Misconceptions in Natural Selection: Conceptual Change Through Time in Biology Classrooms

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Abstract: Our findings concurs with previous studies that high school biology students hold misconceptions explaining and applying key concepts in natural selection. We explored specific misconceptions prior to instruction, immediately following instruction, and five weeks later. We found qualitatively distinct categories of conceptual understanding suggesting levels in the development of conceptual understanding and tracked changes over time. We found classroom practices can impact conceptual change, with students possessing initial misconceptions often developing hybrid understandings.

Theoretical Framework

In the last few decades, the topic of conceptual change has received considerable attention (e.g., Posner, Strike, Hewson, & Gertzog, 1982). We now know that students' existing beliefs have a significant affect on their learning and that instruction needs to address these existing beliefs to be effective (Hewson, Beeth, Thorley, 1998). Considerable research has investigated students' existing beliefs in regard to core science concepts. Natural selection is one of the core concepts in biology that students have traditionally failed to grasp and have instead hung on to their existing beliefs. Clough and Wood-Robinson (1985) found misconceptions centering around natural selection when they interviewed 12, 14, and 16 year olds. They contended that even young children have "well established theories to explain inheritance" which all too frequently include the inheritance of acquired characteristics and confusions about the term *variation*. Brumby (1984) studied the misconceptions that medical students had about natural selection as they applied "intuitive Lamarckian" thought to a series of questions posing adaptive scenarios. Even the most able science student confidently proclaimed organisms "need" to adapt to changing environments and then pass these acquired changes to their offspring. These studies are valuable in that they identify specific misconceptions related to natural selection and illustrate the persistence of these misconceptions. However, the process of conceptual development over time remains unclear and researchers have yet to define levels of conceptual understanding. This information is important to understanding the conceptual change process and addressing practical issues such as assessment and individual student growth over time. The purpose of this study was to define qualitatively distinct levels of conceptual understanding of natural selection and track conceptual change from pre-instruction to post-instruction to five weeks after instruction.

Methods

167 students (33% male, 66% female) enrolled in high school Biology courses during the spring of 2005 participated in the study. A learning assessment targeting two common misconceptions was administered prior to instruction on adaptation and natural selection (Pre), on the exam immediately following instruction (Post), and five weeks after instruction (Follow-up). The first misconception targeted was the belief that change in a species is the result of *individuals* changing (often intentionally) to fit the needs of their environment, rather than adaptation being the result of natural selection acting on a population (individual change misconception). A sample question (modified from Engel Clough &Wood-Robinson, 1985) involved pale and dark caterpillars in a forest being found on pale and dark tree trunks. The students were asked to explain how this came about and predict what would happen if the dark tree trunks began to change. The second misconception targeted was the belief that acquired characteristics can be passed on to offspring (acquired traits misconception). A sample question (modified from Brumby, 1984) involved a married couple (who were not particularly talented naturally as runners) who trained hard to become good runners. The students were first asked whether or not the children would automatically be good runners and then asked to make a prediction about children in this family after several generations of training. Categories representing distinct levels of conceptual understanding were develop through a qualitative analysis. All responses were then coded into these categories by two independent raters. Inter-rater reliability was .91 for items targeting the individual change misconception and .88 for items targeting the acquired traits misconception.

Findings

Due to the limited space, here we describe the findings for the items targeting the individual change misconception (results for items targeting the acquired traits are similar and will be presented in the poster). Five categories emerged for these responses: (1) clear misconceptions (e.g., "The sun in the desert turned the lizards' skin brown"), (2) misconceptions with scientific language (e.g., "They adapted to their environment. …If the dark trees became light then the caterpillars would become light too"), (3) misconceptions competing with correct understanding (e.g., "The caterpillars learned to blend in with their environment…The dark caterpillars would probably die off [if the dark tree became light] because they wouldn't be able to survive that environment"), (4) correct but lacking explanation (e.g., "The caterpillars adapted to the tree…If the color of the tree changed the dark caterpillars would be vulnerable to predators and die off"), and (5) correct understanding (e.g., "The caterpillars that lived on the dark trees survived longer if they blended in with their surroundings so they were dark like the trees….The light ones didn't survive as long because they didn't blend in, so their light-colored genes weren't passed on, but the dark-colored genes were"). Categories 2 and 3 represent a hybridized understanding. That is, the students adopt some of the scientific language (e.g., adapt, evolve) or recognize that when the environment changes, unfit species will die off or become less dominant. However, they still hold onto a belief that individual organisms change in response to the environment. A large percentage of students possessed clear misconceptions or hybridized conceptions prior to instruction (see Figure 1). Students showed conceptual growth over time, however, many students still held onto their misconceptions. Only about 20% were able to fully articulate an understanding of natural selection after instruction. Detailed analysis of change over time reveals that students possessing a clear misconception prior to instruction could achieve a correct understanding, however the majority maintained the same level of understanding or developed a hybridized understanding. See poster for further details.

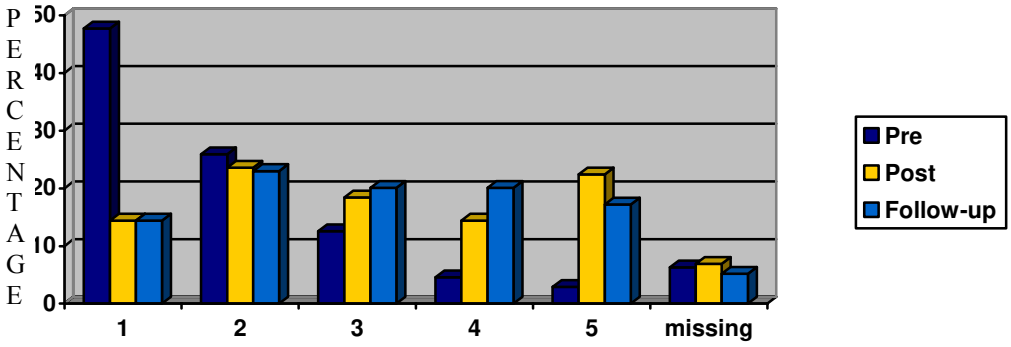

Figure 1. Comparison of students' understanding of natural selection at the Pre, Post, and Follow-up

Conclusions and Implications

Our results concur with previous studies indicating that high school biology students arrive to class with deeply held misconceptions about the mechanism of change in natural selection and acquired characteristics. Our study indicates (a) that conceptions of natural selection can be represented by qualitatively distinct levels and (b) many students incorporate correct understanding of a concept into their faulty framework and construct a *hybrid* understanding resulting in misapplications of fundamental principles. These results provide Biology teachers with a framework for evaluating their students' conceptual level and understanding the process of conceptual change.

References

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