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ABSTRACT

Current literature suggests ways in which science education can be improved within schools; however, curriculum implementation based on current knowledge has not been achieved. The purpose of this study was to evaluate instruction designed to teach preservice science teacher education students content using techniques recommended by the reform literature to determine its effectiveness in preparing future teachers to teach science. Comparing pretest and posttest scores, there were significant changes in the students' (1) attitudes toward science, (2) sense of the relationship between science content and ways of learning, and (3) ratings of future computer usage in the classroom. There were no measured effects of the treatment on changing scores of tests, measuring reasoning patterns, problem solving skills, or overall ratings of certain teaching strategies. (PR)

IMPROVED SCIENCE CONTENT FOR PRE-SERVICE TEACHERS: MODELING OF TEACHING STRATEGIES BASED ON CURRENT SCIENCE EDUCATION REFORM LITERATURE

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ABSTRACT

Internationally universities are struggling with science education reform. Current literature suggests ways in which science education can be improved within schools; however, curriculum implementation based on current knowledge has not been achieved. It is hoped that this study will add to planning and implementation of current science education reform procedures in pre-service teacher education courses for the 21st Century by struggling with and addressing current literature suggestions, thus eliminating "reinvention of the wheel." Many challenges have been made to improve science education in terms of improved science content taught in ways that model appropriate teaching strategies of the classroom teacher. This study was based in response to those challenges. A treatment group of pre-service teachers were taught science content based on recommendations of current science education reform literature. This treatment resulted in significant gains in student attitudes toward science, their overall sense of the relationship between science content and ways of learning, and their ratings of future computer usage in the classroom. In addition, there was no loss in content knowledge and reasoning skills of participating students.

OBJECTIVES OR PURPOSE OF STUDY

The purpose of this study was to evaluate instruction designed to teach pre-service teacher education students in science content to determine its effectiveness in preparing future teachers to teach science. Of particular interest was student acquisition of science knowledge, attitudes toward science, reasoning patterns and problem solving skills, and opinions towards importance and future usage of certain teaching strategies.

Statement of problem: A challenge has been made by society to reform pre-service science teacher education at the college level. Students need to exit teacher education programs with strong science content knowledge and a vision of how that knowledge might best be taught. This rigorous content should be taught in structured programs by instructors modeling process-oriented, student-centered classroom practice that integrates current technological tools. Not only ought science content knowledge and problem solving and reasoning skills be eminent, but students should also exit teacher education programs with positive attitudes toward science. Students must graduate with personal strong methodological backgrounds relevant to the importance of teacher-centered and student-centered classrooms, content-oriented and process-oriented classrooms, and in the knowledge of uses of technology. An understanding of how often these teaching strategies might be utilized in future classrooms is essential for the construction of student knowledge.

This study investigated the evaluation of a course designed specifically to teach science content based on current science education reform literature. A course was designed specifically to educate pre-service elementary teacher candidates in physical science concepts. Inherent in this content were concepts dealing with physics, chemistry, and geology. In addition, this course was designed to instruct students in science content consistent with courses offered through the college of arts and sciences; yet, was also designed to model appropriate teaching strategies.

Questions: The study was framed by the following questions:

1. What is the impact on pre-service elementary teachers regarding science-knowledge scores, science-attitude scores, and problem solving and reasoning scores when students have received rigorous science content instruction which modeled strategies recommended by reform literature?

2. How do pre-service elementary teachers rate the importance of teacher-centered and student-centered teaching strategies, process- and content-oriented teaching strategies, and computer usage teaching strategies, and do their ratings change after receiving rigorous science instruction modeling teaching strategies established by reform literature?

3. How do pre-service elementary teacher's rate how often they will utilize teacher-centered and student-centered teaching strategies, process- and content-oriented teaching strategies, and computer usage teaching strategies, and do these ratings change after receiving rigorous science instruction modeling teaching strategies established by reform literature?

DESIGN AND PROCEDURES

Data were collected using five instruments. To determine science knowledge, a portion of the National Teachers Examination practice test was utilized. Science attitudes were measured through the utilization of the International Science Study Survey on Science Attitudes. Reasoning patterns and problem solving skills were measured by the Reasoning Patterns Test compiled by Tweeten (1991). Opinions of importance and future usage of teaching strategies were measured through a teaching strategies survey. Individual student information was collected through a demographic survey.

A quasi-experimental design in which pre and post tests were included were administered to the treatment group students (Rosenthal and Rosnow, 1991). Instruments were administered the first and last day of instruction to students in the treatment group.

SIGNIFICANCE OF STUDY

Numerous problem areas facing reformists in science education, particularly within pre-service teacher education programs, are focused on increasing the rigor of science content within educational programs and linking rigorous science content knowledge to effective teaching strategies. Questions dealing with relevancy, content discipline, student achievement, and student success are not new. Historically science, and perhaps unfairly, has carried the promise of solving societal problems (DeBoer, 1991). Yet traditional methods of teaching science combined with strict classroom schedules leave little room for incorporation of innovative changes within classrooms (Cuban, 1982). Reform concentrations should focus on such strategic areas as student and teacher-centered classrooms, process and content-oriented classrooms, and adequate uses of technology in the classroom.

Lecture techniques, large-group instruction, reliance on textbooks, and quizzing students through recitation have been common teaching strategy techniques. These teaching strategies are often driven by large class loads, structured time schedules, and the need for adequate scores on standardized texts—in shcrt, survival. Strategies such as these are typical examples of teacher-centered classrooms (Cuban, 1982).

"Survival" teacher-centered techniques do not apply solely to K-12 classrooms; university classrooms typically follow the same traditional structural model. Typical science courses are taught in large lecture halls where reliance on large-group control provides the arena for content presentation through lecture, text, and test (The Holmes Group, 1986). The teacher or instructor is the focus of attention. Students are often not encouraged to think, solve problems, ask questions, or interact with one another. All material comes directly from the instructor and the text, and students may be merely required to mirror that same material back on an impersonal exam (Cuban, 1982).

Reform movements recommend that college classroom structures include teaching methodologies that better enhance learning. Ideally, classrooms would be restructured so that students work independently and together in small collaborative groups to learn science content through solving problems. Classrooms would provide opportunities for students to become fully involved in the educational experience. Classrooms would be supplied with supplementary materials that reflect current societal technological advances from which students may make necessary connections between classroom content and the "real" world interactions between society, science, and technology. College classrooms structured in this way would remove the responsibility for learning from the instructor's shoulder and place it upon the student's. Thus, the classroom would become student-centered (Cuban, 1982).

Conceptual teaching of problem solving and thinking skills, life relevancy, and life experience are recommendations of the American Association for the Advancement of Science (Rutherford and Ahlgren, 1990). Teacher-centered classrooms that focus only on science content presented through lecture may not address these skills. The classroom, in this situation, is centered not only around the teacher but is solely content-oriented (Cuban, 1982). Problem solving and thinking skills that revolve around life experience may be better taught through a student-centered classroom that emphasizes process-oriented learning.

Students must be presented with teaching strategies that challenge their thinking and encourage them to ask questions. This process cannot begin to take form unless students have been first presented with some previous experience of the concept that needs to be taught. Once students are familiar with a small part of the concept and can make links between concept formulation from previous experience, they can then move forward to more complex discussions and experiences with that content. This learning cycle process becomes an integral part of the student-centered classroom (Lawson, Abraham, and Renner, 1989).

Inherent in the learning cycle is inquiry. Students must be interested enough to ask questions and continue asking questions as they move through the science learning process. When questions cease to be asked in science, science as we know it ceases to exist. Opportunities for inquiry are abundant through learning cycle teaching strategies. These opportunities should not be missed and can be fostered in college courses taught by instructors who are informed and practiced at implementing these strategies into the learning experience (Germann, 1991).

Scientific content and proper teaching of that content include another variable. In order for students to emerge from schools with necessary skills to succeed in society, they need to be educated in technologies that impact work places. Technological advancement has experienced its greatest strides through the utilization of computers. Virtually every aspect of modern society is centered around computers (Hazen, 1991). Computer training needs to be an integral part of educational strategies in science classrooms (National Commission on Excellence in Education, 1983). Computer training must effectively be balanced within student-centered, college pre-service education programs. While ways in which students learn must always be considered, Postman (1985) warns that control of education by computer should instead be control of computer by education. Educators must be knowledgeable in the uses and applications of computer technologies (Postman, 1985).

Educational science education reform movements taking place within teacher education programs need to prepare teachers to be professionals. Teachers entering school systems must have strong science content knowledge and positive attitudes toward that content, but a knowledge of science content is not enough. Teachers must know how to effectively teach that content. The adage, "we teach the way we were taught," is appropriate. In order for pre-service teachers to become aware of teaching methodologies, they must first see those methodologies in action. Vigorous modeling of student-centered, process-oriented classrooms integrated with technology must take place in classrooms where pre-service teacher education students actually learn science content (The Holmes Group, 1986).

According to The Holmes Group (1986), in order for education to change, undergraduate pre-service education must change. This change is possible in classrooms where science content and teaching methodologies are modeled and emphasized. Besides classroom experiences, students must be provided with opportunities for structure within their educational programs (The Holmes Group, 1986). This curricular coherence follows spiral learning cycle notions where students are presented with many opportunities of experience as the learning process grows in complexity (Prigogine, 1989). According to The Holmes Group (1986), curricular structure will "provide teachers, especially elementary teachers," valuable knowledge in science content and teaching methodologies that is imperative to their professionalism as teachers. Pre-service elementary teacher classrooms must arm these future teachers with the ability to:

> ...lead a life of the mind. They must be reflective and thoughtful: persons who seek to understand so they may clarify for others, persons who can go to the heart of the matter.
> (The Holmes Group, 1986. p. 47)

Although academic excellence has been targeted, will pre-service education programs change? Too often learning arenas are dictated by structural components. Scheduling, class size, and instructor work load versus the amount of economic compensation are probable reasons for reluctance to change.

A balance must be found between structural limits—what works—and reform proposals. Organizational structures of pre-service teacher classrooms need to change from teacher-centered to student-centered. These classrooms must throw out "formulas" for teaching and become inventive and imaginative where performance and orchestration of stalwart teaching methodologies and rigorous content are at the heart of good teaching practices (Cuban, 1982). When classrooms become "what they should be" at the pre-service teacher level, teacher professionalism will rise, knowledge and attitudes of science and problem solving will rise, attitudes toward importance of student-centered, process-oriented teaching methodologies will improve, and attitudes toward integration of technology in classrooms will become more positive. Inherent in these changes in attitude will be future usage of classroom methodologies that abound in high science content and realistic positive science attitudes.

FINDINGS OR RESULTS

Treatment provided in this study for students in the treatment group resulted in significant changes in:

1. Student attitudes toward science ($t=2.12$, $p < .05$);

Treatment Group Pre/Post Science Attitudes

Source	#	$\bar{X}$	SD	SE	t	df	p
Pre-test	29	57.3103	4.335	.805	-2.12	28	<.05
Post-test	29	59.6897	4.227	.785			
Total	29	58.5					

2. Their overall sense of the relationship between science content and ways of learning ($t=1.80$, $p < .05$).

Treatment Group Pre/Post Future Usage of Overall Teaching Strategies

Source	#	$\bar{X}$	SD	SE	t	df	p
Pre-test	29	130.5517	14.827	2.753	1.80	28	< .05
Post-test	29	134.1034	18.594	3.453			
Total	29	132.32755					

3. Their ratings of future computer usage in the classroom ($t=-2.15$, $p < .05$).

Treatment Group Pre/Post Future Usage of Computer Usage in the Classroom

Source	#	$\overline{X}$	SD	SE	t	df	p
Pre-test	29	28.1034	6.201	1.152	-2.15	28	< .05
Post-test	29	31.8966	7.203	1.338			
Total	29	30.0000					

Treatment provided in this study showed no measured effect on changing scores of tests measuring reasoning patterns and problem solving skills of students in the experimental group. Moreover, treatment provided to pre-service teachers did not appear to affect their overall ratings of the importance of certain teaching strategies, but rather addressed their notions of teaching strategies as a whole.

CONCLUSIONS

It appears that attitudes toward science improve through educational strategies taught with strategies consistent with current science education reform literature. Treatment provided in this study, which incorporated reflection on the learning process in science classrooms, had a positive effect on the experimental group students' awareness of future uses and applications of the teaching learning processes. Inte^ration of computers in education with science content appears to have a positive effect on pre-service teacher education students' ratings of future usage of computers in the classroom. Through modeling of integration of computers in the science education process, the treatment group's ratings of understanding how computers can be utilized in the classroom became more positive. It is important to note that significant gains were noticed in student attitudes toward science and teaching strategies and there was no loss in student content knowledge or reasoning skills.

Recommendations from this study are:

1. To create for pre-service teachers a sequence of science content courses modeling teaching strategies based on current science education reform literature.
2. To integrate science content and computer applications in the classroom in this sequence of courses.
3. To include modeling of recommended teaching strategies with increased content rigor in these courses.
4. To include instructional goals not related to science content of reflective teaching practices in these courses.
5. To encourage research of the interpretation of current science education reform literature translated into practice for both secondary and elementary pre-service science content courses.

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