FEATURE ARTICLE

Acceptance, Understanding & Experience: Exploring Obstacles to Evolution Education among Advanced Placement Teachers

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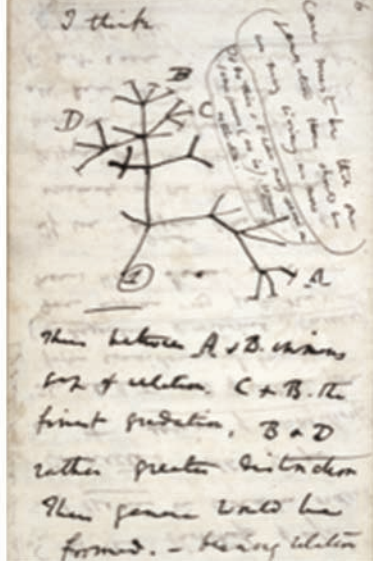

Abstract

Students in the United States who wish to begin early enrollment in college-level coursework often turn to Advanced Placement (AP) secondary coursework such as AP Biology as an accelerated option. As such, it is expected that those teachers who are responsible for the AP Biology courses hold an advanced level of subject-area expertise that extends to topics that are often seen as controversial in K–12 classrooms, including evolution. We surveyed 71 AP Biology teachers in a state in the southeastern United States to see how their levels of evolution content knowledge, evolution acceptance, and understandings of the nature of science compared to results that have been found in similar studies in general biology teachers and preservice science teachers. Our results indicate that AP Biology teachers in the Southeast have understandings and levels of acceptance regarding evolution that are in line with or lower than those of fellow teachers. This suggests that in spite of the nationalized AP curriculum, there are still gaps in fundamental knowledge, understandings, and approach that need to be addressed.

Key Words: *Evolution; advanced placement; teacher perceptions.*

Introduction

Over the past two decades, science education in the United States has seen a resurgence of focus on application, scientific thinking, and process skills in research and practice. Since the development of the *National Science Education Standards* (National Academy of Sciences, 1996) and today's new focus on the *Next Generation Science Standards* (NGSS), a movement toward more uniform expectations nationally for science teaching is clear (National Research Council, 2013). The NGSS emphasize a strong focus on cross-cutting concepts, integration of engineering practices, and vertical scaffolding of content, whereby students begin learning complex concepts earlier and continue to build on them with practical applications in successive years of schooling (National Research Council, 2013). Topics deemed "controversial," such as evolution, are emphasized and included in the NGSS while continuing to be a source of conflict in the southeastern United States (Bowman, 2008; Glaze et al., 2015). In response to the NGSS, states in the Southeast that opposed the content and nature of the NGSS have refused to adopt the new standards, opting to have their respective departments of education reshape them, a right the states retain (Branch, 2015).

It is not uncommon for biology teachers to harbor the same misunderstandings, misconceptions, and feelings of conflict with evolution that are seen in the general public.

As a result of changing leadership in some state departments of education, several states have, or will have, new science standards in the coming years, several of which contain a stronger evolutionary biology focus than previous courses of study approved by those states (Lerner, 2000, 2012). The new standards should bring the level and depth of secondary school classwork to a higher level that more closely mirrors what has been done in Advanced Placement (AP) courses; however, standards alone are not enough to ensure the accurate teaching of evolution in classrooms (Moore & Kraemer, 2005). As a result of standards exceeding those of general biology, expectations for teachers of AP Biology courses require them to teach biological concepts at a higher level than their non-AP counterparts (Evans, 2009; College Board, 2012). AP Biology teachers can and should represent the pinnacle of biology teaching and demonstrate expertise through their knowledge of content. Their understanding and acceptance of evolution should compare favorably to that of teachers not trained to teach AP Biology.

Historically, AP courses have been indicative of high rigor and are often viewed as indicators of readiness and potential for success in college coursework (Walker, 2009; College Board, 2012). As a result, AP coursework is intentionally designed to be equivalent to university coursework (Education Commission of the States, 2006; Evans, 2009). AP Biology teachers are expected to have a level of expertise and understanding that is found in

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introductory college biology courses. High expectations of expertise in AP Biology teachers include greater fluency in scientific practices, the nature of science (NOS), and content concepts including controversial concepts, like evolution that are emphasized in the standards and benchmarks for AP Biology (Musante, 2012). In undergraduate and graduate science programs, evolution is widely, if not unanimously, accepted as the scientifically valid unifying theory in biological science.

Were a university professor to refuse to address evolution in their coursework, it would most certainly be questioned by their colleagues. However, at the secondary level, biology teachers exhibit a range of inconsistent behaviors with respect to teaching evolution, often due to cultural, social, and religious pressures (Goldston & Kyzer, 2009; Glaze et al., 2015). Furthermore, research studies reveal that it is not uncommon for biology teachers to harbor the same misunderstandings, misconceptions, and feelings of conflict with evolution that are seen in the general public, which often results in the perpetuation of these same misunderstandings and misconceptions in the next generation of learners, especially when those same teachers inaccurately teach evolution or avoid it altogether (Martin-Hanson, 2006; Bowman, 2008; Cofre et al., 2017).

In an effort to improve access and rigor across AP Biology courses, the state in which this study took place, Alabama, formed an education partnership with a state-supported budget for training and incentives for teachers based on student performance in AP courses (A+ College Ready, 2017). The program was created with the largest private grant in state history, a $13 million grant from the National Math and Science Initiative aimed specifically at increasing student enrollment and success in courses including AP Biology (College Board, 2012). While the state historically had one of the lowest rates of student success in gaining college credit for AP coursework, the past decade has seen that capital rise in response to efforts to increase access and success, and the state is being lauded as an exemplar for improvement of AP participation and success (College Board, 2007, 2012; Crain, 2017). With this in mind, AP Biology teachers in the state provide a unique lens through which we can examine the state of evolution education in an area where the teaching and learning of evolutionary theory continues to be a point of conflict, both privately and publicly (Bowman, 2008; Branch, 2015). In order to explore whether advanced scientific knowledge is approached in upper-level courses, we look carefully at the shared traits of AP Biology teachers and how their levels of acceptance and understanding compare with their AP non-trained peers in a controversial area, evolution, where there is great need of change (Moore & Kraemer, 2005). Therefore, this study examined the following questions:

1. What are the characteristics of AP Biology teachers in one state in the southeastern United States?
2. How do AP Biology teachers in one state in the southeastern United States compare to their non-AP counterparts in terms of overall acceptance of evolution, understandings of evolution, and understandings of NOS?

○ Methodology

Data Collection

For this study, potential participants were identified through their participation in a statewide program for AP Biology teachers. The state of Alabama has 173 school districts, each of which is governed by the State Department of Education, which has endorsed the partnership program. Within those systems, 123 AP Biology teachers were registered for the program. For this study, AP program leadership forwarded an email to these members to request that they complete the survey measuring evolution acceptance and other elements; the email contained background and consent information for the study as well as a link to the Qualtrics online survey. Upon reading the initial page and consenting, participants were taken to pages associated with each of the instruments for measuring variables, including a segment addressing demographics.

Three existing surveys were included in the study to measure variables of interest. One, the Measure of Acceptance of Theories of Evolution (MATE), was used to determine levels of acceptance (Rutledge & Warden, 2000). This 20-question survey has been used extensively on students in science as well as teachers and has been validated by an expert panel (Rutledge & Warden, 2000). The survey has demonstrated reliability among teachers, with a Cronbach alpha of 0.84 (Rutledge & Warden, 2000). A second instrument, the Evolution Content Knowledge (ECK) quiz, was used to determine participant accuracy in understanding key evolution concepts based on high-school-level proficiency (Johnson, 1986). This 21-question multiple-choice quiz had validity as confirmed by an expert panel and a 0.84 Cronbach alpha level when administered to science teachers (Rutledge & Warden, 2000) and .73 Kuder-Richardson formula 20 in biology students (Johnson, 1986). For the ECK, scores were recorded as the percentage of questions correctly answered out of 100%. Finally, NOS understanding was determined by the scores obtained on the 20-question NOS instrument by Rutledge and Warden (2000). The NOS instrument employed a Likert scale to rate agreement levels with statements commonly employed in conversations about evolution, such as "The age of the earth is fewer than 20,000 years." This survey was also validated by an expert panel and demonstrated a reliability of 0.94 when administered to science teachers (Rutledge & Warden, 2000). For the MATE and NOS instruments, the scores are traditionally grouped by range: very low (20–52), low (53–64), moderate (65–76), high (77–88), and very high (89–100) (Rutledge & Sadler, 2007). The lowest possible score on either measure is 20 and the highest 100, as there are no zero-point responses assigned and the highest point value on any one question is 5.

Limitations

The present study has a number of limitations beyond general margins of error, including questions as to whether acceptance is measurable and whether we can adequately explore understandings of NOS in Likert response forms rather than using open-ended questions. Although these measures are not without criticisms, each is used extensively with students and teachers to explore their levels of knowledge, understanding, and acceptance, and each is generally accepted as appropriate for comparing new data with existing data using the same measures. A particular limitation regarding instrumentation is that the MATE, used to measure acceptance of evolution, may be critiqued based on the nature of the questions asked, many of which focus on statements of fact in relation to evolution ("The earth is 4.5 billion years old") and statements that are specific to Christian creationist dogma ("The earth is less than 20,000 years old"). For the purposes of this study, the MATE was selected because

it was used in a previous study in preservice teachers (Glaze et al., 2015) and in light of the fact that it is used for qualitative comparison rather than correlational analysis.

While survey scores elicit questions about the actuality of what is measured – acceptance, understanding, or belief – it is recognized that the value of using these scores for predictive research must consider at length the shallow level of understanding that is captured through the use of quick-report measures as opposed to more in-depth, open-ended probes. In addition to the measures themselves, there is always a question of accuracy on self-reported measures due to the duration of surveys and the human nature of participants. It is further noted that the size of this study, taking place in only one state and representing a small percentage of the overall population of AP teachers, therefore cannot be generalized and that the sample size itself restricted the application of additional statistical treatments to explore correlations among the variables of interest. However, over time, collecting samples across groups and locations can give us insights into the broader picture that better inform our larger efforts to improve the teaching and learning of evolution.

Data Analysis

For data analysis we transferred data from Qualtrics to SPSS/PASW 21 for analysis. We then generated descriptive statistics based on participants' responses to the demographic questions. Participant totals and percentages were generated to determine whether the sample was representative of the general population of teachers for which data were available. Next we documented other descriptive factors related to teaching, such as certification, content area, and years of teaching experience. For the purpose of answering the main question of this study, we employed a descriptive analysis of factors to allow comparison with values reported for the same measures in the existing literature. Additional statistical treatment was not conducted due to the small sample size in comparison to the number of variables of interest.

○ Results

Alabama has ~170 public school systems, including county systems and independent city systems. At the inception of A+, only 94 of those systems offered at least two AP classes (Southern Regional Education Board, 2017). However, in the past decade, the number of students in the state who are taking AP courses has increased from ~3000 to >11,000 (College Board, 2012). As a result of initiatives, many more systems have access to AP programs in which biology is a course option through alternative offerings such as virtual classes. In rural systems, AP Biology teachers are often shared across schools or even districts, with virtual classes developed to allow AP representation in smaller systems that lack the personnel or credentials to teach AP courses. The 42 state systems (25%) were represented in this study by 71 active AP Biology teachers of the 123 registered in the state-mandated program. The AP teacher participants represented 39% of the counties in the state and each of four major cities.

As shown in Table 1, participants in this study were mostly white females, with very few men or other racial groups. While these numbers are high, they are not surprising, as the Alabama State Department of Education (2017) reports that in the 2016–2017 school year, 79.4% of all public school teachers in the state were female and 78.5% were white—compared to 82% nationally (U.S. Department of Education, 2016). Although the sample is somewhat in line with the demographics reported statewide, there is no measure of the overall state demographics of the AP teacher subgroup for comparison. It can be pointed out from the data that AP teachers have similar gender representation, yet higher representation among white teachers than those of other races compared to the state average.

Table 1. Demographics of study participants (n = 71).

Demographic	n	%
Female	56	79%
Male	11	15%
White	58	82%
Asian	1	1%
Hispanic	1	1%
African American	4	7%
Other	1	1%
Non-responding Gender	4	6%
Non-responding Race	6	8%

Participants in this study represented a range of backgrounds and experience. As part of the demographics, participants were asked to describe their upbringing in terms of the size of their community as either rural (<19,999) or urban (20,000+). Among the participants, 64% (45) noted that the city where they attended high school would be classified as rural, while only 36% (26) identified their background as urban. While these numbers are low in comparison to the large scale of cities in other parts of the country, it is noted that the largest city in the state represented in this study has a population of <250,000, making the qualifier for "urban" relative.

Regarding years of experience, Table 2 demonstrates that a majority of the sample in this study (60%) were considered experienced career teachers, with 43 teachers having ≥11 years of experience and 25 having ≥16 years. Of the remaining 34% of teachers who responded, 16 reported having 6–10 years of experience, while only eight reported having ≤5 years of teaching experience. In addition to years spent teaching, 69% of the teachers (49) in the study also held graduate-level certification on their teaching credentials and 13% (9) of the teachers held certifications at the highest level, which is reserved for teachers who have conducted at least half the hours required for a doctoral degree.

In terms of performance on the three primary measures – acceptance of evolution, understandings of evolution content, and understandings of NOS – participants in this sample demonstrated low to moderate mean scores in each. Table 3 shows that the mean level of acceptance among participants was 68.47 out of 100 points, which represents moderate acceptance of evolution among participants. In addition to acceptance, the participants demonstrated very low understanding of NOS, with a mean of 52.72 out of 100 points and a low understanding of the basic content concepts surrounding evolution, with an average score of 56.49%. In regard to deviation in the scores for each measure, Table 3 demonstrates the high values for standard deviation that

Table 2. Teacher certification levels and content areas (n = 71).

Demographic	n	%
B (Bachelor's)	17	24%
A (Master's)	40	56%
AA (Specialist/Doctoral)	9	13%
Biology	32	45%
General Science	34	48%
Non-responding Degree	5	7%
Non-responding Content	5	7%

Table 3. Summary of measures (n = 71).

Measure	Mean	SD
MATE-Acceptance	68.47/100 (moderate)	29.46
NOS-Understanding	52.72/100 (very low)	21.53
ECK-Content	56.49% (low)	34.72

are present in key variables, including standard deviations of 34.72 points for content knowledge, 29.46 points for acceptance of evolution, and 21.53 points for understanding of NOS.

○ Discussion

Regarding some variables, the demographics in this sample closely align to those of the larger population of teachers in the United States as well as the state where the study took place. In the sample, AP teachers appear to be well trained, highly experienced, and aptly certified in their fields, which suggests a comfort level and background that should support greater understanding and acceptance. However, in a 2009 study of science teachers as they taught evolution, Goldston and Kyzer (2009) observed changes in teacher persona during the teaching of evolution that suggest that discomfort and misunderstanding transcended years of teaching experience and background, which suggests that traditional indicators are not necessarily applicable when it comes to controversial topics (Sinatra et al., 2003). In the present study, the majority of participating teachers had a wealth of experience in the classroom – almost 90% having ≥6 years of experience and 60% having ≥11 years of experience – yet the levels of understanding and acceptance were still much lower than desired, aligning to results suggesting that experience is not an indicator of accuracy of teaching evolution (Nadelson & Nadelson, 2010). As such, it was not only in content that we saw breaks in logic between our expectations and the reality of the situation. In fact, even with lengthy teaching experience, controversial topics can override logical expectations (Sinatra et al., 2003; BouJaoude et al., 2011).

Ron Johnson (1986) noted in an early acceptance study that biology teacher performance was more in keeping with acceptance and understandings of evolution held by nonmajors in biology courses. Furthermore, Johnson (1986) characterized biology majors as being more open in their thinking and their willingness to consider evolution than nonmajor students. Decades later, studies indicate similar results despite the implementation of standards to align practices (Rutledge & Mitchell, 2002; Bowman, 2008; Glaze et al., 2015). It stands to reason that teachers of science should be more open to scientific explanations; however, that is not always the case, and frequently teachers exhibit a willingness to divest themselves of the responsibility to accurately teach controversial topics in science (Bowman, 2008; Goldston & Kyzer, 2009).

In terms of the key measures deployed in the present study, participant teacher scores somewhat paralleled those of other science teacher samples but were notably lower in others (Rutledge & Warden, 2000; Rutledge & Mitchell, 2002; Nadelson & Sinatra, 2009; Nehm et al., 2009). Overall, acceptance of evolution in this study was moderate, with participants scoring an average of 68/100 on the MATE. This is noticeably lower than that of other teacher samples in the United States, where teacher acceptance means were documented at 77.59 in Indiana (Rutledge & Warden, 2000), 85.9 in Oregon (Trani, 2004), and 87 in Ohio (Korte, 2003). Compared with moderate to high levels of acceptance, understanding of NOS in our study was on the borderline between very low and low at a mean of 52.72/100. This is only slightly lower than what has been reported in Indiana teachers, whose average on the same NOS instrument was 59.49, also in the low range (Rutledge & Warden, 2000). Despite higher occurrence of graduate-level training and advanced certification in the sample, the level of content knowledge demonstrated among AP teachers in our study was also low, with a mean score of 56%. This is a good measure lower than the content knowledge reported on the same instrument in Indiana teachers, whose average score was 71% (Rutledge & Warden, 2000).

Each of the evolution measures in this study demonstrated a range of variability among responses, with standard deviations ranging from 21 to 35 points. The greatest variability was found in content knowledge and the least in NOS understanding. It is not uncommon in studies of evolution understanding and acceptance for there to be higher values for standard deviation as a result of both high and low outliers that must be addressed prior to statistical analysis (Trani, 2004; Glaze et al., 2015). This is often explained in terms of content knowledge by the variability in required coursework in teacher education, where courses specific to evolution are often not a part of the plan of study (Glaze & Goldston, 2015). Furthermore, existing tensions in the southeastern United States around evolution often result in teachers and students actively avoiding discussions of the subject, resulting in future teachers coming into their program with existing gaps that are not sufficiently addressed in survey courses (Goldston & Kyzer, 2009). Outlying cases in the area of acceptance are also common, as previous studies have demonstrated that there is very little correlation between actual knowledge of evolution and acceptance, which is often influenced by extrinsic and intrinsic factors (Glaze et al., 2015). It is not uncommon for a person to be wholly accepting of evolution but to reflect very little actual comprehension and understanding of the processes of evolution. Conversely, it is also possible for an individual to be highly knowledgeable of the processes and facts surrounding evolutionary theory, but to actively elect rejection of those parts that are not in alignment with their worldview (Glaze et al., 2015).

Although there were no comparable studies of in-service teachers in the same state or other states in the region, there was a comparative group of preservice science teachers who had attempted all three measures utilized in this study within a five-year window of data collection for this study. In comparing the performance of in-service AP science teachers and preservice science teachers in the same state, we see consistent measures in the acceptance of evolution, with preservice teachers in the state demonstrating an average score of 70.90/100 points on the MATE compared to the 68.47/100 of the AP teachers (Glaze et al., 2015). At the same time, we see what could be the impact of greater training and experience in the AP teacher group in terms of content, as the reported content scores in the preservice sample demonstrated an average score of 37.63% (Glaze et al., 2015) compared to the 52.72% of the AP teachers in this study. Conversely, the preservice science teacher sample demonstrated a greater understanding of NOS, with an average score of 65.45/100 points compared to 56.49/100 points in the AP teacher sample.

○ Conclusion

It has been stated that "antievolution is one of the greatest challenges for biology education" (Nehm & Schonfeld, 2007), especially in light of the role evolution plays as the unifying theory in biological sciences. Teachers in many ways represent the front lines in the battle for scientific literacy and trust in science. While a percentage of the population goes on to higher-education experiences, the other portion of the population closes the chapter of their formal education training at or before graduation from high school. As such, many in the population receive their only formal experiences with science during their grade school coursework.

In this study, we sought to determine whether AP Biology teachers have higher overall acceptance of evolution, understandings of evolution, and understandings of NOS than other science teachers. In comparing results from this study with those of other studies in the United States and one preservice study in the same state, the answer to that question is "no," AP teachers in this sample do not have higher scores on evolution-related variables than other science teachers. Those variables include acceptance of evolution, understanding of NOS, and evolution content knowledge, factors with demonstrated patterns of influence upon one another and upon teacher choice of what, and whether, to teach evolution in the classrooms (Rutledge & Warden, 2000; Goldston & Kyzer, 2009). AP teachers demonstrated levels for each of those areas that are in keeping with existing studies among other teachers, which include moderate to high acceptance, low content knowledge, and low understanding of NOS (Rutledge & Warden, 2000; Korte, 2003; Trani, 2004; Glaze et al., 2015).

Our results add to an unfolding pattern among biology teachers with respect to understanding evolution, misconceptions about evolution concepts, and acceptance of evolution. A great deal of focus in university programs has been placed on increasing content background and practical experiences in science as a driver for improved science content teaching. However, we "can't assume that biology teachers with extensive background in biology have an accurate working knowledge of evolution, natural selection, or the nature of science" (Nehm & Schonfeld, 2007, p. 716). In fact, research indicates that science teachers across grade levels hold misconceptions and misunderstandings that are not being addressed in their preparatory experiences (Nehm & Reilly, 2007; Nehm & Schonfeld, 2007; Glaze & Kyzer, 2009). It is well known that common misconceptions and misunderstandings influence teaching and learning of science and can result in self-perpetuation of the very problem we are hoping to solve (McComas, 2003). As such, there is a need at all grade levels to address misconceptions, strengthen understandings of science and how scientific knowledge is generated, and target areas of science viewed publicly as "controversial."

The responsibility for overcoming obstacles to teaching and learning of evolution falls squarely on the shoulders of professors in teacher education, who are often a single point of contact for science teachers when it comes to the pedagogical aspects of teaching so-called controversial topics. As such, teacher educators and those who provide support to in-service science teachers are tasked with finding creative and accessible ways to ensure that the impact made in those classrooms is accurate and meaningful. While AP Biology courses are held in high regard for rigor, depth, and breadth of content addressed, it is clear there is still a need to address teacher content knowledge, acceptance, and understanding with respect to evolution. If the upper echelon of our science teachers struggle with these same issues, it is clear that our work is far from complete.

○ Suggestions for Future Study

Research in science teacher preparation tells us there are a variety of approaches to certification, including alternative certification, master's-level initiation, and others that can result in a variety of backgrounds as well as levels of training in content and pedagogy, even at the same level of teaching experience and certification. It is not clear, at this time, the role those elements may play, if any, in the range of scores found in measures surrounding evolution acceptance and understanding. Therefore, it would be beneficial in future studies to explore forms of certification as a variable of interest. Another direction building on this study would be to explore whether states with mandatory training and College Board certification for AP Biology teachers have teachers and students with higher levels of understanding and acceptance than those without. If there is existing training that can be utilized to close some of these gaps in acceptance and understanding, then we certainly should be utilizing those resources on a wider basis.

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