RESEARCH ON LEARNING

Boosting Students' Attitudes & Knowledge about Evolution Sets Them Up for College Success

B. ELIJAH CARTER, LYNN M. INFANTI, JASON R. WILES

Abstract

Students who enter college with a solid grounding in, and positive attitudes toward, evolutionary science are better prepared for and achieve at higher levels in university-level biology courses. We found highly significant, positive relationships between student knowledge of evolution and attitudes toward evolution, as well as between introductory biology course achievement and both precourse acceptance of evolution and precourse knowledge of evolution, among students at a medium-sized private northeastern university. Teachers who scant the teaching of evolution or who do not foster good attitudes toward evolution are compromising their students' potential for success in science at the college level.

Key Words: *Evolution; attitudes; acceptance; understanding; achievement; college preparation.*

Forty-one years ago, Theodosius Dobzhansky (1973) famously explained in this same forum that "Nothing in biology makes sense except in the light of evolution." And since that time, his apt assertion has been cited by the National Association of Biology Teachers and numerous other scientific societies, education organizations, and scholars, in hundreds upon hundreds of research articles, position statements, and other documents, overwhelmingly ratifying the notion that evolution is the most fundamental concept in all of the life sciences and serves as a powerful scaffold around which a comprehensive and integrative understanding of biology and related fields can be built. It would seem to follow, then, that students who understand evolution ought to have higher levels of achievement in biology and related science subjects than those who do not. But while evolution is overwhelmingly accepted in the scientific community and informs essentially all biological research, a large fraction of the general public, including many students, reject the solid scientific consensus (Miller et al., 2006; Wiles, 2010). This is important to teachers for many reasons, including the fact that students who do not accept a concept may not develop an understanding of the concept (Scharmann, 1990; Cobern, 1994; Meadows et al., 2000; Smith, 2009; Wiles & Alters, 2011).

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Students' prior knowledge of, and attitudes toward, evolution have been of major concern to science education researchers, but the relationship of these constructs to achievement in postsecondary science has been a matter of particular contention, with legal ramifications. For example, the University of California system was sued by a group of Christian high schools over a policy of rejecting certain secondary courses from religious schools that do not treat evolution in a manner consistent with the consensus of the scientific community, on the grounds that such courses do not adequately prepare students for college-level study in the biological sciences (National Center for Science Education, 2008). This policy, which has been upheld by the courts, is predicated on the notion that achievement in postsecondary courses in the life sciences is related to students' prior knowledge of evolution. The National Science Teachers Association (2013) agrees with this assessment, explaining that "if evolution is not taught, students will not achieve the level of scientific literacy needed to be well-informed citizens and prepared for college and STEM careers."

Results from Berkman and Plutzer (2011) indicate that biology teaching tends to reinforce the sentiment of the local community. This suggests that the teaching of evolution is more likely to be compromised in those areas with the largest disconnects between public understandings and scientific consensus. This has implications for students from such communities, including their potential to excel in science. Belin and Kisida (2012) reported a clear and consistent relationship between a state's public acceptance of evolution and the levels of science achievement among students in that state. This assessment seems congruent with our data, which indicate that it is essential for college preparation to give students opportunities to develop a solid understanding of evolution and positive attitudes toward evolutionary science.

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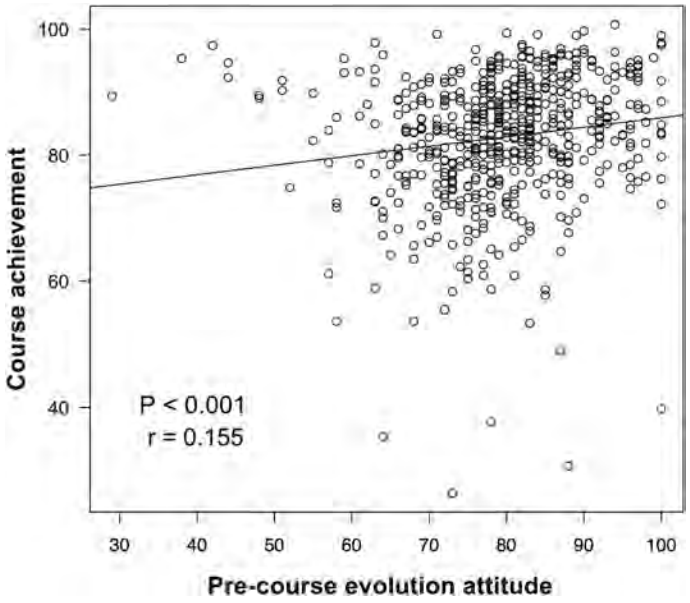
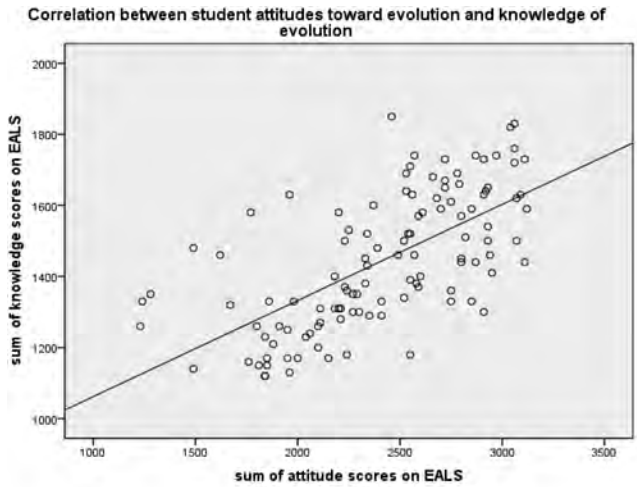
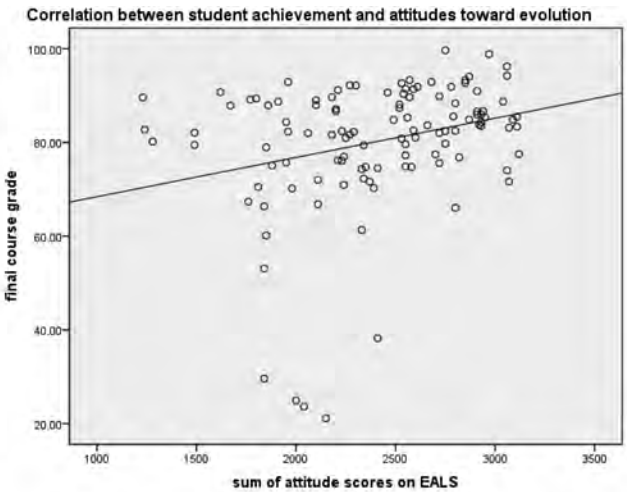


In a study of students in a large introductory biology course at Syracuse University, we found a highly significant correlation between students' attitudes toward evolution at the beginning of the course and their achievement in the course ($r = 0.155$, $p < 0.001$, $N = 620$; see Figure 1). In other words, their attitudes toward evolution before setting foot in the classroom appear to be somewhat predictive of their final course grade. Our data were collected under the same methodology and concurrently with those reported in Carter and Wiles (2014).

Figure 1. The relationship between precourse evolution acceptance and course achievement. In this figure, the x-axis represents students' numeric scores on the Measure of Acceptance of the Theory of Evolution (MATE) instrument from before the course began. The y-axis represents course achievement, in terms of students' final numeric scores in the course. In this figure, r (0.155) represents Pearson's correlation coefficient. Results were highly significant, with $P < 0.001$.





Correlations from pre-survey data

Measure	Knowledge score	Final course grade
Attitude score	.653**	.270**
Knowledge score		.461**

**p < 0.01

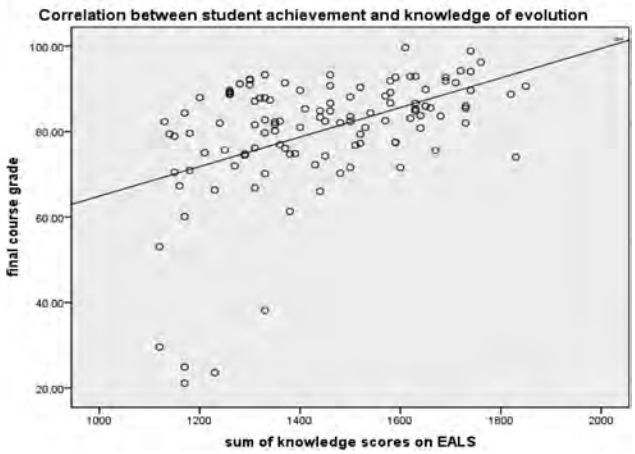


Figure 2. Relationships between precourse attitudes and precourse knowledge of evolution, between achievement and precourse attitudes toward evolution, and between achievement and precourse knowledge of evolution. Clockwise from upper left, a strong, positive relationship was found between precourse attitudes toward evolution and precourse knowledge of evolution ($r = 0.653$, $P < 0.001$); a smaller, positive relationship was found between precourse attitudes toward evolution and achievement in the course ($r = 0.270$, $P < 0.004$); and a strong, positive relationship was found between precourse knowledge of evolution and course achievement among students in an introductory-level university biology course ($r = 0.461$, $P < 0.001$).

Table 1. Resources for the teaching of evolution.

Type of Resource	Resource	Location
Lesson plans, background information for teachers, and helpful tips for teaching evolution	Understanding Evolution Evolution and the Nature of Science Institutes (ENSI)	http://evolution.berkeley.edu/ http://www.indiana.edu/~ensiweb/
Where to go if you have community/political issues	National Center for Science Education	http://www.ncse.com
National standards on evolution teaching	*National Science Education Standards* *Next Generation Science Standards*	http://www.nap.edu/catalog.php?record_id=4962 http://www.nextgenscience.org/hsls-nse-natural-selection-evolution
Compendium of position statements in support of teaching evolution	Voices for Evolution	http://ncse.com/voices
NABT and NSTA	Position statements and concise guidelines for common issues	http://www.nabt.org/websites/institution/index.php?p=110 http://www.nsta.org/about/positions/evolution.aspx

It is important to note that the assessment of student attitudes we used, the Measure of the Acceptance of the Theory of Evolution instrument (MATE; Rutledge & Warden, 1999; Rutledge & Sadler, 2007), was not designed to test students' knowledge about evolutionary science, but simply their attitudes toward it. The instrument can be found in its entirety in appendix A of Rutledge and Sadler (2007).

The distinction between knowledge and acceptance of evolution is an important one, given the observation that students are sometimes able to separate their acceptance of evolution from learning about evolutionary science (Southerland et al., 2001; Wiles, 2014). Also, acceptance is only one aspect of overall attitudes toward evolution, which can also include, among other factors, students' conceptions of the relevance of evolution to ongoing scientific research or to their daily lives (Hawley et al., 2011). It appears that knowledge of evolution and overall attitudes toward evolution are very much related to each other among our students, and both constructs influence how well students fare in the life sciences at the college level. We used the methodology detailed in Infanti and Wiles (2014) in a smaller (N = 116) but more detailed investigation of undergraduates in an introductory biology course at the same university. The Evolutionary Attitudes and Literacy Survey (EALS; Hawley et al., 2011 [see table 1 therein for the full instrument]) was employed to explore students' understandings of evolution and a wide variety of attitudes toward evolutionary science. We found highly significant relationships between both of these constructs and course achievement, as well as a strong relationship between attitudes and knowledge (see Figure 2).

Ingram and Nelson (2006) suggest that students' attitudes should be addressed directly and respectfully, and they posit that acknowledgment of students' attitudes may lead to decreased effects of attitudes toward evolution on course achievement. And, citing his findings that some students may experience stress when they perceive affronts to their religion, Long (2012) reminds us to be sensitive to our students' beliefs. However, we would caution teachers against treating evolution as less important or less scientifically sound in an attempt to assuage students' (or parents' or administrators') concerns. Construing evolution as "*only* a theory" or framing it in terms of the "tentative" nature of science with the intent or effect of suggesting that evolution is somehow in doubt, or that its status as the most powerful explanatory principle in biology is at all likely to change, are not helpful practices. Evolution is as well evidenced as any core concept in science, and it should be presented as such. Our understanding of evolution is based on abundant and consistent knowledge generated over decades of interdisciplinary study, and there is no scientific explanation for the diversity of life apart from evolution (American Institute of Biological Sciences, 1994; National Science Teachers Association, 2013).

Teachers who perceive pressure from students, parents of students, or school administrators ought not feel they must navigate this territory alone. National benchmarks, state standards, professional societies, and textbooks all prescribe and present evolution as a fundamental component of modern science education, and teachers can confidently lean on the established curriculum. Wiles and Branch (2008) offer more advice on such matters, and resources have never been more widely available (see Table 1 for a few suggestions). Scanting instruction on evolution, or teaching it in a fashion that casts or fosters doubt regarding the veracity or importance of evolution, does students a great disservice. At the very least, it misrepresents a foundational principle in the life sciences, but it also diminishes students' chances of success in higher education and science-based careers.

References

American Institute of Biological Sciences. (1994). AIBS Board Resolution on Evolution Education. Available online at http://www.aibs.org/position-statements/19941001_evolution_resolution.html.

Belin, C.M. & Kisida, B. (2012). State science standards, science achievement, and attitudes about evolution. In *Proceedings of the 37th Annual*

Conference of the Assocation for Education Finance Policy. Available online at https://aefpweb.org/sites/default/files/webform/State%20Science%20Standards,%20Science%20Achievement,%20and%20Attitudes%20about%20Evolution.pdf.

Berkman, M.B. & Plutzer, E. (2011). Defeating creationism in the courtroom, but not in the classroom. *Science, 331,* 404–405.

Carter, B.E. & Wiles, J.R. (2014). Scientific consensus and social controversy: exploring relationships between students' conceptions of the nature of science, biological evolution, and global climate change. *Evolution: Education & Outreach, 7,* 6.

Cobern, W.W. (1994). Belief, understanding, and the teaching of evolution. *Journal of Research in Science Teaching, 31,* 583–590.

Dobzhansky, T. (1973). Nothing in biology makes sense except in the light of evolution. *American Biology Teacher, 35,* 125–129.

Hawley, P.H., Short, S.D., McCune, L.A., Osman, M.R. & Little, T.D. (2011). What's the matter with Kansas?: The development and confirmation of the Evolutionary Attitudes and Literacy Survey (EALS). *Evolution: Education & Outreach, 4,* 117–132.

Infanti, L.M. & Wiles, J.R. (2014). "Evo in the News": *Understanding Evolution* and students' attitudes toward the relevance of evolutionary biology. *Bioscene: Journal of College Biology Teaching, 40,* 9–14.

Ingram, E.L. & Nelson, C.E. (2006). Relationship between achievement and students' acceptance of evolution or creation in an upper-level evolution course. *Journal of Research in Science Teaching, 43,* 7–24.

Long, D.E. (2012). The politics of teaching evolution, science education standards, and being a creationist. *Journal of Research in Science Teaching, 49,* 122–139.

Meadows, L., Doster, E. & Jackson, D.F. (2000). Managing the conflict between evolution & religion. *American Biology Teacher, 62,* 102–107.

Miller, J.D., Scott, E.C. & Okamoto, S. (2006). Public acceptance of evolution. *Science, 313,* 765–766.

National Center for Science Education. (2008). Victory in California creationism case. Available online at http://ncse.com/news/2008/08/victory-california-creationism-case-001374.

National Science Teachers Association. (2013). Teaching of evolution in schools: NSTA position statements. [Online.] Available at http://www.nsta.org/about/positions/evolution.aspx.

Rutledge, M.L. & Sadler, K.C. (2007). Reliability of the Measure of Acceptance of the Theory of Evolution (MATE) instrument with university students. *American Biology Teacher, 69,* 332–335.

Rutledge, M.L. & Warden, M.A. (1999). The development and validation of the measure of acceptance of the theory of evolution instrument. *School Science and Mathematics, 99,* 13–18.

Scharmann, L.C. (1990). Enhancing an understanding of the premises of evolutionary theory: the influence of a diversified instructional strategy. *School Science & Mathematics, 90,* 91–100.

Smith, M.U. (2009). Current status of research in teaching and learning evolution: II. Pedagogical issues. *Science & Education, 19,* 539–571.

Southerland, S.A., Sinatra, G.M. & Matthews, M.R. (2001). Belief, knowledge, and science education. *Educational Psychology Review, 13,* 325–351.

Wiles, J.R. (2010). Overwhelming scientific confidence in evolution and its centrality in science education – and the public disconnect. *Science Education Review, 9,* 18–27.

Wiles, J.R. (2014). Gifted students' perceptions of their acceptance of evolution, changes in acceptance, and factors involved therein. *Evolution: Education and Outreach, 7,* 4.

Wiles, J.R. & Alters, B. (2011). Effects of an educational experience incorporating an inventory of factors influencing students' acceptance of biological evolution. *International Journal of Science Education, 33,* 2559–2585.

Wiles, J.R. & Branch, G. (2008). Teachers who won't, don't, or can't teach evolution properly: a burning issue. *American Biology Teacher, 70,* 6–7.

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