General Biology: Creating a Positive Learning Environment for Elementary Education Majors

Ann Stalheim-Smith Lawrence C. Scharmann

How much and what kinds of science content are to be included in preservice teacher education programs have received renewed attention. These questions were of direct interest to us as we developed a biology course for elementary education majors. The students' performance in the course we developed was better than we had predicted. After describing the course, we will discuss some factors that contributed to the students' success.

The revitalized interest in science content is both consistent with and based upon several reform initiatives begun in the early 1980s (Coleman & Selby 1983; Duschl 1990; Gardner & Larsen 1983; Harms & Yager 1981). It is certainly not, however, the first instance of directed activity aimed at enhancing science instruction among preservice elementary education majors (DeBoer 1991). It has been almost 20 years, for instance, since the following was reported:

> In retrospect, it seems that it is indeed possible to help future elementary school teachers develop a positive feeling for science teaching. This can be done by placing sufficiently few demands on their powers of abstract reasoning and quantitative skills, while giving positive reinforcement in the form of satisfying grades to the efforts they are able to make. Whether the resulting reduction in content can be justified within the context of a college course is a matter for each instructor to decide with his own conscience (Garmon, Madeley & Lockhart 1974, p. 359).

Implicit in such a statement is a tacit proposition that somehow elementary education majors are not capable or academically talented enough to perform well in more traditional science courses. Although there may exist much anecdotal evidence to suggest that this may be the case, the reasons for poorer performance by elementary education majors occurs perhaps for reasons other than ability or level of academic talent (National Research Council 1982).

Ann Stalheim-Smith, Ph.D., is Assistant Professor in the Division of Biology and **Lawrence C. Scharmann** is Associate Professor in the Department of Secondary Education in the Center for Science Education at Kansas State University, Manhattan, KS 66506.

Indeed, one of the more salient factors in the current reform effort, compared to the most immediate previous attempt, is a basic recognition that within a population of students, individuals learn in different ways and therefore learners require course or curricular structures more conducive to their personal learning styles and interest orientations (Nastase & Scharmann 1991).

Certainly the approach offered in the Garmon et al. quote would increase the popularity of an introductory biology course. But, should we treat an introductory course differently in order to improve its popularity among elementary education majors? We believe that the answer is no and yes: No, the content integrity should not be compromised; and yes, the different learning styles of students should be considered. The content is far too important in the development of a more comprehensive understanding of biology to be compromised; content should be both personally enriching and provide quality elementary school science instruction.

Purpose

It is the authors' intention in this paper to describe and report the results of an attempt to provide an environment more conducive to the personal needs, learning styles and interest orientations of elementary education majors in an introductory course of study in the biological sciences. Thus, a special recitation section of the course Principles of Biology taught at Kansas State University (KSU) was designated for elementary education majors only. In addition, the special recitation section was to be an integral part of a multi-year National Science Foundation (NSF) project funded to improve science and mathematics teaching in the elementary grade levels. Finally, for research purposes, the authors wished to establish a learning environment within an existing standard majors'/nonmajors' introductory course at Kansas State University (KSU) rather than create a new course. The rationale for using an existing course was to test elementary education majors' achievement in comparison to biology majors and other nonmajors, according to the following three related hypotheses:

Hypotheses

There will be no significant differences in achievement, as measured by overall grade distribution, for an elementary education majors' recitation section of Principles of Biology:

H1. Compared to past recitation sections taught by the same instructor.

H2. Compared to all other recitation sections of the course taught during the spring semester of 1992.

H3. Compared to 10 years of cumulative data for the Principles of Biology course.

Context

In the second semester of the NSF project, the students were put into a single recitation section in the Principles of Biology course. The Principles course was set up in 1968 as an audio-tutorial class based on *The Audio-Tutorial Approach To Learning* by Postlethwait, Novak and Murray (1969). The subject matter to be studied by the student and the lab exercises to be performed during a particular week are introduced on audio tapes in the laboratory. Instructors are available in the lab to answer questions. No lectures are given. Each week a student spends four to six hours in the audio-tutorial lab listening to the tapes (about 45 minutes of that time), performing the lab exercises, and observing displays—many of which involve manipulation. Written lab exercises are completed, handed in, and graded each week. After completing the audio-tutorial lab, each student attends a recitation class where biological topics are discussed under the guidance of an instructor. In addition, the graded lab exercises are returned to the students during class time. The recitation section, which averages 24 students each, is an innovation at Kansas State University to make the subject matter relevant to the student and is not a part of the audio-tutorial approach of Postlethwait, Novak and Murray (1969). Help sessions are available at regularly scheduled times each week, but attendance is not required. A standardized weekly exam is given to all students, which covers the subject matter assigned in the audio-tutorial lab for that week only. All exams are written by the course coordinator (16–47 questions per exam). The questions are based on the objectives listed in the lab manual for each lab exercise. Every student, enrolled in any section of Principles of Biology, takes the exam at 6 p.m. each Monday. Thus, the exam is the same for each student. During the spring semester (1992), 768 students took the course. The course enrollment averages about 750 students per semester.

Description of Subjects

Students majoring in elementary education at KSU had an opportunity to apply for participation in an enriched science and math curriculum supported by a National Science Foundation (NSF) grant. The selected students entered a curriculum of science and math courses together. The goal of the designed curriculum is to give the students entering the elementary classroom a solid background in science and math that will help to develop their confidence in these subjects, resulting in their enjoyment of teaching them. If the latter occurs, the outcome hoped for is that more and higher quality science will be taught in the elementary classroom.

Students were recruited from a broad base and every effort was made to contact under-represented groups in elementary education. Students choosing to participate in the NSF elementary science project submitted an application that was reviewed by the Project Director and Senior Faculty Associates on the grant. Thirty students applied and 28 were selected. The group included an Asian, African Americans and Caucasians (males and females).

During their first semester in the program, the students were introduced to the scientific method, science processes and constructivist teaching/learning models (i.e. learning cycles) in their first set of interrelated courses. The only students in these courses were the students in the NSF project; thus, the students got well-acquainted with one another.

In the second semester of the project, the students were put into a single recitation section in the Principles of Biology course, which was taken concurrently with a Biology Teaching Methods course. Although 28 students were enrolled in the NSF project and Methods component, only 14 students took the Principles of Biology course. The reasons for this were twofold: Some students had taken the course at a junior college; others had taken the KSU Principles of Biology course prior to their acceptance into the NSF project.

It was obvious from the first two sessions of recitation that the elementary education students were very comfortable with each other from their earlier classes together. In addition, from an instructional perspective, teaching them in even the first few sessions was similar to what is only experienced with most recitation sections at the end of the semester. In other words, the NSF students were permitted ample opportunities to interact and these students took advantage of such opportunities. Even at the start of the semester, the students felt secure in asking questions and participating in discussion. Consequently, teaching of the subject matter in recitation could relate more directly to the topics the students were having problems with as well as initiate a discussion of topics they had expressed interest in knowing more about.

In addition to the usual instruction from the teaching staff, the students were expected to teach each other biology as they studied the subject matter. To enhance the likelihood of this interdependence, students were put into groups. The Science Teaching Efficacy Belief Inventory (Enochs & Riggs 1990) was given to each student to assess his/her level of self-confidence concerning science and science teaching. Using the scores obtained from this inventory, each student was placed into an assigned group. Each group contained three to four students: one student with strong confidence (high efficacy), one-two students with average confidence (moderate efficacy), and one student with low confidence (low efficacy). Students were encouraged to work with their groups as they did the weekly lab exercises in the audio-tutorial lab and to study outside of class together. Although no specific instruction was provided on how to work in groups during the current semester, NSF students were provided with both a formal introduction and opportunities to practice cooperative/collaborative learning processes during their previous semester in the program. Hence, students were already somewhat familiar with the benefits and problems associated with group versus individual learning dynamics.

Curricular Organization

The Principles of Biology and Biological Teaching Methods courses were organized to be similar to a Learning Cycle (Karplus & Thier 1967; Lawson, Abraham & Renner 1989; Renner & Marek 1988), a three-stage learning-teaching model (i.e. Exploration → Concept Invention/Term Introduction → Concept Application) that attempts to emulate how scientists generate and test new knowledge claims. A distinct line of demarcation doesn't exist between where exploration ends and concept invention/term introduction begins; however, the essential element is that students make an attempt to understand and apply personal conceptions prior to either formal class discussion or an instructor's intervention. Each student was exposed to the subject matter in the following sequence in each one-week period. The subject matter was introduced first in the audio-tutorial biology lab (exploration), then it was discussed in a 50-minute recitation on a subsequent day (concept invention/term introduction), and ultimately followed by an application of the weekly subject matter in the Biological Teaching Methods course (concept application). The latter took place after students had completed their weekly examination. An example of this is: Cell structure was studied in the audio-tutorial lab (about four to six hours of lab work that could be done anytime within a two-day period); the topic "Cell to Whole Organism" was presented and discussed in the recitation class; and then "Whole Organism to Cell" was modelled as a Learning Cycle (including observation of living organisms) in Biological Teaching Methods. Thus, the Biological Teaching Methods course provided not only the final component of each weekly learning cycle (concept application) but also made use of an entire learning cycle to model the weekly topic. This summary learning cycle was conducted in a manner consistent with how, as eventual student teachers, they might approach the topic in the elementary school (Scharmann 1991). Finally, as a part of the experiences of the methods course, students were required to design, plan and conduct three learning cycle instructional episodes with progressively more rigor and responsibility:

1. For their peers
2. For a small group of after-school elementary *Science Club* students
3. For a whole class of grade school elementary-aged students at a local elementary school. In each episode, students worked with their assigned group members. For the methods course experiences, groups were assigned on the basis of NSF students' elementary grade level preferences. Thus, although methods groups were assigned using a different rationale than biology groups, all instruction was performed with the support of others within their peer group.

Results & Discussion

At the conclusion of the semester, student grade frequencies were obtained for the NSF Elementary Education majors' section, all other spring (1992) course sections, and 10 years of cumulative grades for the Principles of Biology course. Because different sections of the course within the current semester were taught by different instructors and since grade frequencies were collected over the past 10 years, statistical analyses were conducted using the nonparametric X^2-test and Kruskal-Wallis 1-way ANOVA tests (Conover 1980).

An initial test, to determine the representativeness of the data from the target semester, revealed no statistical differences compared to the 10-year cumulative data ($X^2 = 2.06 < {}_{.95}X^2 = 9.49$; df = 4). Thus, it can be inferred that the spring (1992) semester sections of the Principles of Biology course were no different than those sections taught over the past 10 years. The testing of the actual research hypotheses produced the following results:

Hypothesis 1

There will be no significant differences in achievement, as measured by overall grade distribution, for an elementary education majors' section of Principles of Biology compared to other past sections taught by the same instructor.

This hypothesis was tested in two ways. First, controlling for instructor, day and time, only other sections taught by the NSF Principles of Biology instructor on Friday at 12:30 p.m. during three of the past four semesters were tested. A Kruskal-Wallis 1-way ANOVA produced a significant statistical result ($X^2 = 10.41$; $p < 0.01$). Second, in an attempt to generalize to other days and times, all other sections taught by this same instructor were included in a subsequent analysis. This second test also produced a statistically significant result ($X^2 = 25.03$; $p < 0.01$). These results supported the instructor's anecdotal evidence that the preservice elementary NSF-sponsored recitation section was the best overall group of students with whom the instructor has had the privilege to work.

Hypothesis 2

There will be no significant differences in achievement, as measured by overall grade distribution, for an elementary education majors' section of Principles of Biology compared to all other sections of the course taught during the spring semester of 1992.

The observed versus expected grade frequency distribution for the NSF-section were compared to all other sections of the Principles of Biology course. A chi-square test produced a significant statistical result ($X^2 = 11.67$; $p < 0.05$) for this comparison. This result therefore indicated that the NSF-sponsored recitation section outperformed all other spring semester (1992) sections of Principles of Biology.

Hypothesis 3

There will be no significant differences in achievement, as measured by overall grade distribution, for an elementary education majors' section of Principles of Biology compared to 10 years of cumulative data for the Principles of Biology course.

The final comparison conducted was a test between the observed versus expected grade frequency distribution for the NSF-section against all sections of Principles of Biology for a cumulative period of 10 years. A chi-square test, once again, exhibited statistical significance ($X^2 = 10.39$; $p < 0.05$). This final result, coupled with those reported for the previous two hypotheses, served notice that the NSF-sponsored section of Principles of Biology was the single best recitation section (in achievement terms) over the past 10 years of the course.

Conclusions & Implications

In this large, standardized Principles of Biology course where the text assignments, laboratory exercises and exam questions were identical for all 768 students, the NSF-sponsored recitation section of 14 students in the elementary education program performed significantly better than the other students in the course. In addition, this group of 14 students performed better than other recitation sections taught by one of the co-authors (over the past five-year period). Finally, they performed better than the 10-year average of all students taking the Principles of Biology course.

We relate the better performance by the elementary education students to four factors that were unique for this group of students. First, the priority from the NSF grant to make these students knowledgeable, comfortable and confident in science (a focus in the courses in their first semester in the program and of the Principles of Biology recitation professor). Secondly, these 14 students were cohorts going through a second semester of courses together and felt comfortable asking questions and discussing the subject matter with each other, the recitation professor and the instructors in the laboratory. Thirdly, the class was put into groups and encouraged to perform lab exercises together and study together. As a result, they taught and supported each other. Fourthly, the students were exposed to new knowledge in a Learning Cycle format (biological content was followed with pedagogical applications).

The elementary education students commonly worked together in small groups in the laboratory and in learning the subject matter before the exams, even though the group of students was often not the four assigned into a group by us. Due to schedule conflicts and other factors, the assigned group of four often could not meet at the same time. However, when the assigned groups could not get together, the students made their own small groups to perform the lab exercises and to study the subject matter in preparing for the weekly exams. The students carried this further by coming in pairs and small groups to the professor for help on the subject matter. Usually, student appointments with a professor are one on one, but these students felt comfortable discussing what they did not understand in front of their peers. We relate the tendency for these students to work in groups to our encouragement for them to do so. This was also facilitated by the fact that they knew each other from courses together the previous semester.

Factors, in addition to the four listed above, that may have contributed to the success of the elementary science education students include accounting for individual study preferences and reducing the size of the recitation section from 24 to 14 students. Each of the six factors probably played a unique role in generating a significantly improved effort in a course of study in the biological sciences.

The data on the performance of these elementary education students clearly indicates that they learned the science content not only as well as, but better than, other students (including both biology majors and non-majors) who were taking or had taken the course. This evidence shows that the science content of a course (both factual recall and higher-order problem-solving formats) does not have to be altered for elementary education students to be successful. Creating a learner friendly environment to engender positive attitudes towards a course or discipline of study is not a new idea; however, many past efforts were accomplished through what critics perceived to be simpler, watered-down versions of more rigorous courses of study.

A major implication from the current study provides evidence that reducing the perceived content integrity of a course may not be necessary. The successes reported here for elementary education majors enrolled in a rigorous course of study in biology provide striking evidence to the contrary. Perhaps by aiding the students' chances of success in rigorous science courses, science instruction in higher education may be able to perform a more worthwhile service for both a traditionally science-anxious group of learners and, potentially even more importantly, for the future students this traditionally anxious group will teach in the elementary school classroom.

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