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The Relation of High School Biology Courses & Students' Religious Beliefs to College Students' Knowledge of Evolution

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Abstract

We examined how college students' knowledge of evolution is associated with their self-described religious beliefs and the evolution-related content of their high school biology courses. On average, students entering college know little about evolution. Religious beliefs, the absence of evolution-related instruction in high school, and the presence of creationism-related instruction in high school were all associated with significantly lower scores on an evolution exam. We present an ordered logistic model that helps to explain (1) students' diverse views and knowledge of evolution, and (2) why college-level instruction about evolution often fails to significantly affect students' views about evolution.

Key Words: *Evolution; religion; high school biology.*

Although evolution is the foundation of modern biology, teaching evolution is often difficult. To appreciate this, one has only to look at recent polls. Most Americans – that is, *our former students* – reject evolution in favor of religious and other supernatural explanations of life's diversity (National Center for Science Education, 2010). Discrepancies in the acceptance of evolution by biologists and the general public have been attributed to a variety of factors, including ineffective teaching and the ongoing efforts of anti-evolution organizations such as Answers in Genesis. Students entering college have based their views of evolution on many of these influences, not just those that are scientifically valid. This helps to explain why creationism is so prevalent among college students, including biology majors (Moore & Cotner, 2009, and references therein).

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It is important for instructors to appreciate students' conceptions (and misconceptions) about evolution, for a key aspect of effective teaching involves engaging students at their initial levels of understanding (Bransford et al., 2000). If instructors fail to do this, students will memorize new information for the purpose of passing an exam but later revert to their original way of thinking; this explains why courses about evolution and the nature of science may increase students' knowledge of evolution, but not their acceptance of it (Nehm & Schonfeld, 2007, and references therein). If instructors are to help students better understand and accept evolution, they must link new information with resident information (Bransford et al., 2000). This requires instructors to appreciate students' views when they enter our classrooms. This is often difficult, for students do not enter college as a "blank slate" regarding evolution. On the contrary, college students have diverse views of evolution, ranging from "young Earth" creationism to philosophical materialism. With what are these diverse views associated?

Moore and Cotner (2009) have shown that the content of students' high school biology courses has a lingering influence on their acceptance of evolution when they enter college. However, the *acceptance* of evolution is not the same as *knowledge* of evolution. Moreover, Moore and Cotner (2009) did not address another important variable that affects students' views of evolution – namely, their religious beliefs. Many biology teachers base their views and teaching of life's history on personal religious beliefs rather than scientific evidence (Kraemer, 1995; Trani, 2004; Berkman et al., 2008). Do college students base their acceptance and knowledge of life's history on the same thing?

To examine how students' high school biology courses and religious views are related to their acceptance and knowledge of evolution when they enter college, we tested the null hypothesis that neither would have an effect.

Methods

Study Population

During the week before classes, we surveyed students enrolled in several sections of an introductory biology course at the Twin Cities campus of the University of Minnesota. All the students had taken a biology course in a public high school. On average, the students were in the 84th percentile (± 12% [SD]) of their graduating class and had an ACT composite score of 25 ± 4. The median age of the students was approximately 19 years, and the sample was 54% female and 46% male.

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The Survey Instrument

We designed our survey to assess the students' background in, and knowledge of, the theory of evolution. First, we asked the students to tell us whether their high school biology course included evolution but not creationism, creationism but not evolution, both evolution and creationism, or neither evolution nor creationism (Table 1). We then asked 10 basic, discriminating questions about evolutionary topics with which we and other biology instructors at our university assumed that entering students would be familiar (e.g., fitness, natural selection, evidence for evolution). These questions, which were developed and tested over a period of several years with students in introductory biology courses in authentic exam settings, are hereafter described as the Knowledge of Evolution Exam (KEE) and are available elsewhere (Moore et al., 2009) and from the authors. Students' scores on the KEE had a potential range of zero (no questions answered correctly) to 10 (all questions answered correctly).

We also asked the students to identify their religious beliefs as conservative, liberal, middle-of-the-road, or nonexistent (i.e., not religious). Copies of the survey (including the KEE) and the students' responses are available from the authors. The survey, which was voluntary, anonymous, and approved by the university's Institutional Review Board, was distributed electronically to the students 1 week before classes started. To ensure that neither the instructor nor the course influenced the students' responses, we closed the survey on the morning that classes began (i.e., before the first meeting of the class). The students' responses were tabulated electronically and had no affect on their grades. The survey was completed by 179 students.

Analysis & Model

Because KEE scores are not continuous (i.e., no value exists below zero or above 10), the probability of earning any particular KEE score is not equal. Thus, we used an ordered logistic model to test our null hypothesis that neither the content of students' high school biology classes nor their religious views would affect their level of knowledge about evolution.

Given the assumptions of nonlinearity used in logistic regression models, we could not directly interpret the coefficients for the independent variables. Instead, we used a Monte Carlo simulation to transform the logistical regression results into predicted probabilities. Specifically, we used the program CLARIFY to simulate 1000 parameters for each item based on the original logistic regression models and likelihoods of dependent outcomes at specified levels of the independent variable (King et al., 2000; Tomz et al., 2001). Predicted probabilities were generated for every possible combination of independent variable categories. For ease of interpretation, we created a new grade category, "Fail," by summing the probabilities for each level of the dependent variable that would constitute a failing grade (0–5). Similarly, we added the generated probabilities of passing-level grades of the dependent variable (6–10) to create the category "Pass."

Results

The evolution-related content of the students' high school biology courses is shown in Table 1. Although ~13% of the students reported that they were taught neither creationism nor evolution in their high school biology courses, nearly twice that many (22%) said that their high school biology courses included both evolution and creationism. Only 2.6% of the students reported being taught creationism but not evolution, and 62% reported that their high school biology courses included only evolution.

The average KEE score was only 53%, and that of the highest-scoring subset of our population was only 57%. Despite evolution being a mandated part of the curriculum in public high schools, students enter college knowing little about evolution.

Thirty-five percent of the students described their religious views as liberal or progressive, and 9.4% reported conservative views (Table 1). Students holding either moderate or atheistic/agnostic/not religious views numbered ~28% each.

Overall, the students' scores on the evolution quiz averaged 5.30 ± 2.2 (SD). The KEE scores of particular populations of students (e.g., those who were taught neither evolution nor creationism) are shown in Table 1. For example, students taught only evolution in their high school biology courses averaged 5.7 on the KEE, whereas those taught neither evolution nor creationism earned an average KEE score of 4.2.

The results of our ordered logistic model are listed in Table 2. They reject our hypothesis that the content of students' high school biology courses and their religious views do not affect their knowledge of evolution. In fact, students' knowledge of evolution is strongly correlated with their religious views ($p < 0.05$) and the evolution-related experiences in their high school biology courses ($p < 0.01$).

Table 1. How students' religiosity and the evolution-related content of their high school biology courses affect their scores on the Knowledge of Evolution Exam (KEE). Cell entries are KEE scores with a minimum score of zero and a maximum score of 10 (± SD).

Group of Students	Percentage of Students	KEE Score
All students	100%	5.3 ± 2.23
My high school biology course included		
neither evolution nor creationism	13	4.2 ± 2.70
creationism only	3	4.8 ± 2.16
both evolution and creationism	22	5.0 ± 2.08
evolution only	62	5.7 ± 2.1
My religious beliefs are		
conservative	10	4.6 ± 2.29
moderate	27	4.7 ± 2.06
liberal/progressive	35	5.6 ± 2.3
atheist/agnostic/not religious	28	5.5 ± 2.2

Table 3 shows how students' self-described religious views are related to their knowledge of evolution (i.e., their KEE scores) when they enter college. The only students who were likely to pass the KEE were (1) religiously liberal students whose high school biology courses included evolution only, and (2) atheist/agnostic/not religious students whose high school biology courses included evolution only or evolution plus creationism. Regardless of their religious views, the students' knowledge of evolution was highest when their high school biology course included evolution only, and lowest when the course included (1) creationism only, or (2) neither evolution nor creationism (Table 3).

○ Discussion

Limitations of the Study

All studies based on surveys have limitations, and ours is no exception. For example, parts of our survey (i.e., asking students to describe their high school biology course) relied on students' recollections of their high school classes, and these recollections may not be accurate. Also, (1) the students were not selected randomly, but instead by their enrollment in a required course; and (2) because the surveys were voluntary and distributed at a large Midwestern university, it may be difficult to generalize our data to larger populations. However, these concerns are minimized by the facts that (1) we used a large sample (N = 179) from throughout the Midwest, (2) there was no incentive for students to bias their responses, and (3) our students' recollections of their high school biology courses were similar to those reported elsewhere (see discussion in Moore & Cotner, 2009).

Table 2. Results of an ordered logistic regression of the predictors of students' scores on the KEE.

High School Biology Course Content	0.4374** (0.1349)
My Religious Views	0.3222* (0.1403)
N	179
Pseudo R^2	0.02
χ^2	15.83***
Log likelihood	–381.09

Note: *p < 0.05; **p < 0.01; ***p < 0.001. Entries in the upper two cells are ordered logistic regression coefficients with standard errors in parentheses.

The Influence of Creationism in High School Biology Courses

As has been noted in many studies (Kraemer, 1995; Berkman et al., 2008; Bowman, 2008), the teaching of creationism is surprisingly common in high school biology courses. Our finding (Table 1) that approximately one-fourth of students are taught creationism in their high school biology courses is less than the percentages reported by others (Weld & McNew, 2004, and references therein; Moore & Kraemer, 2005) and may, in fact, underestimate the occurrence of creationism in high school biology courses (see discussion in Bland & Moore, 2011). Similarly, our report that 16% of students were not taught evolution in their high school biology courses is less than most other comparable reports (e.g., 25–33% of biology teachers in Oklahoma, Kentucky, Tennessee, and Indiana place little or no emphasis on evolution; see Weld & McNew, 2004; Moore & Cotner, 2009). The teaching of creationism occurs despite the fact that it is unconstitutional, violates most states' science education standards (including Minnesota's), and contradicts the recommendations of numerous professional organizations (Moore & Cotner, 2009). For many biology teachers, personal religious beliefs – and not science – determine the curriculum (Shankar, 1990; Trani, 2004).

The teaching of creationism in high school biology courses is important, because students who are taught evolution in high school are significantly more likely to accept evolution and its associated tenets (e.g., an old Earth, the mutability of species) than students whose high school biology course included creationism (Moore & Cotner, 2009). But students' *acceptance* of evolution is not necessarily synonymous with their *knowledge* of evolution. Our results indicate that the evolution-related content of students' high school biology courses is strongly associated with students' knowledge of evolution when they begin college (Table 1). For example, the KEE scores of students whose high school biology course included neither evolution nor creationism (4.2) or creationism only (4.8) were lower than those of students who were taught both evolution and

Table 3. The likelihood of passing the KEE is associated with students' religious views and the evolution-related content of their high school biology courses. Cell entries are the probabilities that students in a particular group will pass the KEE, derived from the ordered logistic regression model in Table 2.

		High School Biology Course Content			
		Neither Evolution nor Creationism	Creationism Only	Both Creationism & Evolution	Evolution Only
Religious Views	Conservative	16.3*	22.4	30.7	40.6
	Moderate	20.5	28.0	37.5	48.2
	Liberal	26.0	34.8	45.1	56.1
	Atheist or Agnostic	32.4	42.2	53.0	63.4

* For example, religiously conservative students whose high school biology course included neither evolution nor creationism had a 16.3% chance of passing the KEE.

creationism (5.0) or evolution only (5.7). Depending on their religious views (see below), students with no exposure to evolution in high school failed the KEE between 68% and 84% of the time. The corresponding failure rates for students whose high school biology courses included evolution only dropped to between 37% and 59% (Table 3).

The inclusion of creationism in high school biology courses is strongly associated with students' knowing less about evolution when they get to college (Tables 1–3). Indeed, students exposed to creationism but not evolution in high school have KEE pass-rates that are not significantly different from those who were exposed to neither creationism nor evolution. When creationism is taught with evolution, the likelihood of passing the KEE improves slightly over that of students taught creationism only, but continues to lag behind evolution-only biology education. In these instances, depending on religious beliefs, a student's likelihood of failing the KEE is between 47.0% and 69.3%. Taken together, these results indicate that the inclusion of creationism, even in conjunction with evolutionary theory, diminishes students' knowledge of evolution. The only mitigating or countervailing factor to a biology course that includes creationism is a student's religious views.

The Impact of Religion

Our results document a significant relationship between students' religious views and their knowledge of evolution. For example, students with conservative and moderate religious beliefs scored much lower (4.6–4.7) on the KEE than atheists/agnostics/nonreligious students and liberal/progressive students (5.5–5.6). These results indicate that the more conservative a student's religious beliefs, the less likely they are to pass the KEE. That is, on average, conservative religious beliefs are strongly associated with a poor knowledge of evolution, regardless of the students' evolution-related instruction in their high school biology courses. Students who report holding conservative views fail the KEE between 83.7% of the time (when neither creationism nor evolution is taught in their high school biology courses) and 59% of the time (when only evolution is taught). These results are consistent with the report that individuals having the strongest religious beliefs are most likely to reject evolution (Lawson & Worsnap, 1992). However, the impact of students' religious views extends beyond the conservative end of the religious spectrum. For example, even students with moderate religious views usually fail the KEE, regardless of the content of their high school biology courses (Table 3).

Students who held self-described liberal/progressive religious views scored significantly higher on the KEE than their more conservative counterparts. In fact, religiously liberal/progressive students had a greater probability of passing than failing the KEE. Agnostics and atheists also earned significantly higher KEE scores than all religious believers. While a lack of evolution instruction or an exposure to creationism in high school reduced significantly their likelihood of passing the KEE, students holding atheistic/agnostic/no religious beliefs passed the KEE at rates approximately 150–200% higher than their conservative classmates.

In summary, the absence of evolution education, the presence of creationism in high school biology courses, and the holding of religious beliefs – especially more conservative ones – reduce the knowledge of incoming college students about evolution, be they majors or nonmajors (Moore & Cotner, 2009). Indeed, of the 16 possible combinations that result from our two independent variables, only three – that is, (1) religiously liberal students exposed to evolution-only high school biology courses, (2) atheist and/or agnostic students exposed to evolution-only high school biology courses, and (3) atheist/agnostic students exposed to creationist and evolution-based high school biology courses – had a greater than 50% chance of passing the evolution quiz (see shaded cells of Table 3).

The importance and lingering influence of high school biology courses on students' views of evolution (Table 1; Moore & Cotner, 2009) highlight the impact of the surprising popularity of creationism among biology teachers (Kraemer, 1995; Weld & McNew, 2004; Moore & Kraemer, 2005; Bowman, 2008). We suggest that the ongoing popularity of creationism in high school biology classrooms is primarily attributable to biology teachers' religious beliefs. Teachers' personal views of a subject influence their teaching of the subject (Carlesen, 1991), and many biology teachers who teach creationism do so because of their religious beliefs (Shankar, 1990; Trani, 2004). Moreover, (1) almost one-fourth of biology teachers believe that creationism is scientifically valid (Kraemer, 1995; Moore & Kraemer, 2005), (2) 15% of biology teachers believe that evolution is not scientifically valid (Moore & Kraemer, 2005), and (3) in some states (e.g., South Dakota), as many as 39% of biology teachers believe that creationism should be taught in schools (Weld & McNew, 2004, and references therein). This is not a new development; for example, almost 70 years ago Riddle (1941) reported that fewer than half of biology teachers were teaching evolution, and that a primary reason for not doing so was that evolution contradicted the teachers' "personal beliefs." Astonishingly, one-sixth of today's high school biology teachers accept young-Earth creationism (Bandoli, 2008), a worldview dictated by Biblical literalism that rejects modern biology, geology, chemistry, paleontology, and other sciences. Similar results apply to today's students; for example, students whose high school biology courses included creationism are more than twice as likely as other students to use the Bible as a basis for rejecting evolution (Moore & Cotner, 2009). When high school science teachers model facile rejection of such a core idea of the natural sciences, we can hardly be surprised when incoming college students are equally dismissive and ignorant of evolutionary biology.

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