Biology Educators and the History of Biology

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Abstract: Both teachers and learners can benefit from looking at the history of scientific discovery and science teaching. This paper draws together examples and discusses their implications particularly for biology teachers. Much has been written about effective and relevant biology teaching over the years. Biology educators ought to be aware of this history of life science curriculum change as well as the importance of the thought processes of prominent biologists in history.

Keywords: history of biology, science curriculums, induction/deduction in science, science teaching, creativity

CHANGE IN SCIENCE CURRICULUMS

Striving for excellence in teaching is an on-going task; one is constantly aware that knowledge and process change. The teacher is implored to be abreast of revisions and innovations in science teaching methods. Attention must be given also, to the history of biology as it relates to effective teaching. An examination of the concepts and reasoning developed by earlier scientists and educators, as presented in this paper, will enhance the effectiveness of the current classroom teacher.

Over the years, the methods of teaching science and the curriculums of science have undergone significant changes. Instruction in science has profited from innovative programs such as BSCS, PSSC, ISCS, ESCS, and many other projects with acronyms that are readily recognized. More recently, programs such as the BioQUEST Curriculum Consortium, Project Wild, and case-based learning approach to biological concepts have made problem-solving and decision-making inseparable from the content of the discipline. These programs individually and collectively have enlightened science teachers and students at all levels of instruction.

The presence of projects like BSCS, have had their origin through the efforts of college and university science faculty in cooperation with teachers of school science. As a result of the pursuit of curriculum improvement and the adoption of new programs, the college and university teacher has been obligated to revise and adapt teaching methods. The teaching profession is ever demanding. There is a constant need for the teacher to improve in a chosen discipline, e.g., in methods of teaching and a need to inspire students to want to learn and to be self-reliant in their ability to derive and apply knowledge.

Ost (1975) identified and reviewed curriculum patterns in the sciences, mathematics and social studies. Ost concluded that, "As with any change in education, it can only be as good as the changers; output is always a function of input." Thus it is with the teacher, the "changer", that the profession requires more than just employing practices which make us comfortable, practices which may not have been reviewed for validity in too long a time. Membership in the teaching profession implies an obligation to promote and to advance the profession.

THE REWARD IN TEACHING

Most teachers enter teaching for the satisfaction the profession provides in pursuing a particular field of interest and for working with students to foster enthusiasm for that field and do not make monetary wealth an objective of their endeavors. Henry David Thoreau (1995), was rather candid in his appraisal of teaching as a means of making a living: "For more than five years I maintained myself thus solely by the labor of my hands, and I found, that by working about six weeks in a year, I could meet all the expenses of living. The whole of my winters, as well as most of my summers, I had free and clear for study. I have thoroughly tried school-keeping, and found that my expenses were in proportion or rather out of proportion, to my income, for I was obliged to dress and train, not to say think and believe, accordingly, and lost my time into the bargain. As I did not teach for the good of my fellow-men, but simply for a livelihood, this was a failure."
While not to be faulted for his view on teaching, Thoreau's observations underscore the inherent nature of teaching. It is unequivocally about the bond between student and teacher. The best of teachers are facilitators who guide student learning. Satisfaction for the teacher comes with the light in a student's eyes; the "aha syndrome; the enthusiastic understanding of a particularly challenging concept. Teachers who share in that discovery are the best models for students.

The Historical Context of Science Teaching

Our legacy in science teaching methods can be traced back several centuries: John Amos Comenius (1592-1670) (Cubberley, 1922), the Czech educator, emphasized that science instruction must move from words to things and the teaching of useful knowledge; Johann Heinrich Pestalozzi (1746-1827) (Cubberley, 1922), a Swiss educator, advocated learning by doing and argued that teaching and learning must be largely analytical. Huxley (1968 [1854]) tends to reduce the anxiety of scientific investigation thus: "Now a great deal is said about the peculiarity of the scientific method in general, and of the different methods which are pursued in the different sciences...So far as I can arrive at any clear comprehension of the matter, Science is not, as many would seem to suppose, a modification of the black art,...Science is, I believe, nothing but trained and organized common sense....the vast results obtained by Science are won by no mystical faculties, by no mental processes, other than those which are practiced by every one of us, in the humblest and meanest affairs of life. A detective policeman discovers a burglar from the marks made by his shoe, by a mental process identical with that by which Cuvier restored the extinct animals of Montmartre from fragments of their bones. The man of science, in fact, simply uses with scrupulous exactness the methods which we all habitually and at every moment, use carelessly;...If, however, there be no real difference between the methods of science and those of common life, it would seem, on the face of the matter, highly improbable that there should be any difference between the methods of the different sciences."

Nearly 40 years ago the yearbook of the National Society for the Study of Education (NSSE) (1960) was devoted to the review of science education. The results of the NSSE's deliberations are succinctly concluded in this summary statement: "With reference to the acquisition of scientific methods and attitudes, it seems obvious that if students are to develop these abilities they must have practice in them." This comment seems to follow the "common sense" pronouncement of Huxley.

The employment of induction and deduction in science, maintains Huxley (1968), is the same when applied to the discovery of a new planet, or when used in deciding how to remove a stain from a garment. With regard to inductive-deductive teaching, a controlled experimental study by Boeck (1951) compared achievement of high school chemistry students, taught by a method that stressed the inductive-deductive approach, with achievement by students taught by the traditional deductive-descriptive method. Boeck's results indicated that the inductive-deductive class did as well or better in attaining the knowledge expected from a high school chemistry class, and did significantly better relative to the attainment of the methods of science and the development of scientific attitudes.

Nobel laureate George Beadle and his wife Muriel (1966) emphasize the importance, not of the experiment and the facts, but of application of the experience encountered in the investigation and the information derived. Much can be learned by the student of biology by examining the work of the great scientists; how they envisioned a problem, and how they developed a process to provide data which might have contributed to a solution for the problem...for example: studying the work of Semmelweis, or Hooke, or Pasteur. The Beadles comment that, "...the excitement of learning about science lies as much in following the reasoning behind the discoveries as in knowing the results". One of the great challenges in the science curriculum is the balancing of content and process within the discipline. Equally important is tying content and process to the student's personal life.

Science educators have placed much effort in determining what science should be taught, and how to teach science. However, the nature of the learner ought not be neglected. How do students learn? An understanding of the psychology of learning has been fundamental to successful teaching and learning as witnessed in the work of Piaget on developmental growth and comprehension in young people; in the work of Ausubel on concept formation and reception learning, in the work of Bruner on discovery (inquiry) learning, and in the work of Gagne on guided learning, which has some similarity to the work of Ausubel. We may not agree with all or any of the practices advocated by these researchers; but, as Novak (1977) states, "The value of theories derives less from their permanence than from their contribution to the generation of new and better concepts and practices."

Effective learning is typically linked to the importance or relevance of the concept to the student. For most of us, the content or processes of the sciences
are best internalized in the context of models we have constructed for some phenomenon. Even children in the early elementary school grades have mental models for relatively sophisticated systems like the physical dynamics of the solar system, the process of photosynthesis, and the predator/prey interactions in an ecosystem. While the models may be inaccurate or incomplete, whether for child or adult, they form the basis for student entry into the learning process. A model exists which can be improved or discarded. It is important to recognize the existence as well as the variation in models our students have developed or learned.

THE TEACHER'S RESPONSIBILITY

It is the charge, the obligation, of the teacher to identify what a student knows in the sciences, to carry the student forward in the assimilation of new concepts and skills, and to help the student develop desirable scientific attitudes. Inherent in this obligation is the task of identifying that student who may be the creative person, one whom we would certainly wish to encourage to pursue a career in science.

Identifying the creative individual is not easy, but perhaps Koestler (1967) may be of help. Koestler insists that creativity in science, that is scientific problem solving, is dependent upon the ability of the person to make analogies and recognize interrelationships between or among events or phenomena where none apparently exist. Koestler states, "Thus the real achievement in discoveries … is seeing an analogy where no one saw one before … The essence of discovery is the unlikely marriage … of previously unrelated forms of references or universes of discourse, whose union will solve the previously insoluble problem." Many examples may be cited which illustrate the discovery of interrelationships: Benjamin Franklin's work with the Leyden jar and his observations on lightening and electricity; Ignaz Philipp Semmelweis's discovery of the relationship between the "clean hands" of the physician and the ultimate reduction of mortality in puerperal (childbed) fever; Alexander Fleming discover of penicillin; Paul Erhlich work with compound 606, Salvarsan, as a control for syphilis; and Robert Hooke's experiment with springs, and elasticity. Those teachers who have taught for some time have a responsibility to nurture new teachers. This may, of course, be done by modeling effective techniques in the classroom. However, its clear that much can be gained by a study of the history of biology, 300 years past as well as 30 years ago.

If we keep Koestler's suggestions on creativity before us as we teach, maybe we will take note of that student who brings novel solutions to problems, one who "sees" interrelationships where apparently no one else does. Not many students fit this scenario, but who knows which future scientist may be in our biology class.

Teaching biology is all about "letting students in" that trained and common sense approach to asking and answering questions about the natural world. Perhaps our approach to instilling biological literacy in students could be characterized as a three-step process; 1) promoting awareness of the elements of the natural world, 2) encouraging appreciation for the elements of biological systems from the cell to the ecosystem, and 3) facilitating student action; that helps people learn by doing. Active involvement in the scientific process of discovery gives the student ownership over his/her learning.

References