Research Paper

Evolution Misconceptions in Nonscience Majors: A Pretest and Posttest Evaluation

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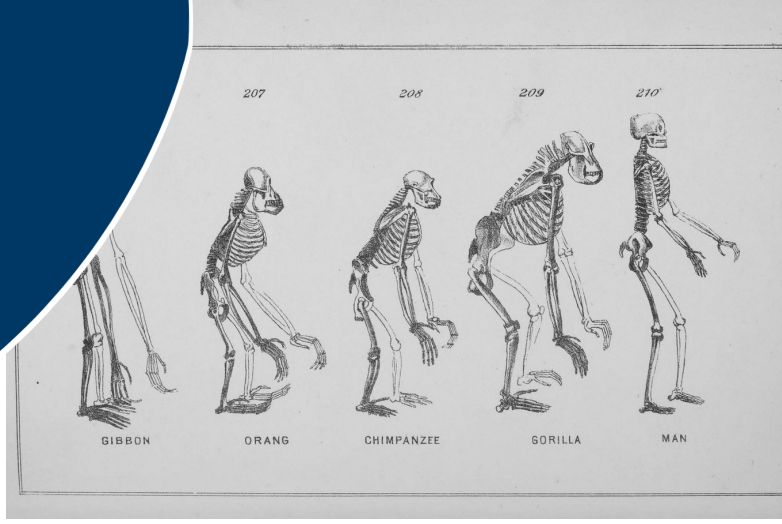

Abstract

Most biology students have preconceived ideas about what evolution is and how it works, and understanding what these misconceptions are is integral to teaching evolution effectively. Nonscience majors in BIO 110 (Principles of Biology) at Wayne Community College were given a pretest with 12 True/False questions to determine what evolution misconceptions they initially had, if any. At the end of the semester, the same test was given again to figure out which of these misconceptions were dispelled and which ones remained. On the pretest, there were four questions that at least 75% of students got correct, while nine questions were correctly answered by more than 75% on the posttest. The misconceptions that individuals adapt and that individuals evolve showed the largest amount of improvement between the pretests and posttests. The two main misconceptions persisting at the end of the course related to the understanding of natural selection and how adaptation works and may, therefore, be the focus of future evaluations.

Keywords: evolution, misconceptions, biology, pretest, posttest

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Evolution is a commonly misunderstood and rejected concept, especially by Americans. Out of 34 countries surveyed, the United States ranked second to last in public acceptance of evolution (Miller et al., 2006). Numerous studies have investigated evolution misconceptions held by students, and they demonstrated that misconceptions exist at all levels of education from high schoolers up to graduate students (Yates & Marek, 2015). So, what can biology educators do to dispel these misconceptions? The first step is to determine which misconceptions are most prevalent among students. Wescott and Cunningham (2005) highly recommend that educators develop their own unique tool to assess the misconceptions specific to their students and their courses. In this evaluation, True/False pretests and posttests are used to determine what misconceptions nonscience majors at Wayne Community College initially have, which are corrected during the course, and which remain at the end of the semester.

Methods

During the spring and fall semesters of 2018 and 2019, students in face-to-face sections of BIO 110: Principles of Biology (a nonscience major's course for Associate of Arts students) were given a pretest on evolution misconceptions. This test consisted of 12 True/False questions (Table 1) and was administered in class before beginning the unit on evolution. Students were given 10 minutes to take the test and told they would get a completion grade for trying their best. The pretest answers were not discussed in class, and students did not find out how they scored. After completing the evolution and ecology units, the same 12 True/False questions were given again as a posttest at the end of the semester. It was administered in class just as the pretest had been.

The percent of students who correctly answered each question was calculated. An unanswered question was considered incorrect. Comparisons were made between the pretests and posttests by deter-

mining how many questions were answered correctly by at least 75% of students. The difference in percent correct between the pretest and posttest was calculated for each question. Students who did not take both the pretests and posttests were removed from this evaluation.

Table 1

Evolution Misconceptions Test Questions, Answers, and Responses

		Percent of Students Who Answered Correctly	
True/False Question	**Answer**	**Pretest**	**Posttest**
A. An individual cannot evolve.	True	45	94
B. Natural selection occurs when organisms get what they need as they try to adapt.	False	38*	72
C. An individual can adapt to its environment.	False	12	78
D. Evolution says that humans evolved from modern apes and monkeys.	False	45*	78
E. Evolution is a scientific theory.	True	93	83*
F. The human population has evolved recently and is continuing to evolve.	True	74*	87
G. Evolution explains the origin of life.	False	54	74
H. Humans share a common ancestor with apes and monkeys.	True	80	96
I. Evolution is only a theory, so it is not supported by facts.	False	72	91
J. Evolution can occur without natural selection.	True	45	71
K. Evolution always produces better and better organisms.	False	77	90
L. Evolution is defined as genetic change in a population over time.	True	88	97

Note. An asterisk indicates that one student left the question unanswered.

Results

Over the four semesters in 2018 and 2019, a total of 69 students completed both the evolution misconceptions pretests and posttests. For each question, the percent of students who correctly answered it is shown in Table 1.

Pretest Results

There were four questions that greater than 75% of students got correct on the pretest. Question E, *Evolution is a scientific theory*, is True and was correctly answered by 93% of students. Question L, *Evolution is genetic change in a population over time*, was correctly determined as True by 88% of students. Question H, *Humans share a common ancestor with apes and monkeys*, is True, and 80% of students determined this. Question K, *Evolution always produces better and better organisms*, is False, and 77% of students got this correct.

The most commonly missed question was C, *An individual can adapt to its environment*. This question is False, and only 12% of students correctly determined this. There were four additional questions that fewer than 50% of students answered correctly. Only 38% of students correctly determined that question B, *Natural selection occurs when organisms get what they need as they try to adapt*, is a False statement. Questions A, D, and J were each answered correctly

by 45% of students. Question A, *Individuals cannot evolve*, is True. Question D, *Evolution says that humans evolved from modern apes and monkeys*, is False. Question J, *Evolution can occur without natural selection*, is a True statement.

Posttest Results

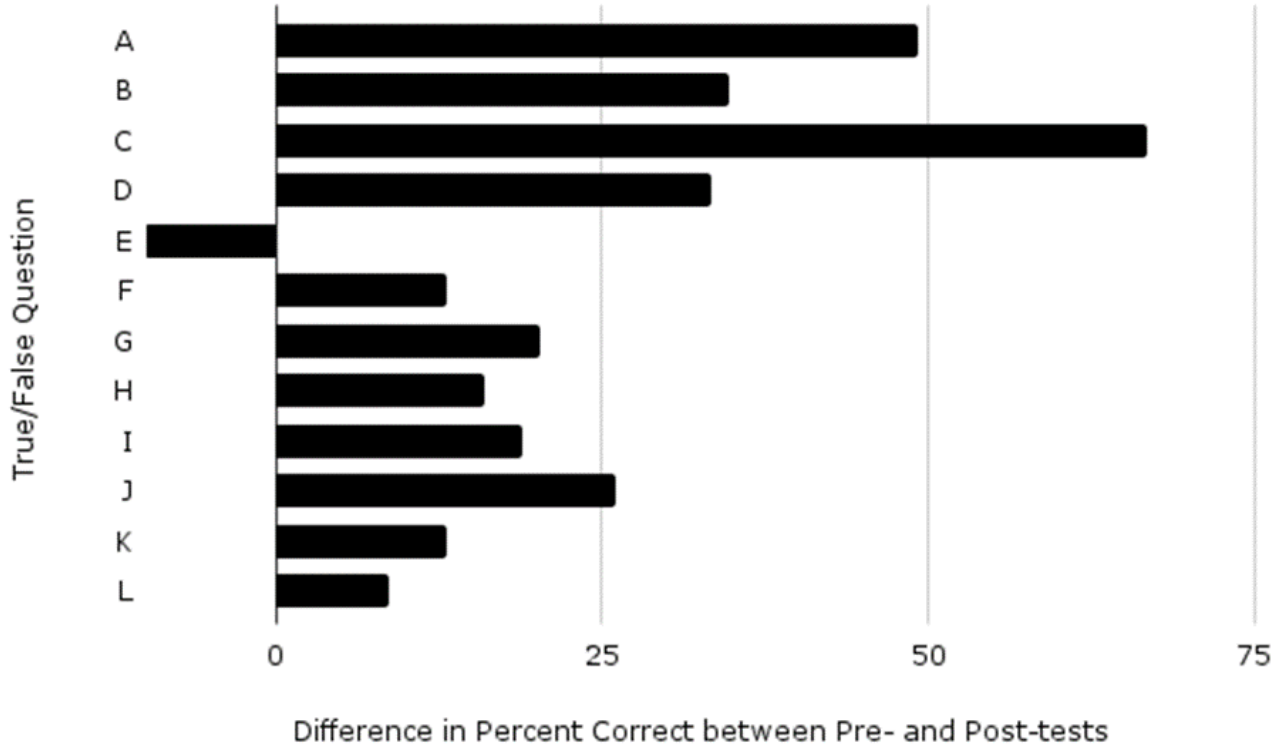
The posttest results showed that 9 of the 12 questions were correctly answered by at least 75% of students (see Table 1). Question G, *Evolution explains the origins of life*, is False and was correctly determined by 74% of students on the posttest. Questions B and J were correctly answered by 73% and 71% of students, respectively. All 12 questions were answered correctly by more than 70% of students.

Five questions were answered correctly by at least 90% of students on the posttest. Question K was correctly answered by 90% of students. Question I, *Evolution is only a theory so is not supported by facts*, is False and was correctly answered by 91% of students. Question A was correctly answered by 94% of students and question H by 96%. Question L was answered correctly by 97%, which was the highest percentage correct out of all 12 questions.

The difference in percent correct between the pretests and posttests is shown in Figure 1. The largest increase was seen in question C, *An individual can adapt to its environment*. Initially 12% of students correctly determined that C was False, while on the posttest, 78% of students answered this question correctly. Questions A, B, and D also showed large increases in the percent of students who correctly answered them. The response to question A increased from 45% correct to 94% correct, B increased from 38% to 72%, and D increased from 45% to 78%. One question, E, had a decrease in the percent of correct answers from the pretest to the posttest. It was correctly answered by 93% of students on the pretest but only by 83% of students on the posttest.

Figure 1

Difference in Percent Correct between Pretests and Posttests



Discussion

Common Misconceptions of BIO 110 Students

A third of adults in the United States do not accept the concept of evolution (Miller et al., 2006); therefore, it is not surprising many BIO 110 students have common misunderstandings about it. Four of the most common evolution misconceptions found during this evaluation were that individuals can adapt, individuals can evolve, natural selection involves trying, and evolution can only occur if natural selection does. These were each answered correctly by fewer than 50% of students. The first two misconceptions appear to be mostly corrected throughout the evolution unit, while the latter two misconceptions persisted at the end of the semester.

Easiest to Correct

The two misconceptions showing the largest improvement between the pre and posttests relate to the smallest unit capable of undergoing evolution. Contrary to popular thought, it is not the individual that can evolve or adapt, but the population.

Individuals Can Adapt. Before covering evolution, the most common misconception that BIO 110 students had was that individuals can adapt. Almost 90% of students incorrectly thought that individuals are capable of undergoing adaptation to their environment. This is a common misconception because everyday language regularly uses the term *adapting* in reference to an individual or person adjusting to new conditions; however, this is not what adaptation in the context of evolutionary biology means. Adaptation is an evolutionary process in which a population becomes better suited for surviving and reproducing in its environment over generations through natural selection. This is definitely not something an individual organism can do. By the end of the semester, the majority of students, almost 80%, knew this. This misconception, based on the discrepancy between the everyday use and scientific meaning of a word, is called a *vernacular misconception* (Keeley, 2012), and it exhibited the most improvement between pretests and posttests.

Difficult to Correct

Three questions were answered correctly less than 75% of the time on the posttest. One question relates to human evolution, which is not a topic covered in much detail in BIO 110. The other two relate to natural selection, a topic covered extensively during the evolution unit. BIO 110 students seem to continue to struggle with really understanding how natural selection and adaptation work. This is consistent with other studies that indicate the process of natural selection is not well understood by people of varying educational backgrounds (Gregory, 2009).

Natural Selection Involves Trying and Getting What Is Needed. A very common initial misconception of BIO 110 students was that natural selection occurs when organisms get what they need as they try to adapt. According to the pretest, over 60% of students believed this to be true. Since natural selection is a major process that leads to evolution, it is covered in three chapters and two lab activities. Therefore, one would expect a large improvement on understanding this topic. On the posttest, 72% of students answered question B correctly. This means, however, that almost 30% of students still thought that natural selection grants organisms what they need and involves trying. This shows that while students may be able to memorize the fact that individuals do not adapt, they may not really understand how the process of adaptation works. If they understood why individuals cannot adapt, they would know that there is no trying in natural selection. Individuals cannot simply get what they need because evolution does not create new traits just to help with survival.

Natural Selection Is Needed for Evolution to Occur. The misconception that evolution cannot occur without natural selection may also be difficult for students to correct. Initially, 55% of students believed this misconception. This decreased to about 30% at the end of the semester. While this is definitely an improvement, it still seems low considering that an entire chapter is devoted to covering the many mechanisms of evolution. Therefore, students should know that in addition to natural selection, there are four other processes that lead to evolution: genetic drift, gene flow, mutation, and sexual selection.

A Decrease in Percent Correct on Question E. There was one question, E, that had a lower percentage of students answer it correctly on the posttest than on the pretest: *evolution is a scientific theory*. Initially, 93% of students knew this was a true statement, and this was the highest percentage correct out of all 12 pretest questions. However, only 83% indicated this statement was true on the posttest. Why did this question show a decrease in percent correct? One possibility is that students do not understand what a scientific theory is. This is a term shown time and time again to be commonly misunderstood by students and the general public (Yates & Marek, 2015). The meaning of a scientific theory is something discussed in the first chapter of BIO 110 because *theory* has a different meaning in vernacular language than it does in biology. The word *theory* is often used to describe a guess somebody has, but in science, a theory is a rigorously tested explanation that has an abundance of evidence supporting it. On the posttest, 91% of students knew that question I, *Evolution is only a theory so it is not supported by facts*, was False. This indicates that students know evolution is supported by facts. However, they may not recognize that something well supported by facts is a scientific theory. Perhaps there was a decrease in percentage on question E because initially students thought of evolution as something that is questioned, which fits the common use of the word theory. Then as students learned evolution was supported by evidence, perhaps they no longer thought of it as a guess. They may have incorrectly determined it was not a scientific theory because their vernacular misconception persisted throughout the semester. There may be other explanations for what happened with question E, so this may be worth investigating in future studies.

Can Evolution Misconceptions Be Corrected?

By the end of the semester, all 12 questions were answered correctly by 70% of BIO 110 students. Therefore, it appears that misconceptions about evolution can be corrected. With the implementation of pre and posttests, an educator may be able to determine which misconceptions are persistent. This could help to improve future teaching practices to target certain problem areas, such as understanding adaptation and natural selection.

References

Gregory, T. R. (2009). Understanding natural selection: Essential concepts and common misconceptions. *Evolution: Education and Outreach, 2*, 156-175. https://doi.org/10.1007/s12052-009-0128-1

Keeley, P. (2012). Misunderstanding misconceptions. *Science Scope, 35*(8), 12-13, 15. https://www.jstor.org/stable/43184609

Miller, J. D., Scott, E. C., & Okamoto, S. (2006). Public acceptance of evolution. *Science, 313* (5788), 765-766. https://doi.org/10.1126/science.1126746

Wescott, D. J. & Cunningham, D. L. (2005). Recognizing student misconceptions about science and evolution. *MountainRise 2*(2), 1-8.

Yates, T. B. & Marek, E. A. (2015). A study identifying biological evolution-related misconceptions held by prebiology high school students. *Creative Education, 6*(8), 811-834. http://dx.doi.org/10.4236/ce.2015.68085

Author's Note

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