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ABSTRACT

This study was designed to investigate the influence of a diversified instructional strategy to overcome misconceptions held by freshmen undergraduate students with respect to the nature of a scientific theory. The theory of evolution was selected because it is the most significant unifying theme within the discipline of biology. Two classes were pretested for background knowledge of evolutionary biology concepts, attitude regarding evolution, and an understanding of the nature of science. Intact groups received instruction from independent biology faculty members, both of whom agreed to make use of the same course outline and sequential introduction of topics. After having been exposed to an introductory lecture on the unit of evolution, the investigator provided the experimental group with an opportunity to discuss their positions regarding the theory of evolution. Discussion groups were asked to resolve potential conflicts arising among themselves and present a consensus opinion. The investigator further provided an interactive lecture/discussion to resolve misconceptions arising as a result of the small group discussions. Both groups were posttested using the same measures administered on the pretest. The analysis of between group posttest scores revealed no significant differences for evolutionary concepts; however, with respect to an understanding of the nature of science/attitude toward evolution, a significant difference was found for the experimental group. (CW)

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by

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INTRODUCTION

Many biology teachers have experienced frustration, challenges, and even criticism when the study of evolutionary biology is presented as an instructional unit. The issue can certainly be a sensitive one and the potential confrontation it engenders is very real. This can be especially true, if students perceive the topic of evolution to be in conflict with their own beliefs and value structures. One response by secondary teachers, to avoid potential confrontation or conflict, is not to present evolution as a unit of study (Johnson, 1985; Eglin, 1983; McCormack, 1982).

Such a perception of conflict is often surprising to biologists, who consider evolutionary theory as the most significant unifying theme within the discipline of biology. In fact, since topics such as genetics, reproductive strategies, animal behavior, and ecology are taught in some form in virtually all secondary and college biology courses, teachers by default discuss evolutionary biology. The problem may not reside with evolution specifically, but instead, more generally with the general public's and students' misconceptions regarding the nature of science and as a consequence, the nature of scientific theories (Johnson & Peeples, 1987; Scharmann & Harty, 1986; Kitcher, 1982).

The validity of a scientific theory depends upon the establishment of criteria by which to judge its utility (Nelson, 1986; Kitcher, 1982; Kuhn, 1970). Multiple lines of corroborative evidence, patterns in present evidence, and testability of hypotheses inferred from a theory are but a few such criteria. However, not all implied tenets encompassed within a theory are necessarily testable by direct observation, nor do they need to be (Kuhn, 1970). This premise of scientific philosophy creates a special problem for biologists attempting to teach evolutionary theory, especially when students do not possess a high degree of tolerance for ambiguity but instead exhibit "dualistic" behaviors (Perry, 1970); moderate ambiguity that by necessity, is present in the nature of scientific theories. How then do we provide an appropriate context for students to deal with their own acceptance of ambiguity, and hopefully as a consequenc-, to understand the nature of scientific/evolutionary theory?

Nelson (1986) argued that a diversified instructional strategy that incorporated foundational content/context, provided opportunities for student discussion, and resolved misconceptions arising in such student discussions, was an unusually effective means for dealing with the specific issue of evolutionary theory, and for more honestly teaching scientific theory in general.

The intent of this study, therefore, was to investigate the influence of a diversified instructional strategy to overcome misconceptions held by freshmen undergraduate students with respect to the nature of a scientific theory, using evolution as an example.

METHODOLOGY

Data were collected from two concurrent general biology classes (N=30), during a three-week summer session course when evolution was taught as a unit of study. The groups were selected on the basis of the willingness of two independent instructors to participate in the study.

Experimental Design and Procedures

The design of this study was a "Nonequivalent Control Group Design" (Campbell & Stanley, 1963). This design was necessary since the two classes of students participating in the study represented intact groups. The intact groups received instruction from independent biology faculty members. To minimize potential differences, both instructors agreed to make use of the same course outline and sequential introduction of topics. The experimental group (n_1 = 13) differed from the control (n_2 = 17) along one dimension: after having been exposed to an introductory lecture on the unit topic of evolution, which occurred for both groups during the second week of instruction, the investigator provided the experimental group with an opportunity to discuss their positions regarding the theory of evolution. The control group received the same content information; however, the mode of instruction was traditional lecture only.

Experimental group students were initially asked to respond individually, in written format, to a set of four questions regarding a potential controversy between evolutionary theory versus creation origins. The students were then randomly assigned to a small discussion group of 3-4 students, and requested to share with their classmates, their written responses to the four questions, resolve potential conflicting opinions within the group, and if possible, arrive at a consensus position to be eventually shared with the entire class. The investigator further provided an interactive lecture/discussion to resolve misconceptions arising as a consequence of the small group discussions. This interactive lecture focused on the conflicting claims of scientific validity for evolution versus creationism.

Both groups were given a posttest upon the completion of the summer session course, using the same measures administered on the pretest. Data were analyzed using nonparametric statistical techniques, because the control group pretest scores were not normally distributed.

Instrumentation

To collect data with respect to attitude toward evolution and an understanding of the nature of scientific theory, an untitled instrument, developed by Johnson and Peeples (1987) was used. The questionnaire consisted of 25 Likert-type items; 20 item statements measured student understanding of the nature of science and its methods, while 5 item statements measured student acceptance of evolution. All 25 item statements were scored in a similar fashion, +5 was awarded for responses most consistent with the intended model, while +1 represented responses that were least consistent; +3 was given for neutrality. Scores thus potentially ranged from a high of 125 to a low of 25. Johnson and Peeples (1987) reported internal consistency reliabilities of 0.78 and 0.77 for the two respective sections of the questionnaire, from a population sample of 1,812 undergraduate students from 34 participating higher education institutions. Validity was established by means of the known group differences technique. The developers reported that the instrument discriminated an acceptance of evolution as a function of a progressive understanding of science.

To assess potential instructor differences, an additional 10 items, written by the investigator to reflect knowledge of evolutionary content, were added to the Johnson and Peeples (1987) questionnaire. These item statements were written using a similar Likert scale format used by Johnson and Peeples (1987). The total score for the combined instrument ranged from a high of 175 to a low of 35.

RESULTS & DISCUSSION

Preliminary data analyses, using the Mann-Whitney U-test and Wilcoxon test, indicated that no significant differences existed between groups or within either group with respect to evolutionary content understanding, attitude toward evolution, or an understanding of the nature of science. The groups were thus considered to be fairly equivalent. The analysis of between group posttest scores also revealed no significant differences for evolutionary content items; however, with respect to the understanding of the nature of science and attitude toward evolution, significant differences were found, using the nonparametric Mann-Whitney U-test. The experimental group possessed significantly greater combined understanding of the nature of science and attitude toward evolution ($U = 1.75$; $p < 0.05$).

In terms of posttest within group analyses, using the Wilcoxon test for repeated measures, the control group ($Z = 2.33$; $p < 0.01$) and experimental group ($Z = 2.98$; $p < 0.001$) both exhibited significant differences toward greater understanding of the nature of science and greater acceptance of evolution. There was not, however, a significant difference in an understanding of evolutionary content for either within group analysis.

CONCLUSIONS

It was concluded that both a traditional as well as modified, through diversified instruction, lecture strategy were effective in presenting evolutionary concepts. In addition, both provided a basis for student growth in an understanding of the nature of science and its methods as well as acceptance of evolution as an organizing theme of biology. However, on the basis of the between group analyses, a diversified instructional strategy, was superior to the traditional lecture technique in enhancing student acceptance of evolutionary theory and an understanding of the nature of science and its methods.

Therefore, the discussion and follow-up interactive instruction provided students with an opportunity to resolve potential misconceptions that may act as impediments to a more comprehensive understanding of scientific claims; such claims, constructed upon theoretical evidence, and possessing potential competing patterns of explanation. This conclusion is consistent with the findings of Nelson (1986) and Duschl (1988), both of whom argue that the validity of scientific knowledge claims and how new knowledge is generated, should be considered on the basis of historical and cultural criteria in addition to empirical and logical criteria. If scientific theory is presented using all four criteria, student misconceptions can be addressed in a more systematic manner.

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