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Teaching Animal Science: Education or Indoctrination?¹

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ABSTRACT: Traditional animal science curricula ignore sociological aspects of scientific research and therefore portray scientific knowledge as value-free. This view gives rise to a teaching method that involves imparting lists of scientific facts that are to be accepted by students without critical evaluation. This amounts to little more than indoctrination and misrepresents science as a system of knowledge. An alternative approach is based on the view that science is a creative human activity that reflects the values and biases of its practitioners. The goal of this approach is to teach students to think analytically and to make independent judgments about scientific claims. This requires a scientific literacy: an under-

standing of principal scientific theories, the nature of scientific research, and the relationship between science and society. To achieve this goal, a teacher must become less of an authority figure, whose role is to simply pass on information, and more of a facilitator, whose role is to promote questioning, exploration, and synthesis. This requires a learning community in which students feel comfortable taking risks and develop the courage to make and defend judgments. This teaching approach enhances the intellectual and ethical development of students, allowing them to serve themselves and society in responsible ways.

Key Words: Teaching, Science Education

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Introduction

A major contemporary issue within the animal science profession is the identification of appropriate educational goals for animal science curricula. At one level, there is discourse concerning the degree to which animal science courses should emphasize basic science (Harmon, 1992; Kauffman, 1992). A more fundamental concern deals with the way in which science is portrayed as a system of knowledge. Animal science deals with the application of scientific theories to the management of livestock. Therefore, all educators in this discipline are confronted with the task of teaching their students something about the science of animal production. Those who view science as a search for truth tend to emphasize the presentation of scientific "facts." This approach to teaching is undesirable for two reasons. First, it misrepresents science as a system of knowledge. Second, it impairs the intellectual and ethical development of students. In this paper, I advocate a teaching approach that is aimed at educating students about science: teaching them to think independently and analytically about

scientific claims. This approach is consonant with a view that portrays scientific research as a creative human activity rooted in culture, and scientific claims as probable opinions about which judgments can and should be made.

Scientific Activity: A Search for Truth or Imaginative Speculation?

The scientific revolution of the 16th and 17th centuries gave rise to the belief that universal truths can be discovered through objective observation and experimentation. This view was later advocated by John Stuart Mill (1806-1873) and Karl Pearson (1857-1936) and remains popular (Bauer, 1994). The belief that scientific research is paradigmatically objective and rational and therefore guarantees discovery of truths has been challenged. No scientific claim is completely unbiased. All observations and experiments are "theory laden" (Medawar, 1984; Chalmers, 1991). To derive empirical information from observations and experiments requires the prior formulation of specific hypotheses. Our hypotheses are influenced by our values and world views. In other words, they are rooted in our culture. We are born into a set of beliefs about the nature of things much as we are born into the language we speak (Polanyi, 1950). For example, the Western belief that nature is

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governed by the laws of a Creator gave rise to a science that is devoted to discovering these laws and the order of nature (Needham, 1969). Scientific theories frequently arise from “uncritically acquired foundations” (Polanyi, 1950), and the extent to which they are accepted depends as much on the strength of scientists’ beliefs as empirical results. Gould (1977) characterizes science as “creative human activity” and its geniuses as inspired artists whose imaginative preconceptions of reality gave rise to our most important scientific theories. Medawar (1984) concurs with this view and asserts that developing an important scientific theory is much the same as creating a great work of art; neither can be premeditated and both arise from creative inspiration. He describes the day-to-day activity in science as “making observations and experiments to find out whether this imagined world of our hypotheses corresponds to the real one.” Of course we can never know how well our imagined world corresponds to reality. Judgment of scientific theories must involve something else.

If observation presupposes theory and scientific theories are little more than imaginative speculations, then is it possible for scientific information to be reliable? If reliable means something other than “true,” then the answer to this question is “yes.” Russel (1959) classifies much of what we believe as “probable opinion” (neither absolutely true nor completely false). A coherent system of probable opinions is more likely to be true than a single opinion. Scientific theories, therefore, become reliable when they are based on a logically connected set of scientific beliefs. Chalmers (1991) describes scientific knowledge as an “unrepresentative realism.” It is real in the sense that it allows us to cope with some aspect of nature, but unrepresentative insofar as it may not represent reality in a precise way. According to this view, reliable scientific knowledge is that which becomes accepted because it has been proven to be useful in coming to grips with a particular natural phenomenon. Central to this view of reliability is cooperation and consensus among scientists. Bauer (1994) notes that the most reliable scientific knowledge is that which has progressed through a “knowledge filter,” consisting of various stages of literature, each of which is scrutinized by members of the scientific community. In other words, scientific knowledge is consensual truth. Scientific activity is similar to solving a jigsaw puzzle (Bauer, 1994). According to this analogy, scientists are puzzlers, each of whom uses different strategies to find pieces that fit. Whether or not a piece fits requires consensus among scientists, and consensus determines what is valid knowledge.

Teaching Science: Uncertainty or Authority?

When scientific knowledge is viewed as an unrepresentative realism, and the roles of scientists’ imaginations and values in theory development are

acknowledged, it becomes appropriate to teach students how to deal with the uncertainty of science. In doing so, students must be encouraged to question the assumptions upon which scientific claims are made and to make judgments about such claims. Animal production courses taught in this manner would emphasize critical evaluation of the research upon which management practices are based. Rather than accept popular practices as “right,” students would be allowed to study a particular management problem and then select and defend their own solutions. Their decisions would be based on appropriate analytical skills but would reflect their developing lifestyles and values. For example, students who find feedlots undesirable might be encouraged to explore alternatives to grain-finished beef cattle. This approach permits a broader view of livestock production and promotes creativity. It also enhances students’ intellectual development, the ability to reason and perceive differences. In addition, this approach contributes to students’ ethical development, the ability to make judgments based on standards of conduct.

The alternative to uncertainty is authority. A teacher who portrays scientific knowledge as a set of eternal truths assumes the role of an authority whose purpose is to pass on these truths. This approach precludes critical thought because scientific claims are viewed as beyond reproach. Students taught in this manner do not develop intellectually because they are not presented with choices and are not required to make qualitative decisions about such choices. Furthermore, they are forced to accept their teacher’s views and therefore miss opportunities to make judgments that reflect their own values. Indeed, their ethical development is stifled.

Educating Students

Before students can communicate clearly about the science of animal production, they must have an elementary grasp of terminology and the most reliable facts. However, if students are to become truly educated, they must be capable of more than communication; they must become scientifically literate so they can think critically about animal science. According to Bauer (1994), scientific literacy involves not only an understanding of the principal scientific facts, but an understanding of the nature of scientific activity and the relationship between science and society. To accommodate this increased depth of coverage, teachers must de-emphasize memorization of facts. For example, in reproductive physiology courses, more emphasis might be placed on evaluating experimental evidence supporting theories of the endocrine control of the estrous cycle, onset of puberty, or gamete production and less on memorizing estrous cycle lengths, dimensions of the reproductive tracts, and characteristics of semen.

When the teaching goal is restricted to establishing a foundation of terminology and principles, knowledge

is treated as a collection of facts with a disregard for context. A teacher's primary task, under these circumstances, is to make the facts clear. To stimulate critical thought about scientific claims requires a different definition of knowledge: the qualitative assessment of contextual observations and relationships (Perry, 1970). The issue concerning use of bovine growth hormone (**bGH**) serves as an excellent example for illustrating the difference between these forms of knowledge. The observation that bGH consists of 192 amino acids can be stated without reference to context. In contrast, a decision about whether bGH should be used in a commercial dairying operation requires an evaluation of research concerning its efficacy, considerations of management practices, and possibly assessment of social and economic impacts.

Compelling students to make qualitative assessments is a more difficult task than requiring them to memorize lists of facts. To make this transition, teachers must take on more complex roles in their classrooms. They become less authority figures, whose purpose is to deliver facts, and more facilitators whose purpose is to encourage questioning, exploration, and synthesis in their students (Perry, 1970). Those teachers who are most successful in this transition reveal their own thinking regarding their commitments to particular beliefs. They also make students feel part of a learning community that is devoted to assessment of claims, where students develop the daring to take risks and the courage to make commitments to particular judgments they may make (Perry, 1970).

A strict lecture format is probably not an effective means to develop thinking skills. Critical thinking involves making judgments. If students are expected to acquire the ability to make and defend their judgments, they must have time to think about, discuss, and develop opinions about material presented in class. This can be accomplished by presenting problems to students and providing time for them to discuss possible solutions in small groups. Students can also present their oral or written assessments for peer review and discussion.

Developing examinations that accurately assess students' progress is a difficult task. The most effective examinations are those that reflect and reinforce the educational goals of the course. In cases in which critical thinking is an important goal, examinations must be skill-oriented. In other words, they must provide opportunities for students to make comparisons and judgments using acceptable methods and criteria. An appropriate examination might require students to develop and(or) assess hypotheses about important phenomena and discuss methods for testing them. Another approach is to ask students to select the most appropriate theory from a list of possibilities and give rationales for their choices.

Because such skills require more time than is usually available during a class period, take-home exams or projects may be more suitable than in-class exams. Projects that require students to research the scientific and popular literature provide exposure to a variety of contemporary viewpoints and provide opportunities to compare and contrast opposing arguments.

An appropriate scheme for grading examinations that emphasize thinking skills is based more on the quality of arguments supporting particular answers than on the extent to which answers correspond to dogma.

Why Education?

An appropriate and commonly accepted goal of education is to teach individuals to think independently in an analytical and critical way (Bauer, 1994). Teaching students to understand the limits of science and encouraging them to make informed judgments about scientific claims are consistent with this goal. It is an important goal because individuals who can think independently and analytically will serve themselves and their communities in responsible ways. Examination of sociological aspects of science has not been a traditional goal of animal science curricula because science is commonly portrayed as a value-free activity (Bauer, 1994). Rollin (1996) highlighted some of the dire consequences arising from this belief. The failure of animal scientists to consider the sociological and ethical underpinnings of molecular biology research has precluded rational discourse concerning important issues and has allowed perpetuation of activities that society might find to be undesirable.

If there is to be meaningful public discourse about scientific issues, scientists and nonscientists must have a scientific literacy and a "reasonable skepticism" (Lewontin, 1992) of scientific claims. This reduces the chance that a society will adopt a potentially dangerous technology or ideology. For example, scientific activity aimed at documenting differences in intelligence between races has been used as an ideological weapon to support discriminatory policies in some societies. A scientifically illiterate citizenry that regards scientific research as value free is more inclined to accept racially biased research and adopt racist policies than a citizenry that recognizes that science, like any other human activity, is prone to the biases of its practitioners. Science touches virtually every aspect of our lives. For example, to make informed decisions regarding use of drugs, selection of foods, and even social policies requires individuals to make judgments about scientific claims. As educators, we can give our students the courage and tools to make such evaluations or indoctrinate them to a scientific community that alienates them from the society in which they live.

Implications

The goal of promoting critical thinking in animal science curricula can be achieved only if the uncertainty of scientific activity is acknowledged. Students who understand that scientific theories reflect the biases of scientists will appreciate the importance of questioning and making judgments about scientific claims. To accomplish these goals, teachers must become facilitators who create a learning environment in which questioning, groping, synthesizing, and discussing are encouraged. Adoption of such methods will enhance the intellectual and ethical development of students rather than indoctrinate them to the dogma of the animal science profession.

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