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ABSTRACT

Science may be the subject area in which elementary teachers are the least confident and prepared to teach. The purpose of this project was to develop an effective model to better prepare teachers by enhancing their content background, and helping them teach inquiry-oriented science. Three departments, Biology, Chemistry, and Education, combined efforts to redesign the science program for elementary teachers by developing and implementing a new sequence of science courses. The first content course integrated chemistry with biology and emphasized the interdisciplinary nature of science. A companion methods course facilitated student's ability to use process skills and to apply the concepts in the content course. The treatment group had significant posttest gains for the cognitive test, but the companion group did not. In regard to attitudes, no group was significantly different in their attitudes toward science and attitudes of students did not become more positive after completing either of the science courses. (YP)

The Science Preparation of Elementary Teachers

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ABSTRACT

The Science Preparation of Elementary Teachers

The subject area in which elementary teachers are the least confident and prepared to teach is science. The purpose of this project is to develop an effective model to better prepare teachers by enhancing their content background, and helping them teach inquiry-oriented science.

Three departments, Biology, Chemistry, and Education combined efforts to redesign the science program for elementary teachers by developing and implementing a new sequence of science courses. The first content course integrates chemistry with biology emphasizing the interdisciplinary nature of science. A companion methods course facilitates student's ability to use process skills and to apply the concepts in the content course.

To assess the first two pilot courses a pretest/posttest design was used with a nutrition class, the course elementary majors usually took, as a comparison group. Both content and attitude data was collected. Anecdotal records were kept and all classes were audiotaped. ANOVA showed that the treatment group had significant posttest gains for the cognitive test, but that the comparison group did not.

In regard to attitudes, no group was significantly different in their attitudes toward science and their attitudes did not become more positive after having either of the science courses. The elementary education majors had a significantly more positive toward science teaching, but none of the groups were more positive after the classes. A number of revisions were made both during and after the first set of classes and have been implemented in the second set of classes.

Introduction

In the period of the late seventies and early eighties a number of factions in the nation concluded that the science education of American students was in a state of crisis. Several status studies portrayed science education as troubled or worse (Helgeson, Blosser, Howe, 1978). Project Synthesis (Harms 1980, Harms, Yager 1981), an outcome of the status studies, summarized the findings and spawned a number of initiatives to determine what constituted excellence in science programs. In the Focus on Excellence series, Penick and Johnson, (1983) identified teachers as a crucial factor in programs of excellence.

A multifaceted and complex question is how to effectively educate all students to be scientifically prepared and literate in a world where gains in knowledge and technology out pace society's ability to deal with them. Appropriately the problem is being addressed at many levels. As various factors come into play on how to improve the quality of science education for all children, one element that cannot be overlooked is the quality of the teacher and his/her preparation for teaching science.

Examination of teacher training programs indicates that perhaps the weakest component is the elementary teachers' preparation in science content. It is an exception for the elementary education major to have more hours in science than are required by the institution for graduation, which is frequently as few as one or two courses.

It is common knowledge that many elementary teachers feel

unprepared to teach science, and that they believe they have inadequate time and facilities to do the job well (Shymansky and Kyle, 1986). Goodlad (1983) reported that science is the only subject teachers perceive themselves as unprepared to teach. As a result textbooks often serve as the primary source of curriculum for science. In an analysis of eleven text series Staver and Bay (1987) found that most text information focus on the Project Synthesis goal of academic preparation and that inquiry was extremely limited or absent. If change in elementary science is to occur, then teachers must have the background and confidence necessary to teach science differently.

Purpose

While many agree that of all subjects elementary teachers are least prepared to teach science, the approaches and strategies for solving this problem are varied. One means of addressing the problem is to rethink the needs and training of teachers at the preservice college level. Currently reform and revision are pervasive forces in both secondary and elementary teacher training programs.

Fewer than a third of all colleges and universities have science courses specifically designed for teachers. At no time has there been a science course specifically designed to meet the need of the elementary teacher at Rollins. In 1988 the Education, Biology and Chemistry Departments at Rollins College made a commitment to improve the science content background of elementary education students. The aim of this project was to develop a program to adequately prepare preservice and inservice

teachers to teach science effectively. The underlying goals utilized in designing and implementing a new sequence of science and method courses were: to provide a broad-based knowledge of science concepts in the areas of biology, chemistry, earth science and physics; to increase the students' operational knowledge of science process skills by doing hands on, activity-oriented science; and to have teachers develop a more positive attitude toward science and science teaching.

Methodology

Development The program has been developed in two phases of three semesters each, with one semester overlap. The first phase included the development and implementation of an interdisciplinary biology and chemistry course, BC 201, and a companion science methods course. The second phase began with the development of a new course with the objective of integrating the principles of physics with earth science. The first two courses were taught in the spring of 1989. Revisions were made and the courses were offered again in the fall of 1989 to both preservice and inservice teachers. The first offering of the physics/earth science course is currently underway. All of these courses have become part of the requirements for elementary majors.

The first content course was correlated with the science methods course in which students were concurrently enrolled. For example, each week's lesson had a topic or theme, such as classification. In the methods class students examined and practiced the process of classifying via the learning cycle

approach. This exercise was followed by a chemistry oriented class with exercises in the classification of matter, elements, compounds and molecules. Finally in a subsequent class students experimented with the classification of biological organisms. Practical applications of how the exercises could be used in the elementary classroom were provided each week. Thus teaching methodology, chemistry and biology were continuously connected and explored.

A major element of course design was the presence of both faculty (from Biology and Chemistry or Physics and Earth Science) in all of the class sessions. Although in any given class period, one of the instructors had primary responsibility, the presence of the second faculty member facilitated spontaneous conversations which served to better integrate the biology and chemistry components. This helped to emphasize the interdisciplinary relationships of the two fields. While this type of team teaching was not always possible, in the sessions in which this was done the students expressed great satisfaction in being part of a scientific discussion.

Instrumentation The project had several goals amenable to testing. The first goal was to increase the students' basic knowledge and understanding in science. A forty item content test containing equal numbers of questions from biology and chemistry was developed for the pre and post testing of cognitive skills. This test was designed to cover all biological and chemical topics generally covered in introductory courses in these fields. Split-half reliability for the

cognitive test was 0.86.

To measure the second goal, the development of more positive attitudes towards science, the test Attitudes Towards Science (ATS) and Science Teaching (ATST) developed by Redford (1974) was used. The forty item Likert type scale had two subscales designed to measure attitudes towards science and attitudes towards science teaching. Seventeen items related to attitudes towards science and twenty-three items related to attitudes towards science teaching. The split-half reliability for ATS was 0.88 and for ATST was 0.84.

Subjects The subjects in the program included regular undergraduate students, elementary education majors, evening studies students and inservice teachers who enrolled in the various courses. For the spring BC 201 class 16 preservice teachers with a mean age of 20 enrolled. For the fall BC 201 class 11 preservice teachers and 5 inservice teachers enrolled having a mean age of 24.

Prior to this grant the science course taken by most elementary education majors at Rollins was a nutrition course taught by the biology instructor who team taught BC 201. This course was designed to fulfill a general education requirement for the regular undergraduate program (B 112), and for nontraditional students in the evening program (B 112G). In the regular nutrition class 20 students with a mean age of 20 enrolled and in the evening class 22 students with a mean age of 27 enrolled. For all groups the average number of high school science courses was less than 3 and the average number of

college science courses was about 0.5.

Findings

The Integrating Biology and Chemistry classes (BC 201) served as the treatment group and the nutrition classes (B 112, B 112G) as controls. The pre and post test differences for both cognitive and attitude measures were analyzed using a two way analysis of variance.

The cognitive test scores for the experimental groups were significantly better than the scores for the students in the nutrition classes (Table 1 and 2). Scheffe's analysis of the test scores indicated that the scientific knowledge of the students completing BC 201 in both spring and fall terms increased significantly but the nutrition classes did not. An analysis of subtest scores showed that students performed equally well on the biology and chemistry items. The nutrition classes exhibited little or no gain in either the general chemistry or biology subscores.

It was anticipated that the attitudes toward science and science teaching of the students completing the integrated course would show improvement. This was not supported by the analysis of the pre and post attitude measures (Tables 3-6). All groups showed a somewhat positive attitude towards science with mean scores in the range of 48-53 for the four groups where 68 reflects a strongly positive attitude and 0 represents a strongly negative attitude. Likewise, all groups showed a somewhat positive attitude towards science teaching with mean scores ranging from 56-69, where 92 represents a very positive

attitude and 0 a very negative attitude. As might be expected, the education majors in the treatment classes had a significantly more positive attitude toward teaching science than the two comparison groups. Only one significant difference in attitudes towards science was noted. B 112 had a less positive attitude than BC 201F89. Anecdotal data seemed to indicate that the education majors felt more positive about teaching inquiry science than the attitude measure indicates.

Discussion

The results do support the hypothesis that a course incorporating both biology and chemistry would serve the general needs of the elementary education major or inservice teacher more satisfactorily than a specialized, though intrinsically interesting, course such as nutrition. The idea that preservice teachers' understanding of broadbased science concepts was inadequate was supported by the content test data. Narroely focused non-major science courses such as the nutrition class do not give the elementary teacher the necessary background to teach science with understanding.

Faculty observations and student comments would also seem to indicate that the emphasis on laboratory experience rather than lecture created a higher level of confidence. Preservice teachers reported that they felt more able to carry out similar exercises and explain the results in an elementary school environment. Student comments ranged from "I have finally learned not to be afraid of science", " BC 201 makes sense now" (sic at the end of the course), to "I feel I need more exposure

to science concepts" and "it has opened up my thinking a lot."

Currently in most institutions of higher education, the natural and physical sciences are taught separately leaving the integration to the student. An interdisciplinary format incorporating different scientific fields was used to emphasize the interdisciplinary nature of modern science. By designing a course that focuses on biological concepts as extensions of chemical models and principles, the students were expected to have a better understanding of how the two subject areas interrelate. A general perception among the students taking the courses was that chemistry is more difficult than biology. Because the students were more nervous about chemistry as a science and expected to have a lower level of performance, the course was designed to minimize anxiety about chemistry by linking it directly to biology. The data suggests that this strategy may have worked because there were no differences in improvement between the biology and chemistry subscores. Few students predicted that this would be the case.

Although it was anticipated that students taking the new courses would show improved attitudes toward science, this was not indicated by scores on the instruments used. It should be noted that the elementary education majors had a significantly more positive attitude toward science teaching than the control groups. This is probably a reflection of long held beliefs which contributed to their decision to major in education. It may be unrealistic to expect fundamental changes in attitudes based only on one set of courses. Even students who evaluated

the courses very positively and students in the popular nutrition course did not show general overall changes in their attitudes. A number of changes were made between BC 201S89 and BC 201F89 and this may account for the positive trend of the latter's attidues towards science scores.

CONCLUSIONS: The goals of this project were to design and implement a series of courses that would better prepare elementary teachers to teach science and to improve teachers' attitudes towards science and science teaching. The initial offering of the first series of courses met with moderate success. Although the courses increased the students cognitive knowledge, the magnitude of the improvement was not what we had anticipated. As measured by the attitude instrument there was no change in the attitudes of the students towards science or science teaching.

The science content course was revised and is being offered again for both preservice and inservice teachers in the fall. The revisions included lengthening the class time so that the material could be covered at a more relaxed pace, and more active team teaching by the instructors to further emphasize the interrelations between chemistry and biology. According to student anecdotal written records these changes have had a positive impact on the students' attitudes towards the course even though we did not see changes in attitudes toward science in general.

Because the classroom teacher enrollment was less than hoped for due in part to both time and budget constraints, the course will be offered in late afternoons again in the fall for inservice and preservice teachers. Overall the courses have had the greatest impact on the undergraduate elementary program at Rollins. Preservice teachers are now required to take the new science series. With additional electives, the elementary major will be able to have science as an area of content concentration for certification endorsement in Florida. Thus although our goals were met with varying degrees of success our primary aim has been attained.

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TABLE 1: MEANS AND STANDARD DEVIATIONS FOR COGNITIVE TEST

	Pre-test	Post-test	Marginal
BC201 Sp89			
Mean	22.00	26.79	24.39
S.D.	4.19	3.60	4.54
Count	14	14	28
BC201 F89			
Mean	19.38	26.25	22.81
S.D.	3.65	4.20	5.21
Count	16	16	32
B112			
Mean	20.40	20.20	20.30
S.D.	4.02	6.53	5.35
Count	20	20	40
B112G			
Mean	18.30	20.60	19.45
S.D.	4.74	3.53	4.28
Count	20	20	40
Marginal			
Mean	19.89	23.01	
S.D.	4.31	5.54	
Count	70	70	

TABLE 2: ANOVA FOR COGNITIVE TEST

	DF	Var.	F-ratio	Sig.
Groups	3	171.60	8.58	.0001
Test	1	342.58	17.13	.0002
Interaction	3	83.06	4.15	.0078
Residual	132	20.00		
Total	139	26.95		

TABLE 3: MEANS AND STANDARD DEVIATIONS FOR ATTITUDES TOWARDS SCIENCE

	Pretest	Post-test	Marginal
BC201 Sp89			
Mean	53.15	49.23	51.19
S.D.	6.50	6.26	6.57
Count	13	13	26
BC201 F89			
Mean	52.60	55.13	53.87
S.D.	6.45	7.84	7.17
Count	15	15	30
B112			
Mean	49.55	47.90	48.72
S.D.	6.53	5.78	6.15
Count	20	20	40
B112G			
Mean	51.84	51.16	51.50
S.D.	7.37	7.87	7.53
Count	19	19	38
Marginal			
Mean	51.58	50.70	
S.D.	6.75	7.35	
Count	67	67	

TABLE 4: ANOVA FOR ATTITUDES TOWARDS SCIENCE

	DF	Var.	F-ratio	Sig.
Groups	3	153.78	3.25	0.0236
Test	1	25.98	0.55	0.4672
Interaction	3	51.29	1.08	0.3585
Residual	126	47.28		
Total	133	49.61		

TABLE 5: MEANS AND STANDARD DEVIATIONS FOR ATTITUDES TOWARD SCIENCE TEACHING

	Pretest	Post-test	Marginal
BC201 Sp89			
Mean	65.69	62.00	63.85
S.D.	10.24	12.41	11.34
Count	13	13	26
BC201 F89			
Mean	69.73	70.00	69.87
S.D.	11.88	14.44	12.99
Count	15	15	30
B112			
Mean	56.50	56.45	56.47
S.D.	10.42	10.83	10.49
Count	20	20	40
B112G			
Mean	58.84	60.21	59.53
S.D.	9.58	9.86	9.61
Count	19	19	38
Marginal			
Mean	61.91	61.63	
S.D.	11.56	12.55	
Count	67	67	

TABLE 6: ANOVA FOR ATTITUDES TOWARDS SCIENCE TEACHING

	DF	Var.	F-ratio	Sig.
Groups	3	1130.51	9.07	0.0001
Test	1	2.69	0.02	0.8781
Interaction	3	34.76	0.28	0.8421
Residual	126	124.68		
Total	133	144.42		

TABLE 7: MEANS AND STANDARD DEVIATIONS FOR CHEMISTRY COGNITIVE TEST

	Pretest	Post-test	Marginal
BC201 Sp89 & F89			
Mean	9.67	12.70	11.18
S.D.	2.45	2.77	3.01
Count	30	30	60
B112 & B112G			
Mean	8.77	9.41	9.09
S.D.	3.23	3.19	3.21
Count	39	39	78
Marginal			
Mean	9.16	10.84	
S.D.	2.93	3.42	
Count	69	69	

TABLE 8: ANOVA FOR CHEMISTRY COGNITIVE TEST

	DF	Var.	F-ratio	Sig.
Groups	1	148.64	16.86	.0.0002
Test	1	97.51	11.06	0.0015
Interaction	1	48.52	5.50	0.0193
Residual	134	8.82		
Total	137	10.77		

TABLE 9: MEANS AND STANDARD DEVIATIONS FOR BIOLOGY COGNITIVE TEST

	Pretest	Post-test	Marginal
BC201 SP89 & F89			
Mean	10.97	13.80	12.38
S.D.	2.66	2.16	2.79
Count	30	30	60
B112 & B112G			
Mean	10.51	11.05	10.78
S.D.	2.13	2.67	2.42
Count	39	39	78
Marginal			
Mean	10.71	12.25	
S.D.	2.36	2.80	
Count	69	69	

TABLE 10: ANOVA FOR BIOLOGY COGNITIVE TEST

	DF	Var.	F-ratio	Sig.
Groups	1	86.96	14.87	0.0004
Test	1	81.42	13.93	0.0005
Interaction	1	44.65	7.64	0.0066
Residual	134	5.85		
Total	137	7.27		

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