Abstract
In this course portfolio, I address issues related to the teaching and learning of mechanisms of evolution related to human origins research for a class titled A105: Human Origins and Prehistory. A number of assessments were added to the class to determine extant student knowledge of human evolution and to improve student ability to identify and correctly define and discuss mechanisms of evolution as well as to evaluate and critique the use or misuse of these mechanisms in popular and scholarly media.

Introduction (or Background or Context)
During the Spring 2011 semester at Indiana University (IU), I was the instructor for a 2nd 8-weeks section of ANTH A105: Human Origins and Prehistory (hereafter “A105”). I have previously instructed A105 as both a summer 6-week course and a traditional 16-week course, at IU and at Indiana University-Purdue University, Indianapolis (IUPUI). My duties as instructor of A105 included organizing the course according to my own interests and liking, though within a basic disciplinary framework that includes the topics discussed below under “Learning Objectives.” Thus, I created the syllabus (attached as Appendix 1), crafted and presented lectures and activities, organized reading discussions, and wrote and graded exams and assignments.

Background Information
A105 is an introductory level course on Human Origins that does not count towards an Anthropology major at IU. A diverse range of students tend to enroll in the course, which carries a Science and Humanities distribution credit. This semester I had 26 students in class. The breakdown of students was as follows: 1 Freshman, 7 Sophomores, 6 Juniors, and 12 Seniors; 16 Female, 10 Male. Additionally, this semester’s class had 6 students (23%) who were not born in the United States and whose first language was not English. For the most part, these numbers are not extraordinary—because the class was a 2nd 8-weeks course in the spring semester, I foresaw having a large number of seniors who needed an additional class to graduate. However, the large number of international students was surprising and added an additional challenge (and benefit) to my teaching that I will discuss below.

Course Subject, Format, and Learning Objectives
A105 is an introductory anthropology course that covers theories of evolution and human development, primate characteristics and behavior, the early fossil record on human origins, and the prehistory of Homo sapiens. In the beginning of the course, students learn about the four sub-fields of anthropology, the scientific method, and archaeological methods, which are integrated into future discussions on human origins and prehistory. Though the class is not for majors, it does contribute to the overall anthropology curriculum by providing a knowledge base about the scientific method and anthropological methods, topics, and goals. The class is also meant to encourage students to take anthropology classes by fostering their interests in the subject matter.
Typically, the format of the class is PowerPoint lectures with 1-2 lab-days spent analyzing fossil casts of apes and early human ancestors. This semester, in addition to lectures and labs, the class included two videos and four Reading Discussion Activities, which were graded discussions where students were responsible for answering a series of questions about some of the readings assigned for that day.

It is hoped that by the conclusion of the course, students will understand: The biological and cultural bases for some human behaviors, activities, and changes throughout time; general theories of evolution and the mechanisms of evolution; potential ethical implications of biological, anthropological, and archaeological research; and their own ideas and concerns about biological and anthropological research.

**Objectives for Teaching Innovation**

Having instructed A105 in the past, I was able to reflect back to previous semesters and identify teaching and learning challenges that I hoped to address during this semester’s class. I decided to focus on one teaching/learning topic in particular: the theory of evolution, and its relation to human origins and prehistory research. My learning objective for this topic is for students to be able to identify and correctly define and discuss mechanisms of evolution (such as Natural Selection, Mutation, Sexual Selection, Genetic Drift, Gene Flow, and Memetic Evolution), but also to evaluate and critique the use or misuse of these mechanisms in popular and scholarly media. Additionally, I hope that students will combine their knowledge of evolution and the scientific method to gain the skill to critically think about and analyze many forms of scientific data that they will undoubtedly encounter in their future lives.

I chose this learning objective because in past semesters I have noticed that students have many misconceptions about evolution and the archaeology of human origins when they enter class. These misconceptions include believing in statements such as:

- Mutations arise as needed.
- Natural Selection = Survival of the fittest.
- Humans are more “advanced” than other species.
- Evolution is inherently anti-religion.
- Evolution is about the creation of first-life.
- Evolution has a purpose.

In past semesters, I chose to deal with these misconceptions by presenting students with a handout that critiqued many of the statements above, and by testing students on their abilities to recall the various postulates and principles of Natural Selection and Mendelian inheritance. While students were relatively successful in remembering and recalling these pieces of data, I was often disappointed to see the same misconceptions about evolution reappear at the end of the semester, either in a final exam or in their final debate assignment (where they debate topics such as: “Are we still evolving?” and “Are genetically modified foods good or bad?”). I repeatedly noticed that students struggled when asked to apply these evolution concepts or when asked to evaluate claims (in the media) regarding evolution and human ancestors. Finally, students had trouble explaining these concepts in their own words.

This challenge is, naturally, not mine alone. Every instructor who teaches evolution or human origins encounters students with diverse backgrounds and knowledge and must find ways to identify extant student knowledge and implement innovations in the classroom to meet learning objectives (other articles I encountered during this research include Ingram and Nelson 2006; Leslie and Little 2003; Smith 2010; Sullivan and Smith 2005). As part of my planning for
the innovations I chose (discussed below), I read an article that discussed student misconceptions about evolution (titled: “Teaching the ‘E-Word’ in Tennessee”) (Kramer, Durband, and Weinand 2009). This brief article summarizes a survey accomplished over the past decade on student understanding of fundamental statements about the theory of evolution and the nature of science in general. The survey was given primarily to introductory level students in physical anthropology classrooms in Tennessee. Students were asked four true/false students (e.g. “Science has proven that evolution is true,” “If you believe in evolution, you cannot believe in God”) and asked to provide a definition of “evolution.” The authors reached several interesting conclusions about student knowledge of evolution, including that very few students could answer the four statements correctly and that a number of misconceptions about evolution were present in their definitions. However, the authors of the survey did not include an “exit interview” at the end of the class to test student understanding after instruction and did not elaborate on what teaching techniques they thought would be most effective in the teaching of evolutionary concepts. The article inspired me to think about what teaching techniques I could adapt or create to address my concerns.

**Implementation**

My overarching theory on how to meet my teaching and learning goals described above was to provide students multiple opportunities to practice various “Cognitive Process Dimensions” (Remember, Understand, Apply, Analyze, Evaluate, Create) related to human evolution. I believed students would be better able identify and challenge misconceptions and theories about evolution and human origins by beginning with basic facts and their own misconceptions, then utilizing these data in complex and robust schema (of increasing complexity) to build cumulative knowledge and experience working with concepts related to evolution and human origins. What I hoped to see over the course of the semester was an escalation of the learning curve by all students so that by the end of the semester, students would be able to identify multiple mechanisms of evolution and utilize their knowledge to create a presentation of factual information as well as opinion regarding human evolution.

I was inspired to use this approach after reviewing Bloom’s taxonomy and the tenets of various learning theories. For example, I agree with Information Processing theorists who argue that prior knowledge plays an important part in student learning because the ability to remember or recall comes from creating connections between pieces of known information. If this is true, then teaching students how to organize and apply information is critical to student success. With this, I think, comes a need for students to recognize ideas they might already have that are incorrect and need to be “un-learned.” For this reason, I started my assessments with a survey and discussion of common misconceptions of the theory of evolution. Additionally, I agree with the Behaviorism learning theory’s assumption that learning is hierarchical and cumulative, in that students need practice engaging with information and are helped along the learning process by repeated interaction with material. Although I was not trying to create a Pavlovian response when students heard the word “Evolution,” by providing students with multiple opportunities to identify mechanisms of evolution and critique their use, I hoped students would ultimately become more comfortable with the material and develop more complex ideas. Finally, I support the idea (from Situated and Social theories of learning) that learning often takes place as a result of social interaction and discussion. Thus, throughout the semester I had students engaging in group work and discussions, culminating in the final debate assignment that required students to do collaborative research and discuss their findings.
I re-designed A105 to include a number of new assessments and opportunities for students to express their knowledge and questions. Instead of only assessing student knowledge about evolution through oral questions in class and objective short-answer or multiple-choice questions on exams, I added new assignments, in-class activities, extra-credit opportunities, and reflection opportunities spaced throughout the semester. My goal in adding new forms of assessment and class-discussion were to integrate or align my interests in creating a classroom environment that is “Knowledge-centered,” “Assessment-centered,” and “Community-centered” (Bransford et al. 2000).

The teaching innovations I implemented to gather evidence of student learning were:

1. In-Class Survey (Public Opinion Poll)
   - Students were asked whether they Agree, Disagree, or are Unsure to questions: a) The theory of evolution is about creation and the origins of first life, b) The theory of evolution is inherently anti-religious.
   - Goal was to assess student knowledge and understanding about these issues before beginning to discuss them in class.

2. Minute-Paper on the Theory of Evolution
   - Students were asked to write a minute-paper on the definition of evolution (or how evolution works)
   - Goal was to identify student-vocabulary related to evolution, test their ability to retrieve relevant information from long-term memory (what they learned in high-school or other classes at IU) and note existing misconceptions.

3. In-Class Reading Activity
   - Students read an anti-evolution article that contained several misconceptions or misconstrued ideas about the theory of evolution and human evolution research. Students were asked the question: “Describe and critique one argument Terreros makes for why he believes the theory of evolution is not supported by scientific evidence.”
   - Goal was to see which arguments the students focused on and how they critiqued them.

4. “Mystery of the Black Death” Video
   - Students were asked to write a 2-page response paper to a video that discussed why certain individuals survived the Black Plague. Specifically, students were asked to discuss: a) The mechanisms of evolution referenced in the video, b) How these mechanisms played a role in human evolution or changing of the gene pools of specific human populations, c) How the mechanisms contributed to the support or refutation of scientific theories in the video. Several mechanisms of evolution (e.g. Natural Selection, Mutation, Bottleneck Effect, Gene Flow) were mentioned (though not by name).
   - Goal was to see how well students remembered the various mechanisms of evolution, whether they understood how each mechanism functioned and whether each played a role in the scientific theories of Black Plague and AIDS survivors, and if they could evaluate the use of certain mechanisms by the video-producers and scientists.

5. Exam 1 Questions
   - I included several questions in the first exam designed to test student understanding of evolution and its application to human origins research. Questions were both multiple-choice and short-answer.
6. Mid-semester Teaching Evaluation
- After the first exam, I gave students a mid-semester evaluation that included questions like: What do you think is the most important thing you have learned so far? What has been your favorite part of class? Why? What was your least favorite? Why?
- Goal was to better understand how students were feeling about the class and my teaching.

7. Extra-credit Video Review Opportunity
- I offered the students an opportunity to watch a second video about human origins research on their own time for extra credit. To receive full credit, students were asked to summarize the video, describe the mechanisms of evolution addressed in the video and how they impacted human evolution, and to relate the video-content to something we had learned in class.
- Goal was to compare their abilities to remember, understand, and explain mechanisms of evolution in this assignment to the earlier “Black Death” video-assignment.

8. Final Debates
- Students were split into four groups and provided a topic to debate. The four topics were: a) Primate Research – Good or Bad? b) Are we still evolving? c) Genetically Modified Foods – Good or Bad? d) Media Representations of Archaeology – Good or Bad?
- Students had to present research on their topic to their classmates and write a reflection paper outlining what they learned and what they contributed to their group.
- Goal was for students to use what they had learned in class as a base from which to perform individual research and critique an argument about their topic.

9. 2nd In-Class Survey and Minute-Paper
- With their final evaluations of the course, students were asked the same questions in assessment #1 and also asked to, once again, define evolution and how it works.

Assessment Data and Interpretation
Through the various assessments described above, I was able to collect a vast amount of data on student knowledge and understanding of concepts related to human evolution. I will discuss each set of data separately by the assessment below.

1) Pre-Survey and 2) Minute Paper
From the pre-survey and Minute-Paper exercises, I was able to obtain information on how well students understood evolution before class began. The majority of students (n=13) mistakenly believed that the theory of evolution is about creation and the origins of first life, while six disagreed and two were unsure. A minority of students (n=5) mistakenly believed that the theory of evolution is inherently anti-religious, while 14 students disagreed and two were unsure. These were important facts to realize before starting to teach about the theory of evolution. Many times, students who believe the theory of evolution is anti-religious think so because they mistakenly believe evolution is about critiquing religious (mostly biblical) creation stories. Because it seemed that this was not the case with my students, I guessed that the reason why so many thought evolution was about first life was a basic misunderstanding on how evolution works (scientifically), and not an epistemological objection to its “anti-religiousness.”

The Minute-Paper exercise supported my guess that students have several misconceptions about evolution, but had previously learned about the subject and generally believe it to be well-supported theory about the natural world. No one called into question the theory of evolution in their Minute-Paper, though several students admitted not understanding how it works. Among
the most frequent misconceptions were that evolution is about the “survival of the fittest” (mentioned in 10 of 20 responses), that species evolve out of “need” (8/20), and that individuals “adapt to” their surroundings (6/20). Here are some examples of student responses with the misconception noted after the quote:

- “As the environment changes, the occupants of that environment need to adapt” (Mutations arise as needed)
- “I believe it has something to do with the way that a species changes and adapts to fit its needs” (Evolution has a purpose)
- “Evolution is the process by which creatures mature and develop over the ages…How the survival of the fittest takes place” (Natural Selection = Survival of the fittest)
- “We all started out as something completely different, something smaller, less intelligent, less able and we developed. It takes many years but… [we] became better, stronger, smarter.” (Humans are more “advanced” than other species)

3) In-Class Reading Activity

The In-Class Reading Activity was the first opportunity for students to use their newly obtained knowledge about the theory of evolution to recognize mechanisms of evolution when they are discussed in an article, and critique their use. Students read an anti-evolution article from a Seventh Day Adventist Church publication and were asked to: “Describe and critique one argument Terreros makes for why he believes the theory of evolution is not supported by scientific evidence.” The most frequently critiqued argument was something like: “author said that single-celled organisms were too complex to not have been created via divine intervention” (student argument: no proof of this). While a valid critique, this response shows more of an understanding of the scientific method and the epistemological differences between science and religion than an understanding of the theory of evolution. Far fewer students recognized or critiqued other misconceptions in the article, such as: evolution research is not about first-life, a spurious argument on “biogenesis,” and an incorrect description of Mendelian inheritance. While this activity did demonstrate student understanding of the scientific method, it did not suggest that students were comfortable analyzing or evaluating statements related to evolution yet.

4) Black Death video

A number of mechanisms of evolution are discussed in the “Mystery of the Black Death” video, including: Natural Selection, Mendelian Inheritance, Mutation, Bottleneck Effect, and Gene Flow. For the most part, students did well remembering the various mechanisms of evolution, but struggled to differentiate or evaluate some of them in the film. On average, students mentioned and appropriately described two mechanisms of evolution in their papers, which was an improvement from their analysis of the anti-evolution article in the In-Class Reading Activity. Still, I was disappointed with the number of mechanisms identified.

Positive Example: “The mutation of a gene is a change in the DNA that is randomly passed on and results in genetic variation in future generations. These genetic variations in the population make way for evolution by natural selection. The mutated gene may be more beneficial to the individual who carries it than to the rest of the population that doesn’t, improving that persons chance of survival and ability to pass the same mutated gene onto future generations”
Example with Misconceptions: “[the video] shows that survival of the fittest takes place, and the people of Eyam have proved Charles Darwin’s theory true by still carrying the genetic mutation”

5) Exam 1 Questions

Within the first exam, I included two multiple-choice and two short answers specifically testing student knowledge of how evolution works. Overall, the students did quite well on these questions. The multiple-choice questions were:

1) The idea that evolution by Natural Selection has a purpose and leads to a definite, perfected end for organisms could be described as:
   a. Teleological and inaccurate
   b. An accurate assessment of the process
   c. Evolutionary
   d. None of the above

5) The Delta-32 Mutation found in some descendants of Black Plague survivors
   a. Most likely already existed in the population in Eyam before the Black Plague hit the village
   b. Most likely was created in certain people in Eyam as an adaptation protecting them against the Plague
   c. Protected many people from the Black Plague and has been shown by scientists to be resistant to AIDS as well
   d. Both a. and c.

The majority of students answered both question one (77%) and five (92%) correctly. Zero students responded (b) to question one and only three responded (b) to question five (the two most incorrect answers), showing that several students had a better understanding of evolution than they did when they defined it in their Minute-Papers. The two short-answer questions were:

3) Using Sickle-Cell Anemia as an example, describe why some maladaptive traits persist instead of being eliminated through Natural Selection. (2 points)

5) Correct the following misconception about evolution: “Mutations arise as needed” (1 point)

Though I did not tally how many students received full credit for their responses to these questions, my feeling is that over 80% did. I was especially impressed at student responses for question five because they explained why the misconception was wrong in addition to correcting the sentence, possibly indicating that they wanted to show me their newly acquired knowledge about how mutations affect human evolution.

6) Mid-semester evaluations

The mid-semester evaluation form was taken by the students in the class immediately following the first exam. Student responses revealed quite a lot about how the class was going. I received many positive comments about student understanding of the theory of evolution, which suggested to me that the suite of assessments I implemented was working. However, I also received some negative comments about the assessments, including that there were too many assignments and group activities. Looking back, I wish that I would have included a list of the
activities and assignments we had done in-class and asked students to rank them by their benefit. This type of question would have allowed me to better understand the impact of each assessment.

The most surprising comment I received was that several students expressed displeasure with the amount of new vocabulary they were being asked to learn. Most of the vocabulary issues were likely with the Latin names of human origins fossils (e.g. Australopithecus afarensis) and not with mechanisms of evolution. These comments made me reflect upon my teaching a bit more and realize that I had become too familiar with the material (if that can actually happen)! I have taught A105 so many times that I failed to realize just how much of the vocabulary is new to students. I corrected this oversight in my teaching by creating and posting to Oncourse a glossary of vocabulary terms and by encouraging students to raise their hands in class or email me after class with questions about words.

<table>
<thead>
<tr>
<th>Question</th>
<th>Student Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorite part of class?</td>
<td>- Structure of the class has helped understand the material</td>
</tr>
<tr>
<td></td>
<td>- I really liked the Black Death video and discussing evolution and mutations</td>
</tr>
<tr>
<td></td>
<td>- Learning about the Delta-32 gene (Black Death video). It was informative and entertaining</td>
</tr>
<tr>
<td>Least favorite part of class?</td>
<td>- Frequency of assignments</td>
</tr>
<tr>
<td></td>
<td>- Group activities (x3)</td>
</tr>
<tr>
<td></td>
<td>- Memorizing names</td>
</tr>
<tr>
<td></td>
<td>- Too much new vocabulary (x4)</td>
</tr>
<tr>
<td></td>
<td>- All the readings</td>
</tr>
<tr>
<td>Most important thing you learned?</td>
<td>- Learning about evolutionary theories</td>
</tr>
<tr>
<td></td>
<td>- We have cleared up misconceptions about evolution and learned what truly happened</td>
</tr>
<tr>
<td></td>
<td>- The truths that I’ve never known in regards to evolution</td>
</tr>
<tr>
<td></td>
<td>- Natural Selection and why diversity exists</td>
</tr>
<tr>
<td></td>
<td>- I have a better understanding of evolution</td>
</tr>
</tbody>
</table>

7) Extra Credit Video Review

Because the second video-review was extra credit, far fewer students completed this assessment. Additionally, the video-list I provided the students included some videos that did not discuss mechanisms of evolution in practice, but rather discussed a tangential topic, such as the life of Charles Darwin. This was my mistake and resulted in much less data than I had hoped from the assessment. Those students who did watch a video that included discussion of mechanisms of evolution did an excellent job of identifying and explaining them. For example, the following quote is from a student who received a B- grade for the first video-review because he failed to identify any mechanisms of evolution and instead only summarized the movie.

“The limited resources on the island caused H. floresiensis to become smaller. Being smaller makes it easier to live [on the island] because they do not need to consume as much energy as a large person would. More small people would liven then with limited resources. They also talked about how small mammals became larger too. Few predators were also a factor for mammals becoming smaller.”
8) Final Debates

The Final Debates I witnessed in previous semesters of teaching A105 were the inspiration for this teaching innovation. I was disappointed when students would employ the same misconceptions about evolution and human origins in their final debates as they had at the beginning of class. This semester, the same topics were chosen for the final debates and I was very happy with the outcomes. In the student presentations and papers, only one or two students described a mechanism of evolution in an inaccurate way. And, students discussed how evolution works in much greater detail in their debate presentations and papers (including more use of evolution vocabulary, more mechanisms of evolution identified, scientific reports analyzed through a lens of evolutionary mechanisms, etc.). Unfortunately, the way that the presentations were given, it was difficult to record the number or specific usage of terms related to evolution and human origins.

9) Post-Survey and Minute Paper

Student responses were much improved from the original pre-survey. The percentage of students who thought evolution was about creation and origins of first life changed dramatically, from 62% agreeing with the statement, to 67% disagreeing with the statement. Overall, the number of students who agreed that the theory of evolution is inherently anti-religious did not change dramatically (from 5 to 3), but more students disagreed with this statement at the end of the semester, hopefully reflecting a better understanding of epistemologies and the false dichotomy of science/religion, which we talked about in class extensively.

<table>
<thead>
<tr>
<th>Before: “The theory of evolution is about creation and the origins of first life”</th>
<th>After: “The theory of evolution is about creation and the origins of first life”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>9%</td>
</tr>
<tr>
<td>Disagree</td>
<td>29%</td>
</tr>
<tr>
<td>Unsure</td>
<td>62%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Before: &quot;The theory of evolution is inherently anti-religious&quot;</th>
<th>After: &quot;The theory of evolution is inherently anti-religious&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>9%</td>
</tr>
<tr>
<td>Disagree</td>
<td>24%</td>
</tr>
<tr>
<td>Unsure</td>
<td>67%</td>
</tr>
</tbody>
</table>
The Minute-Paper responses also displayed greater understanding of the theory of evolution:

- “Evolution is the adaptation, over a long period of time, of a species to its surrounding environment”
- “Evolution takes a long time”
- “Evolution works via natural selection. That is, the species that’s most prone to survival will prevail and pass down dominant traits to future generations.”

**Conclusions and Next Steps**

My intention in changing the way I traditionally teach A105 was to help students identify their extant knowledge about evolution and human origins, correct student misconceptions, and provide students with multiple opportunities to evaluate claims about human evolution and create new knowledge. I believe the results I viewed in their final debate presentations indicated students learned more about evolution and human origins this semester than they have in previous semesters. Additionally, a survey I took at the end of class indicates students themselves thought they had a better understanding of numerous course topics at the end of the semester as compared to the beginning.

"How well did/do you understand these concepts?" n=20

**KEY: 1= Not at all, 2= Very little, 3= Some understanding, 4= Broad, 5= I’m an expert**

If I were to teach A105 again in the future, I would make a number of changes based on the evidence collected from this teaching innovation. First, I would develop assessments to test student vocabulary in relation to human evolution, and then develop later assessments to see how well students are coping with the extensive vocabulary of the subject. Second, I would expand the initial pre-survey to include more agree/disagree/unsure questions and ask students to explain their answers. Third, I would eliminate the second optional video-review and replace it with a required assignment to review a video that explicitly discusses mechanisms of evolution related to human origins research. Finally, I would schedule fewer other assignments and less groupwork because some students seemed overwhelmed by the number of assessments done in class.

My overall impression of my teaching innovation was that I attempted to gather data on too many factors and should have focused my efforts on one particular question. Although I feel
that the multiple assessments and opportunities I gave to students did result in greater abilities of recall, understanding, analysis, and critique, these specific learning actions were difficult to measure and identify amidst the overabundance of data created in this study. Regardless of these conclusions, though, as a teacher, I absolutely benefited from the exercise of reflecting upon my teaching practices and learning goals for my students. I look forward to continuing this analysis in my next section of A105, and in developing similar teaching innovations for other classes.

Acknowledgments
Thank you to all to the faculty mentors, fellows, and members of the Learning Sciences and Assessment Team (primarily Katie Kearns and Tyler Christensen) involved in the Teagle Collegium on Inquiry in Action at Indiana University. I know that my teaching greatly benefited from our conversations, and am confident that my students benefited as well!

References
Bransford, John, Ann Brown, and Rodney Cocking (editors) 

Ingram, Ella and Craig Nelson 

Kramer, Andrew, Arthur C Durband, and Daniel C Weinand 

Leslie, Paul and Michael Little 

Smith, Cameron 

Sullivan, Charles and Cameron Smith 