Shaping the Nonmajor General Biology Course

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Contextual Setting

In the aftermath of the launching of the Russian Sputnik in 1957 came the most rapid science curriculum development in the history of American public education. Prior to 1957, science instruction could best be characterized as a disciplined presentation of a body of discrete facts. Students were expected to be able to synthesize, analyze and evaluate this body of knowledge without instruction in any methodology for performing these cognitive thought processes. The ability to carry out these higher order cognitive skills, however, would be required of students if and when they attended a college or university.

University or college science departments, however, typically have perpetuated nonmajor students' underdeveloped higher order cognitive or "critical thinking" skills by demanding they learn still more detailed discrete facts while assuming that the students previously had acquired a methodology to synthesize new knowledge into more pervasive concepts. Thus, the discrepency arose, in the wake of Sputnik, that at no level of a student's educational experiences were critical thinking skills being sufficiently fostered to provide the opportunity to truly understand the nature of science.

It was, therefore, important that the quality of science instruction be scrutinized by representatives from a variety of educational levels if any major changes were to influence the comprehensive science curriculum. In 1959, the National Science Foundation (NSF) supported the establishment of several curriculum study commissions to assess, develop and implement curriculum programs for science instruction based on sound scientific and pedagogical principles. The success or failure of these commissions can be debated but the general goals, processes and intents of the resulting curriculum programs and their associated materials represent the best comprehensive effort to provide an articulate blueprint for the study of science.

In 1960, the Biological Sciences Curriculum Study (BSCS), represented by university biology professors, other university science educators, high school biology teachers, curriculum specialists and educational psychologists issued their assessment of the discrepancies between "what should be" and "what is" the status of biological science instruction. The BSCS Commission findings and subsequent BSCS curriculum materials have influenced both elementary and secondary schools' commitment to the study of the biological sciences.

The BSCS commission for postsecondary biological education assumed that if a sound, relevant curricular design could be produced for K-12 science instruction, then students would be prepared to handle higher level cognitive demands placed upon them in college level science studies. Shymansky, Kyle and Alport (1982) found improvements in student achievement through use of BSCS materials, and also reported that only as few as 20 percent of all secondary biology teachers were instructing with the BSCS materials. This dilemma is currently receiving the attention of individual university faculty concerned with renewing the efforts that began with the BSCS Commission.

The collegiate science curriculum has perpetuated the view of the curriculum as being strictly content. Larson (1982) delineated this by noting that science courses are often bogged down with jargon, symbols, arithmetic metaphors and analytical thought processes which can "turn-off" and discourage nonmajor students. The method of collegiate science instruction is also based almost strictly on content with emphasis on the lower levels of cognitive learning that ignore the development of students' ability to think critically. Singer and Benassi (1981) concluded that a memory-recall approach to science instruction may bring about problems and shortcomings in students' understanding and learning of science. The deficiencies inherent to collegiate nonmajor biology instructions thus come from two sources: (1) insufficient previous student experiences in critical thinking; and (2) inadequately planned collegiate courses of study that neither promote understanding of science nor remediate students' experience in thinking critically. Without a commitment to determining national goals and guidelines for the nonmajor study of biology, collegiate science instruction has plodded down the same time honored path. There is a growing trend, however, for the improvement of nonmajor biology problems among some very innovative biology professors and science educators. As more of their efforts and program successes are reported, there hopefully will be more widespread national interest and support for improving instructional quality and curricular course design at the undergraduate nonmajor level. Another problem postsecondary biology instructors need to address is providing students with an opportunity to apply the concepts of science to their own lives while challenging their ability to solve 'new' problems related to these concepts.

The status of undergraduate nonmajor biology study in the United States can be improved with a little diligence on the part of a few innovative professionals. Research on a quantitative and qualitative basis must continue if the public, government and academic community are to be expected to support future improvements in science education.

Curriculum Considerations

Harms & Yager (1981) reported that most of the current research toward the improvement of science instruction considers four "goal clusters" essential for a presentation of the nature of science and its subsequent impact upon the individual. These "goal clusters", consistent with the BSCS commission findings are: (1) personal needs; (2) societal issues; (3) academic preparation; and (4) career education/awareness.

The content of biology is vast, and certainly every instructor designing a college nonmajor course will place specific emphases on different instructional areas. The selection of general areas needs to include basic competency considerations. Other basic considerations might be synthesized from the BSCS nine "core threads" of salient knowledge (Harms & Yager 1981). Minimally, these considerations need to be included in any college nonmajor biology program. It should also be noted that various syllabi, for a study of nonmajor college biology from a variety of institutions of higher education, all include these content topics with a wide variation of emphases. The degree to which higher level cognitive skills are fostered, however, remains uncertain. The stress that is placed upon curricular considerations other than content also remains indeterminate.

One of the criticisms leveled at science instruction is that it fails to provide the opportunity for students to develop a rational basis for applying scientific principles to their own lives and to interpret current technological innovation. Science instruction also fails to consider the personal needs of the student in understanding potential future events or technological advancements. A most unfortunate aspect of this criticism is that science, and especially biology, is the most appropriate collegiate discipline of study to foster highly personalized critical thinking skills. Toffler (1972) asserted that science education is incomplete if it does not incorporate some preparation dealing with the future of the human race.

The omission of this curricular component has not, however, gone unheeded. Science educators and biology professors have recently begun research studies to determine not only how to incorporate this component but also how to assess entry level needs and evaluate performance improvement based on practice problems requiring critical thinking skills. The greatest emphasis on this skill development has taken place over the past four years and represents a high percentage of the reported research in science education. Moll and Allen (1982) reported that the entry level of students' experiences with critical thinking skills were oriented totally toward memorization and recall of course information; students had difficulty interrelating concepts and had poor retention. Statkiewicz and Allen (1983) also found that the use of practice problems and exercises to develop critical thinking skills can improve student performance and that these skills are transferable to new and unfamiliar problems. Developing analytical reasoning with science concepts is an important but difficult goal to achieve, but with perseverence this curricular component can be achieved with resulting gains.

A natural extension of developing critical thinking skills for use in solving personal problems is to apply those skills to managing present societal issues and future scenarios. The method for integrating this component into the nonmajor biology curriculum can take many forms, but extensive content requirements coupled with the development of critical thinking skills leave little time for implementing this curricular facet during classroom time. If time, however, is accorded to developing personal skills in handling future problems during class time, then teachers can give outside reading assignments so students can supplement and apply those skills outside of class. Measurement or evaluation of reading can take place at the discretion of the instructor through an examination or a "synthesis" paper.

Outside reading for exposure to societal issues having a scientific basis should include books and articles from three key areas: (1) classic works of scientific discovery and their impact upon human society; (2) science fiction; and (3) classic research articles. By studying classic works of fiction and nonfiction, the student is exposed to biological history from a perspective other than factual content. The purpose of this genre is to increase student perceptions, improve students' attitudes and give them an appreciation for science. A quality of good science fiction is that it allows a student to study societal issues and personal impacts from a distance. Knowing that the events depicted in science fiction have not happened, yet could happen, fosters a level of interest and awareness not possible through simple content learning. Science fiction authors are extremely prolific; however, many works are either historically or scientifically inaccurate. Any instructor planning the use of science fiction needs to review the novel carefully prior to including it as a potential choice for student reading. Students take for granted many of the advancements in the biological sciences, especially in medicine, public health, energy and population. Exposure to the historical period immediately surrounding an important discovery, advancement or invention gives a better perspective, appreciation and understanding of the trials that scientists experience in promoting scientific study. Hence, consideration of classic research articles is desirable.

Harms & Yager (1981) also noted that science courses need to provide students with an awareness of a variety of science and technology-oriented careers available to students possessing an array of interests and aptitudes. A criticism that might be leveled at biology instructors regarding this curricular element is that the presentation of potential career possibilities might be too implicit for nonmajor college students to relate to their own personal experiences. Therefore, a more explicit presentation of career possibilities is advisable during the course of a semester.

Concluding Remarks

Our intent has been to present rational arguments for the improvement of instructional quality through expanded curricular considerations for the college nonmajor biology student. The synthesis of these curricular components has been based upon historical precedent, reported literature and curriculum commissions' findings. Integration of the curriculum components which have been suggested require the dedication, attention and time commitment of an innovative college biology instructor. Organizational skills are also necessary if the proposed strategies are to have reasonable chance for success. Implementation of a curricular organization such as proposed here includes several features not normally found in other, more traditional, modes of instruction. These features include, but are not limited to:

1. The application of biological content to the personal experiences and future needs of nonmajor biology students necessary for building positive student attitudes;
2. The maintenance of content integrity; additional curricular components supplement rather than replace traditional course material; the expectations for students are enhanced rather than "watered down";
3. The analysis, synthesis and evaluation of biological content, especially where it has a direct impact on personal or highly relevant societal issues, helps to develop a student's critical thinking skills;
4. The presentation of a variety of careers in science exposes the student to vocational applications and implications inherent to a continued study in the sciences.

We were not specific about how to implement the curricular organization for several reasons. First, we made no attempt to specify content material because the degree of emphasis on specific content topics is related to a function of instructors' competence and their subsequent choices of reference learning materials. Second, the lack of empirical data regarding the developing of students' critical thinking skills by any specific methodology precludes any assumptions concerning the effectiveness of the suggestions for developing higher order cognitive thought processes. An ongoing review of the literature will influence periodic changes in the directions and methods for fostering these skills. Finally, implementation of the suggestions might also provide additional qualitative and quantitative data to support future attempts to curriculum change at other institutions of higher learning. In essence, the suggestions made not only have the potential to promote the cognitive development of nonmajor students, but they also provide them with an opportunity to appreciate or value the study of biology. If undergraduate nonmajors enroll in no other biology courses, at least, they might become aware of potential personal and societal applications or implications, might be cognizant of career possibilities and might continue through their undergraduate preparation with a higher level of cognitive development.

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