BIOLOGY

Challenging Students' Preconceived Notions on Evolution

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When I was offered the opportunity to participate in the Ignatian Mentoring Program, I was, to be honest, initially hesitant to join the program, because at the time I was afraid that the goal of the program was religious indoctrination. This reservation stemmed from the fact that up until then I knew very little about Ignatian pedagogy. At the same time, this lack of knowledge, along with my inherent curiosity, eventually motivated me to join the program and learn more about Ignatian pedagogy.

As a result of participation in the program, reading multiple articles, and several meetings with my mentor Roy Cohen, I quickly learned that the Ignatian approach to education, and to life in general, can offer valuable practical wisdom, even for a non-religious person like me. Consequently, I decided to apply the Ignatian approach in the spring semester of 2009 to a course that I teach and coordinate every spring semester: General Biology II Laboratory (BIO 163; 8 sections; 140 students; 5 different instructors).

Incorporation of Ignatian Pedagogy in General Biology II Laboratory

The major topics covered in General Biology II Laboratory (as well as in the General Biology II lecture course that this lab course complements) are evolution, ecology, animal behavior, and taxonomy. These topics, especially evolution and ecology, are issues that go beyond the classroom. They are topics of discussion in politics, in the popular press, in social settings, in religious settings, and in family settings. Thus many students come to class with at least some preformed opinions on these issues. This fact makes the teaching of these topics even more challenging than they inherently are: How does one present the scientifically established facts in these areas, facts that are bound to be contrary to what some of the students personally believe, without insulting and/or alienating the students? I have been wrestling with this issue for almost two decades, and I believe that for the most part I have found a way to challenge students' beliefs in a non-confrontational manner. Nevertheless, I am always looking for more effective ways to accomplish this goal, and it is to that end that I (along with the other instructors teaching General Biology II Laboratory) will be applying the principles of Ignatian Pedagogy to this course.

I. Methodology

Since coverage of evolutionary principles inevitably crosses paths, by its very nature, with Biblical creationism and intelligent design, we decided to employ the principles of Ignatian Pedagogy to address, rather than to ignore, the relationship between these different points of view about the history of life on this plant. Furthermore, we wanted to identify any misconceptions students might have about the theory of evolution, and, finally, to determine how effective our coverage of evolution is in removing these misconceptions. To that end, we devised a set of 25 statements regarding Biblical creationism, intelligent design, and the theory of evolution and asked the students to evaluate the statements, once before our coverage of evolution in the course and again after we had finished covering evolution.
The 25 statements were as follows:

1. The fact that evolution is considered a theory by the scientific community indicates that evolution is an established fact.
2. The presence of gaps in the fossil record undermines the validity of evolution.
3. Believing in evolution demands that one reject the existence of a creator.
4. Evolution and the literal interpretation of Biblical creationism are incompatible.
5. Evolution is compatible with intelligent design.
6. Darwin was the first person in history to propose that living organisms undergo evolution.
7. Intelligent design is based on scientific evidence.

8. The proponents of intelligent design believe that the intelligent designer is God.
9. All organisms that exist today, including humans, share a common ancestor.
10. The theory of evolution can be scientifically tested.
11. Intelligent design can be scientifically tested.
12. Modern humans are the product of evolutionary processes, the same processes that have shaped all other living organisms.
13. Nearly all scientists accept the evolutionary theory to be a scientifically valid theory.
14. The available data are ambiguous (unclear) as to whether evolution actually occurs.
15. The age of the earth is less than 20,000 years.
16. There is a significant body of data that support the evolutionary theory.
17. The history of life goes back to more than 3 billion years.
18. The evolutionary theory generates testable predictions with respect to the characteristics of life.
19. The evolutionary theory generates testable predictions with respect to the origin of life.
20. The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.
21. Humans exist today in essentially the same form in which they always have.
22. Much of the scientific community doubts if evolution occurs.
23. The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms.
24. With few exceptions, organisms on earth came into existence at about the same time.
25. I am familiar with the tenets purported by intelligent design.

(Some of the above statements, as well as the grading system, came from Rutledge and Sadler, 2007.)

For the initial evaluation, students were given the statements on the first meeting of the semester (i.e., before coverage of evolution in the course). They were directed to read the statements and assign one of the following letter grades to each statement:

A = Strongly agree B = Agree C = Undecided
D = Disagree E = Strongly disagree

In accordance with principles of the scientific method and Ignatian Pedagogy, every step possible was taken to make sure that the answers students provided to the above statements were fear-free and truly based on what they already knew about evolution and how they genuinely felt about the theory of evolution. To that end, it was repeatedly emphasized to the students that the purpose of the survey was <u>not</u> to pry into their personal beliefs, but rather to find out how effective our coverage of evolution in this course is. Furthermore, students were assured that their names would not be used in the analysis of the results, and that any conclusions drawn from the survey would be based on class results, not individual results. Finally, students were repeatedly assured that their grade would not be affected in any shape or form by the answers they provide to the above statements. (And to make sure that students would not search the subject matter prior to their evaluation of the statements, the survey was conducted in the lab.)

The statements were given to the students and they were given as much time as they desired to complete the survey. Completed surveys were then collected and the answers were analyzed. Then once we had finished covering the topic of evolution in the course (five lab periods), students were given the same exact set of 25 statements and were once again asked to assign a letter grade to each statement. Completed surveys were collected again and the answers were analyzed. Finally, their pre-coverage answers were compared with their post-coverage answers to determine whether their knowledge and/or acceptance level of the principles of evolution had significantly changed as a result of our coverage of the evolution in this course (as well as in lecture, which took place simultaneously).

II. Analysis of the Results

This project constituted not only an application of the principles of Ignatian Pedagogy, but also a scientific study. As far as the scientific aspects of the project were involved, it was necessary not only to ensure that the conduct of the study and collection of data were scientifically sound, but also to make scientific analysis of the data possible. For that purpose each statement was assigned a numerical value. More specifically, statements 1, 4, 8, 9, 10, 12, 13, 16, 17, 18, 19, 23, 25 were considered to be true statements and the letters were given the following numerical values:

A = 4 B = 3 C = 2 D = 1 E = 0

On the other hand, statements 2, 3, 5, 6, 7, 11, 14, 15, 20, 21, 22, 24 were considered to be false statements and thus the following numerical value was given to each letter grade:

A = 0 B = 1 C = 2 D = 3 E = 4

Next, the numerical values of all the 25 statements from each student were added together to generate a grand total for that student. The grand total for each student was then used in the following scale and each student was placed, based on their grand total, in one of the categories listed below:

Very high knowledge and acceptance: 89-100
High knowledge and acceptance: 77-88
Moderate knowledge and acceptance: 67-76
Low knowledge and acceptance: 53-66
Very low knowledge and acceptance: <52

The above approach placed the entire student population (all the eight sections of this course) in the above categories, once before our coverage of evolution and once afterwards. Finally, the two sets of data (i.e., the pre-coverage and the post-coverage results) were subjected to a G-test in order to determine whether or not any change seen in the pre- and post-coverage results were statistically significant.

III. Results

The pre-coverage and the post-coverage results from all sections are shown in Table 1.

Table 1. *Pre-Coverage and Post-Coverage Student Responses*. Students in General Biology II Laboratory were given a set of 25 statements once before coverage of evolution and again after coverage of evolution. Students were asked to assign one of five pre-defined letters to each statement. The numerical sum of the responses by each student was then calculated and the student was placed into of the categories listed in the table. The table reflects the results of the two surveys for all the sections (a total of 137 students completed before coverage of evolution while a total of 131 completed the survey after coverage of evolution).

Knowledge/ Acceptance	Pre-Coverage	Post-Coverage	Change
Very High	3	13	333% increase
Hi	12	37	208% increase
Moderate	33	45	36% increase
Low	59	30	49% decrease
Very Low	30	6	80% decrease

As can be seen in Table 1, there was a significant (G = 48.135; p-value = 1.99E-10) increase in the students' knowledge of the principles of evolution, as well as in their acceptance of these principles, between the two surveys. The largest increase was seen in the "Very High Knowledge/Acceptance" (333% increase), followed by the "High Knowledge/Acceptance" category (208% increase). These significant increases were accompanied by significant decreases in the number of students who had shown a very low or low knowledge/acceptance of the principles of evolution (80% and 49% decreases, respectively). Therefore, the results showed that both knowledge and acceptance of the principles of evolution increased significantly among the student population taking General Biology II Laboratory, as determined by the comparison of the pre-coverage results with the post-coverage results.

IV. Conclusions

Two major conclusions can be drawn from the results of this study. First, the significant increase in students' knowledge of the principles of evolution indicates that our coverage of evolution in the lab (as well as in lecture) achieved its intended goal. Second, it can further be concluded that the inclusion of the principles of Ignatian Pedagogy was helpful in correcting misconceptions that students had about evolution.

The role that Ignatian Pedagogy played in this respect was two-fold. First, the very idea for undertaking this project was the direct result of my participation in the Ignatian Mentoring Program. My newly acquired familiarity with the Ignatian approach to education inspired me to incorporate this survey into the course as a means to discuss, in a non-controversial manner, the relationship between evolution, on the one hand, and creationism and intelligent design, on the other hand. Second, the principles of Ignatian Pedagogy played a crucial role in the selection of the statements that were included in the survey. Specifically, a number of statements were included that would relate the evolutionary theory with Biblical creationism and intelligent design, in the hope that these statements would help us identify and address any misconceptions students might have about the concept of evolution and how it relates to creationism and intelligent design. And based on the fact that not only knowledge but also *acceptance* of the principles of evolution among the students increased significantly from pre-coverage to post-coverage, it is reasonable to conclude that lessons learned from the Ignatian approach to education were helpful in correcting students' misconceptions about the relationship between the evolutionary theory and Biblical creationism and intelligent design.

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