PRE	3.7	4	0.9
	17	4	3	2	0	26	POST	4.4	5	1.0
3	3	12	12	0	1	28	PRE	3.6	4	0.8
	15	8	3	0	0	26	POST	4.5	5	0.7
4	17	7	3	1	0	28	PRE	4.4	5	0.8
	22	3	1	0	0	26	POST	4.8	5	0.5
5	5	13	10	0	0	28	PRE	3.8	4	0.7
	9	10	7	0	0	26	POST	4.1	4	0.8

Mode in Boldface.

PART III
STUDENT RESPONSES: HANDS-ON / LABORATORY ACTIVITIES

QUESTION	5	4	3	2	1	N	SET	MEAN	MED	SD
1	10	12	5	1	0	28	PRE	4.1	4	0.8
	19	7	0	0	0	26	POST	4.7	5	0.5
2	20	7	0	0	1	28	PRE	4.6	5	0.8
	22	4	0	0	0	26	POST	4.8	5	0.4
3	18	9	0	0	1	28	PRE	4.5	5	0.8
	17	8	1	0	0	26	POST	4.6	5	0.6
4	11	14	3	0	0	28	PRE	4.3	4	0.7
	20	6	0	0	0	26	POST	4.8	5	0.4

Mode in Boldface.

Data Analysis

Using a standard deviation of $\geq \pm 0.2$ as an indicator of significance [7], it is possible to see that changes occurred in our students from pre- to post-evaluation. Examining Part I, Student Responses Toward Teaching Science as a Process of Inquiry, three questions (#2, 3, 5) showed significant results. Question #2 addressed scientists' attitudes to that of successful science teachers (- 0.3). Question #3 addressed open-ended questions as promoting divergent thinking (- 0.7). Question #5 addressed nonverbal reinforcement as being more effective than verbal praise (- 0.2).

Part II, Student Attitudes Toward Teaching Science in the Elementary School, offered one question with significant change (#4). This question addressed the student's intention to teach science in a hands-on fashion (- 0.3).

Part III, Student Responses Toward Hands-On/Laboratory Activities, offered the greatest change with each question (#1, 2, 3, 4) being significant: question #1 addressed the student's attitude toward science as being more positive (- 0.3); question #2 addressed the importance of hands-on investigations (- 0.4); question #3 addressed the importance of working in collaborative groups (- 0.2); and, question #4 addressed the learning cycle stages as promoting meaningful learning (- 0.3).

Another indicator of significant change for data of these types is a change in mode [7]. Using an increase of two scoring categories as an indicator of significant change, several more questions can be analyzed. In Part I, questions #1(mode 3 to 5) and #4 (mode 2 to 4), and in Part II, questions #1(mode 3 to 4/5) and #3 (mode 3/4 to 5) showed significant change.

Conclusions

These data tend to indicate that a positive influence can be made with pre-service elementary educators with regard to science education. The importance of hands-on activities, the asking of open-ended questions, collaborative groups, and the learning cycle as being positive factors for good science education all showed a significant change from pre- to post-evaluation. Most importantly, the hands-on, participatory design of the science methods course (See Figure 1) provided the pre-service teachers with opportunities to develop the confidence needed to apply inquiry methods of teaching in their future classrooms.

Further research that examines the pre-service teachers' attitudes toward teaching science with inquiry method after they have completed one year of teaching, will be conducted. In Oklahoma, all beginning teachers are involved with a residency year program that includes university supervision and mentoring from teachers in the selected schools. These teachers will provide the cadre of participants for the follow-up study. ■

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