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Challenging Pre-Service Teachers; Evolutionary Acceptance in Introductory Biology

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*In this study, we examine the efficacy of an instructional intervention on pre-service teachers' acceptance of evolutionary theory. We used diagnostic question clusters with ORCAS (**O**pen-ended questioning, student **R**esponses, **C**ontradictory claims, **A**ssessment of contradictions, and **S**ummary) discourse to elicit students' prior knowledge and compel evaluation of claims with evidence. Pre-and post-instruction evolutionary acceptance, nature-of-science understanding, and conceptual knowledge about evolution were measured qualitatively and quantitatively, indicating the instructional treatment was effective in fostering acceptance and understanding of evolution. We discuss implications for further research and preparing pre-service teachers for teaching evolution concepts.*

Challenging Pre-Service Teachers' Evolutionary Acceptance in Introductory Biology

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Abstract

In this study, we examine the efficacy of an instructional intervention on pre-service teachers' trajectories in acceptance of evolutionary theory. This instructional intervention involves diagnostic question clusters (DQCs) being used in conjunction with ORCAS discourse in a whole-class lecture setting. ORCAS consists of **O**pen-ended questioning by the instructor, student **R**esponses, highlighting **C**ontradictory claims, student **A**ssessment of contradictions, and a **S**ummary of the content. The use of this discourse pattern elicits initial responses from students, which demonstrate their prior knowledge and misconceptions, as well as compelling students to evaluate claims with supporting evidence. Following the instructional intervention, students were prompted to revisit and comment on their earlier statements about their acceptance of evolutionary theory, discussing any ways in which their views changed and the reasoning behind those changes. Student scores on pre-instruction qualitative and quantitative assessments regarding evolutionary acceptance and understanding of the nature of science were analyzed in conjunction with post-instruction assessments to identify how acceptance of evolution related to changes in understanding of evolutionary mechanisms and the nature of science. We discuss implications for further research and preparing pre-service teachers for teaching evolution concepts.

Introduction

Evolutionary theory is considered the unifying theory of biology, explaining organismal change over generations in accordance with selective pressures, but it is still widely misunderstood among the general public and science teachers. Within introductory biology courses, naïve conceptions about evolution are apparent in general education students and pre-service teachers. Based on the theory of constructivism, which posits that conceptual models are built based on experiences, these naïve conceptions are most likely built on only a small representation of the category, resulting in over-generalization and associated misconceptions. The purpose of this study is to examine pre-service teachers' naïve conceptions about evolutionary processes before and after an instructional intervention consisting of an alternative discourse pattern engaging students in making and evaluating claims. Prior research demonstrates that discourse patterns employed during whole-class discussion influence students' conceptual development of the content under study (Wells & Aruaz, 2006). We argue that an overarching goal of science education is to privilege evidence and logical reasoning over any one individual's authority. To this end, we suggest a model of discourse that simultaneously challenges naïve conceptions while placing students in the role of evaluator, compelling students to evaluate the validity of claims, supporting evidence, and logical reasoning, rather than turning to the authority of the instructor. This model of dialogic discourse capitalizes on contradictory claims posited by students who hold naïve conceptions by using them as a tool to sustain discussion, deemphasizing teacher authority, and placing responsibility of evaluating claims on students.

Methods

Three assessments were conducted before and after the instructional intervention. Diagnostic question clusters (DeSaix et al. 2011) were used to identify existing misconceptions; the pre-assessment contained 6 items and post-assessment contained 8 items. Also used were the Student Understanding of Science & Scientific Inquiry instrument (SUSSI, Liang et al. 2008), consisting of 25 Likert-scored items (1-5), and the Generalized Acceptance of EvolutioN Evaluation (GAENE; Smith et al. 2016), consisting of 20 Likert-scored items (1-5).

Instructional Intervention:

Before	During	After
• Lecture videos online • Online vocabulary quiz • Written reflections on reading or video	• Pre/post clicker questions • Question-driven lectures • Group discussions	• Problem-based online homework • Hands-on labs • Unit exams

Statistical Analyses:

Paired t-tests were conducted on pre- and post-instruction scores for the SUSSI and pre- and post-instruction scores for the GAENE. One participant's scores were excluded based on Grubb's outlier test of acceptance pre/post difference and admission of providing answers that the participant did not understand: "When I did the first response my answers where [*sic*] the same but I put them only because I knew they were right, not because I understood what they meant."

Results

Quantitative

There was a significant improvement in acceptance of evolutionary theory after the instructional intervention (t=-3.6, df=22, p=0.002, Figure 1), but no significant change in SUSSI scores before and after instruction (t=0.04, df=22, p=0.968, Figure 2).

Qualitative Reflections

I realize that evolution is not saying that we came from monkeys or that monkeys came from us. It is merely saying that certain adaptations and mutations cause changes in an animal.

– Participant #346, +3 change

I never knew how much scientific evidence backed up a theory. That being said, before taking this course I would have chosen to agree that it is incapable to scientifically test evolution. I now know, however, that a theory is backed up by a plethora of scientific evidence and that there is not much evidence going against it. Therefore, I know [sic] *disagree with the statement and believe that evolution can be scientifically tested.*

– Participant #335, +12 change

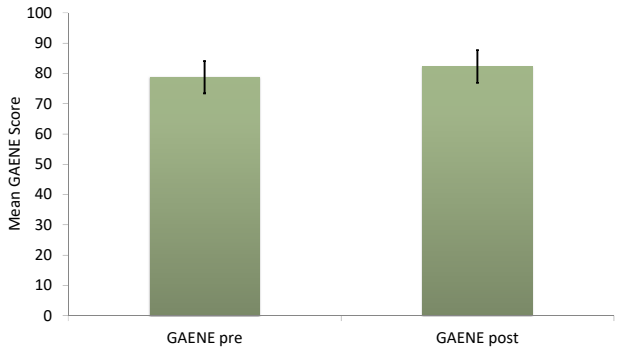

Figure 1. Pre- and post-instruction mean scores of participants on the GAENE. Error bars represent 95% confidence intervals.

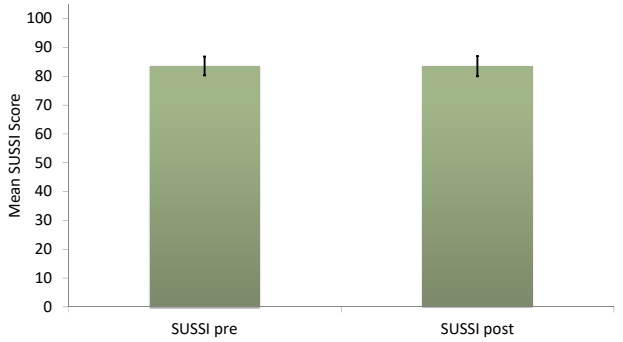

Figure 2. Pre- and post-instruction scores of participants on the SUSSI instrument. Error bars represent 95% confidence intervals.

Conclusions

1. An understanding of the nature of science is not required to increase acceptance of evolution, as evidenced by the significant improvement in acceptance of evolutionary theory without an accompanying improvement in the SUSSI.
2. Qualitative responses of students who demonstrated a low acceptance gain indicate that misconceptions in the form of over-generalizations about evolution and evolutionary mechanisms are still present.
3. Based on qualitative responses of students who did not demonstrate an acceptance gain, reluctance to accept evolutionary theory may be related to misunderstandings of the nature of science. Further instructional interventions could involve creating more robust connections between evolutionary concepts and the nature of science.

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