

Professor Attitudes and Beliefs about Teaching Evolution

by

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ABSTRACT

Teaching evolution has been shown to be a challenge for faculty, in both K-12 and postsecondary education. Many of these challenges stem from perceived conflicts not only between religion and evolution, but also faculty beliefs about religion, its compatibility with evolutionary theory, and its proper role in classroom curriculum. Studies suggest that if educators engage with students' religious beliefs and identity, this may help students have positive attitudes towards evolution. The aim of this study was to reveal attitudes and beliefs professors have about addressing religion and providing religious scientist role models to students when teaching evolution. 15 semi-structured interviews of tenured biology professors were conducted at a large Midwestern university regarding their beliefs, experiences, and strategies teaching evolution and particularly, their willingness to address religion in a class section on evolution. Following a qualitative analysis of transcripts, professors did not agree on whether or not it is their job to help students accept evolution (although the majority said it is not), nor did they agree on a definition of "acceptance of evolution". Professors are willing to engage in students' religious beliefs, if this would help their students accept evolution. Finally, professors perceived many challenges to engaging students' religious beliefs in a science classroom such as the appropriateness of the material for a science class, large class sizes, and time constraints. Given the results of this study, the author concludes that instructors must come to a consensus about their goals as biology educators as well as what "acceptance of evolution" means, before they can realistically apply the engagement of student's religious beliefs and identity as an educational strategy.

DEDICATION

I would like to dedicate this thesis to my father, Tom T. Walker, first for your support and encouragement, and second for constantly challenging me to see all sides of an issue.

You have contributed to this work more than you know. Further, I would also like to dedicate this thesis to Sarah K. Brem. There is no doubt in my mind that you have fostered my growth as an academic, and opened doors for me that I would never have had the opportunity to walk through had it not been for your support. You believed in me when everyone else kept saying “no”, and for that, I will forever be in your debt.

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“Scientists also must realize that the presentation of science, though necessary, is not sufficient in itself. For topics such as evolution or climate change, where there may be religiously-based opposition, “mere” science will not be persuasive on its own. (...) To overcome ideological barriers to the acceptance of science requires establishing a relationship of trust and respect (...) otherwise, an adversarial relationship is the default, to the detriment of the public understanding of science.” Eugenie C. Scott and Elaine Ecklund, AAAS abstract, 2013.

CHAPTER 1

INTRODUCTION

The perceived conflict between religion and science is a large contention in the United States (Scott, 2005). Researchers argue that this contention is caused by an anti-science attitude in a large proportion of American population (Evans & Evans, 2008). Individuals often hold these anti-science attitudes about scientific concepts that they see as contradicting their religious beliefs, such as climate change, stem cell research, and evolution (Alters and Nelson, 2002). Researchers cite fundamentalist religious ideals as the main factor leading to an unusually high proportion of individuals who perceive a conflict between religion and science (Miller et al., 2006). However, another source of this perceived conflict may also be biologists themselves who propagate the conflict and claim that evolutionary theory and many religions, especially Christianity, are incompatible with one another (Dawkins, 2006, Harris, 2004). The propagation of this claim may stem from their tendency to reject religion. Evolutionary biologists have the lowest rates of religiosity among any discipline ever polled, with only 4.7% who report being theists or deists (Graffin and Provine, 2007). However, the rates of religiosity

among evolutionary biologists and the general US population are highly disparate, with 90% of Americans believing in some kind of religion (Gallup, 2011). While the public struggles with how to situate their religious beliefs with claims of evolutionary theory, many biologists are unlikely to experience the same struggles (Alters and Nelson, 2002). Professors may omit this topic because they do not experience these struggles, or even present it in an antagonistic way to students, who may then decide science or biology and their religious value systems are mutually exclusive. Another possibility is that professors do try to be open minded about students' religious beliefs but without religious beliefs and a possible lack of understanding of religion, they fail to establish rapport and trust. For these reasons, it is important to understand educators' current discourse with students regarding evolution and religion and their willingness to engage with these topics.

In this thesis, I will first explain the theoretical framework from which I am working, including perspectives from educational and social psychology. I will then give a background of the evolution education literature and discuss the reasons why educators should consider "acceptance" a goal of evolution education. I will outline how engaging with students' religious beliefs and providing them with religious scientist role models when teaching evolution might be beneficial in eliciting higher acceptance. Then I will discuss why educators may not be open to using such strategies. Next, I will supplement my predictions regarding educator's hesitance with the results of qualitative interviews of tenured biology faculty at Arizona State University. I will explain the themes that emerged regarding the educators most pressing concerns about the barriers of engaging with students' religious beliefs and providing religious scientist role models. I will further identify other themes emerging from the interviews that may represent barriers to

evolution education as a whole. Finally, I conclude that instructors must come to a consensus about their goals as biology educators as well as what “acceptance of evolution” means, before they can realistically apply the engagement of student’s religious beliefs and identity as an educational strategy.

CHAPTER 2

THEORETICAL FRAMEWORK

Constructivism and Accommodation

Pedagogical research has shown that in order to be successful in teaching scientific subjects, we must design our curriculum from a constructivist's perspective, noting that individuals form their perceptions of the world from building on all their previous experiences and beliefs. Any new concepts being taught to them will interact with the students' whole belief systems including their religion (Bransford et al., 2000).

Scientific concepts in general are often harder than other concepts for students to learn because a proper scientific conception surpasses a mere assimilation of the knowledge, and requires an accommodation of that knowledge, accommodation being the more difficult process in which the student changes the structure of their existing knowledge in order to make it consistent with the new incoming conception (Sinatra et al., 2008). Evolution is a particularly difficult subject to teach from this perspective because it interacts with conceptions students harbor that are outside the realms of science, about religious and supernatural aspects of the world. Therefore, we must identify and address previously held beliefs that are likely to interact, or conflict with, student's preconceptions. Particularly, this means addressing religion with respect to evolution, because religious students will likely notice conflicts between their current knowledge framework and evolution.

Conceptual Change

A large literature exists in the educational psychology realm on "conceptual change theory" and how it relates to acceptance of evolution. Conceptual change is

similar to the process of accommodation mentioned previously, which is often necessary in learning scientific concepts. For instance, conceptual change occurs when a child makes a cognitive shift from a belief in a flat earth to accepting that the earth is spherical because it requires the student to revise many different aspects of their current conceptual framework. Researchers writing about conceptual change propose that individuals have “knowledge paradigm shifts” that are similar to the paradigm shifts historically seen in science (Sinatra et al., 2008). Some researchers who are currently involved in the conceptual change literature refer to the transition from a belief in special creationism to acceptance of evolution as the most challenging type of conceptual change, because it requires some of the students’ deepest engrained belief frameworks to be revised (Sinatra et al., 2008). This includes their beliefs about human origins, purpose, and their beliefs about biological essentialism. Professors may underestimate the difficulty of inducing conceptual change in students or how much change they are asking their religious students to make.

Research has shown some consistent requirements for conceptual change to take place and this could inform evolution educators. First, the learner must be dissatisfied with their current conception and then they must see the new conception as intelligible, plausible, and fruitful (Sinatra et al., 2008). To help students who hold creationist perspectives become dissatisfied with their current conception, refutational methods are often used in the classroom (Tippett, 2010). Refutational methods are used when the instructor points out inconsistencies in, and refutational evidence against, creationist hypotheses. However, if an instructor tells students that evolution refutes their religious beliefs, a religious student is likely to think that evolution is not very plausible or fruitful,

which are the third and fourth requirements for conceptual change to occur. However, discussing how evolution might fit in with the students' religious beliefs and providing students with role models who both believe in religion and accept evolution, instead of using classical refutational methods, might help the student see evolution as plausible and fruitful.

The theory of conceptual change has undergone multiple revisions since its inception by Piaget, and in 1993 Pintrich et al. proposed a model of *hot* conceptual change. This model takes into account that students' cognitive processes can be influenced by their motivation and research confirms that students are highly affected by motivational processes while learning science (Bransford et al., 2000). There are times when certain motivations, such as world-view conflicts, keep students from reaching a level of engagement necessary for conceptual change to occur. There are many aspects of evolutionary theory, such as a perceived conflict between religious beliefs and evolution, which may de-motivate religious students, who will then not engage in the exploration of evolution. Therefore, it is important to understand how educators can help students reconcile their religious beliefs with evolution.

Social Psychology

Further, views from social psychology support that students will need to see that "evolutionists" are not all atheists before they will be open to accepting evolution. Identity theory proposes that individuals construct a sense of self partly through the categorization of themselves and others as in-group or out-group (Stets and Burke, 2000). Individuals will notice similarities and differences between groups of people, and those groups that they see as more similar to themselves will be categorized as in-group and

those who are dissimilar as out-group. Certain attributes, ideas, and beliefs are attached to these groups/categories of people. A person has a desire to be consistent in their identity and when confronted with new ideas, decisions, and situations, will choose what to accept based on whether that attribute is perceived as an attribute of their in-group or out-group. The more salient an attribute is to one's identity the more they are motivated to align their behaviors and beliefs with the norms associated with that identity (Stets and Burke, 2000).

Studies have shown that religiosity is heavily salient to a large number of individuals, especially in the United States, and it is likely that most of these individuals see religiosity as more salient to their personal identity than they do evolution. For instance, in 2000, in a review of literature measuring religiosity of Americans, Steensland et al. said religiosity researchers “widely acknowledge that Americans are more religious than citizens in most other modern industrialized nations, and research has demonstrated that religious worldviews shape social and political attitudes in ways that cannot be reduced to social class, *educational attainment*, or other more traditional sociological factors”. In my review of the literature, there were no claims that acceptance of evolution was as salient to American's identity as religiosity. So, given American salience of religiosity, it is likely that if an individual perceives evolution as a belief that belongs to out-group members, the non-religious or “atheists”, they are likely to leave out evolution as part of their belief system and identity, even if it is possible for them to reconcile evolution with their religious beliefs. It may be important for educators to help students understand that there are many individuals and groups of people who are both religious and accept evolution.

CHAPTER 3

BACKGROUND

Researchers and scientists often cite the theory of evolution as the grand unifying theory of biology (Dobzhansky, 1973; Gould, 2002; Mayr 1982; Catley, 2006; Heddy & Nadelson, 2013). The importance of evolution is thoroughly discussed in the Next Generation Science Standards and the National Academy of Sciences, the American Association for the Advancement of Science, the National Center for Science Education, and the National Science Foundation (AAAS, 2009; NAS, 2008; NAS, 1998; Petto, 2008). However, a significant portion of the population say they do not “believe” in evolutionary theory. In 2012, 46% of Americans reported to a bi-annual Gallup poll that they believe God created humans in their present form within the last 10,000 years (Gallup, 2012), a direct contradiction to the conception of common ancestry. Despite decades of research investigating ways to effectively teach evolution, the rejection rate has remained stable over the last 32 years, since the inception of Gallup’s evolution poll in 1982 (Gallup, 2012; Eve et al., 2010). Highlighting the pervasive nature of this anti-evolution sentiment, even among high school biology teachers, rejection rates can reach up to an astounding 33% (Rice et al., 2010; Fowler and Meisels, 2010, Moore & Kraemer, 2005).

Further, the National Academy of Sciences and the American Association for the Advancement of Science have issued several documents that highlight the importance of a scientifically literate society that is equipped to make policy decisions of the future (Singer et al., 2012; AAAS, 2009). They have also proposed that in order to have a society that can make informed policy decisions as well as informed personal health

decisions, we must have a society that understands and accepts evolution. The principles of evolutionary theory are foundationally related to many societal obstacles. For instance, an understanding and acceptance of microevolutionary principles are essential for someone to make informed decisions about how to take their antibiotic prescriptions effectively, and in effect, mitigate the development of antibiotic resistant pathogens that are increasingly becoming a major challenge for physicians to treat effectively worldwide (NAS, 2008; NAS, 1998). Furthermore, an understanding and acceptance of macroevolutionary principles and processes could be necessary for a voting citizen to understand the full repercussions of, arguably, the most pressing challenges facing humanity today: overpopulation, loss of biodiversity, and global climate change. If one does not understand and accept the intertwined evolutionary histories of organisms and the complex ecology that has resulted from evolutionary processes over vast time scales, these individuals will arguably lack a full comprehension of why the aforementioned challenges are such a looming danger to human, and other animal populations.

Understanding, Acceptance, Belief, and Knowledge

Researchers, educators, and the public often confuse and conflate understanding, acceptance, and belief when talking about evolution (Smith 1994; Smith and Siegel 2004; Southerland et al. 2001). “Understanding” is used to indicate one’s capability to describe the principles and outcomes of evolution and apply that framework when solving problems pertaining to evolution. “Acceptance” can be characterized as an individual having confidence that a concept is true *with a justified reason for their acceptance*. Smith et al. suggested scientists and science educators refrain from using the word

“belief” when talking about scientific concepts because belief can be characterized as a more subjective version of acceptance, without necessarily having a *justification* for that belief, which is necessary to have appropriate confidence in a scientific theory. So when speaking of evolution education, it has become normal discourse for one to only use the terms “acceptance” and “understanding”.

Acceptance and understanding of evolution are only weakly, if at all, correlated with one another (Loyd-Strovas et al., 2012; Sinatra et al., 2003). One can hold an expert understanding and this does not necessarily increase the likelihood that they will accept evolution. Pervasive misconceptions about evolution can lead to confusion about the process, however more often social and interpersonal belief systems interfere with acceptance. For instance, when several factors thought to influence evolution acceptance are put into a regression analyses, religiosity becomes the main factor influencing acceptance of evolution and explains far more variability than understanding of evolution (Barnes, in preparation). Given that helping students to understand evolution does not necessarily help them to accept evolution, different strategies will need to be used to help students accept evolution. However, is it even an educator’s duty to help students to accept evolution or is teaching students the material sufficient? In order to achieve our goals as educators, goals must be clearly defined.

Acceptance as a Goal of Evolution Education

It is often said that an educators’ goal is to impart knowledge onto their pupils. Classic Platonian philosophy would propose three criterion for “knowing” or gaining “knowledge: 1) the individual must *believe* the proposition to be true, 2) the proposition

actually is true, and 3) the person is justified in believing it is true. If imparting knowledge is the goal of educators, then acceptance fits this definition, not mere understanding. Further, the goal of education is to help students apply this knowledge to other realms of their lives, making connections between what they learn in class and how it relates to the rest of their conceptual ecology, which would require acceptance. For instance, Sinatra et al. (2003) found that those who do not accept evolution but fully understand it are unlikely to connect their understanding to the rest of their scientific knowledge base and therefore fail to accommodate this knowledge into their conceptual framework. In other words, if someone understands evolution, but does not accept it, then it is unlikely he or she will make informed decisions that require evolutionary knowledge, such as deciding how to vote on factors that will mitigate climate change or loss of biodiversity.

Further, it is unlikely that the goals of understanding versus acceptance would garner as much debate in other areas of science education. If one is teaching the germ theory of disease, would they be satisfied with eliciting understanding without acceptance? Or that DNA is the source of information from which organisms are built? Would an educator be doing her job if she only elicited an understanding, but failed to persuade her students that microorganisms cause illness or that DNA holds genetic information? Is there any reason that there should be a difference between our goals as an “evolution” educator, a “germ theory of disease” educator, or a “DNA” educator?

Factors Influencing Acceptance of Evolution.

Researchers have identified several factors influencing rejection of evolution. Gallup polls consistently find that a person's religious and political affiliation are related to rejection (Gallup, 2012; Pew, 2013). Some researchers have identified a person's level of education as a significant factor (Heddy, 2012). Anton Lawson and William Warsnop found that high school student's reflective reasoning ability is related to acceptance (Lawson and Warsnop, 1992). Other factors that have been identified include socioeconomic status (Heddy & Nadelson, 2013), geographic location (Heddy & Nadelson, 2013), and understanding of macroevolution (Nadelson and Southerland, 2010). Some researchers have surmised that evolved cognitive heuristics make the idea of evolution feel intuitively false to the human mind, just as the idea of a spherical Earth is initially unintuitive to most children (Sinatra, in press). However, of all of these factors, many researchers have concluded that a person's religious commitment is the factor that most predicts rejection of evolution. This has been confirmed by qualitative analysis, and strong bivariate correlations as well as regression analyses (Allmon, 2011; Alters and Nelson, 2002; Barnes, in preparation; Eve et al., 2010, Southerland & Scharmann, 2013; Sinclair et al, 1997; Winslow et al., 2011).

Previous Work on Discussing Religion in the Science Classroom

Given researchers have identified religiosity as the most important factor related to acceptance of evolution, it is important for us to understand how we might dispel the perceived conflict between religion and evolution. In fact, many scientists and education researchers have made this point. In 2013, Southerland and Scharmann discussed how

engaging in students religious beliefs might be one of the most important things to consider when teaching scientific subjects that relate to human origins, because these subjects are perceived to be in conflict with many tenants of the western religions that students are likely to adhere to (Southerland & Scharmann, 2013). Southerland also discussed how teaching the bounded nature of science in relation to religion can help students be more open to subjects that generally conflict with religious ideas (Southerland, 2011).

Further, empirical studies have accumulated preliminary evidence that discussions of religion in the science classroom will help students be more open to evolution. In a study done in Lebanon, researchers found that when they interviewed students about the instruction of a science course, students appreciated a discussion on the relationship between evolution and religion. The author suggests that teaching students about the nature of scientific facts, theories, and evidence is more likely to enhance understanding of evolutionary theory if students are given the opportunity to discuss their values and beliefs in relation to scientific knowledge (Dagher et al., 1997). In Roth's 1998 analysis of case studies of undergraduates, the authors found that in order to help students accept science, educators may have to help students construct mediating concepts that help them reconcile the science and their religious beliefs (Roth, 1998). One study found that having open discussions about the relationship between religion and science increased students' positive viewpoints of science and evolution and students appreciated this discussion (Brickhouse, 2000). Further, a study done by Hermann in 2012 identified students that seemed to have a high understanding of evolution and yet rejected the theory and interviewed them about their beliefs. These students expressed dissatisfaction

with instructors' apparent neglect of addressing how religion relates to evolution, leading the author to conclude that, "Presenting science topics that are controversial without making reference to other ways of knowing (religion) can alienate students."

Some researchers have even analyzed how the availability of religious scientist role models have affected student acceptance. For instance, Winslow et al. found that a significant factor facilitating a transition from creationism to evolutionism in Christian biology majors was these students' interactions with their religious biology professors who reassured them that there need not be a conflict between religion and evolution (Winslow et al., 2011). This may indicate that students will be more open to evolution if they understand that they can hold both religious and scientific identities by providing real world examples of individuals who successfully espouse both.

Is Religious Belief Compatible with Evolution?

It is the general consensus among biologists that a literal interpretation of the Judeo-Christian Bible, the most highly read religious book in America, is not compatible with evolution. However, the evolution education literature seems somewhat divided about "theistic evolution", the belief that evolution has occurred, but that a creator of some sort either started the process, guided the process, or intervened at crucial times. Evidence for this lies in the way different researchers ask students about evolution and how researchers interpret their answers. Acceptance of evolution can take on different definitions depending on the research article (Donnelly et al, 2009). Researchers distinguish acceptance of evolution in vastly different ways. For example, there are studies in which the researchers merely ask "Do you accept evolutionary theory" and a

simple “yes” indicates acceptance (Rutledge & Mitchell, 2002) Some researchers however, when writing about acceptance, will distinguish between atheistic evolution and theistic evolution and then only count the percentage of those who agree with an atheistic stance as accepting evolution (Klymkowski, 2014; Rice et al., 2010; Sinatra & Nadelson, 2009), while others will include theistic evolution as acceptance (Gallup, 2012). Moreover, some researchers will measure theistic and atheistic evolution and remain silent of whether or not theistic evolution is valid (Barnes et al., 2009).

Aiming for atheistic evolution seems to be at odds with the philosophy of scientific inquiry, in which we can make no claims about supernatural entities and involvement due to the lack of testability of such claims (Gould, 2002). Perhaps then, researchers and educators who distinguish theistic evolution as rejection of evolution should reconsider their approach. Further, by counting theistic evolution as rejection of evolution, researchers and educators may be further perpetuating the misconception that to accept evolution one must denounce a role of a creator. It is this misconception that may lay at the heart of rejection of evolution, which makes it important for evolution educators and researchers to carefully and thoughtfully choose what they define as “acceptance of evolution”. Instructors and researchers may have more success in helping students to accept evolution by recognizing and explaining that scientific inquiry can make no claims on the role of a creator and therefore is completely compatible with evolution, as long as it does not contradict our confirmed observations.

Are Biology Educators Willing to Address Religion in the Classroom?

Despite these calls for engaging religious beliefs in the classroom and preliminary evidence that this strategy may be effective, little work has been done how often

educators address religious beliefs when teaching evolution, how they feel about discussing religion, if they are discussing religion in a manner that helps students accept evolution, or if they are even willing to have religious discussions in the first place (Dagher et al., 1997; Griffith & Brem, 2004). This will be important to understand, because biology educators may be uncomfortable addressing religious beliefs in the classroom for several reasons.

First, it may be likely that educators lack training in teaching the nature of science as it is related to evolution and religion. This may make professors feel underprepared to engage in this discussion about how evolution and religion are related (Southerland and Scharmann, 2011). In addition, biology educators may be resistant to this because of their own belief systems. As mentioned before there is a big disconnect between the public's religiosity and that of biologists (Graffin and Provine, 2007). Given their markedly atheistic world-view, it is likely that some biology educators might be generally uncomfortable with religion as a valid source of belief, regardless of whether that belief is consistent with what we can know from science. For instance, many evolutionary biologists may feel uncomfortable with the notion of "theistic evolution", even though technically, evolutionary science can make no claims about this assertion. This could be a hindrance to their ability or willingness to engage with students religious beliefs.

Next, there is a long history of attempts by religious groups to legislate the right of teachers to present creationism as a valid alternative to the theory of evolution. This has been a relentless "battle" between scientists and religious groups since 1925, when John Scopes was the first educator prosecuted for teaching evolution in the classroom

(Numbers, 2006). Since this conflict, religious groups have attempted countless numbers of legislations to either prevent educators from teaching evolution or allow or even force them to teach creationism as an alternative theory. For instance, legislatures recently introduced a bill in Missouri that would require students to receive signed permission from their parents before they can learn about evolution at school (NCSE, 2014). Every year there are multiple anti-evolution bills that are attempted in the United States (NSCE, 2014). Perhaps because of this history, biologists have adopted a defensive disposition when it comes to allowing religious discussions in the classroom. They may see the strategy of engaging religious beliefs in the classroom as a gateway to teach anti-evolution sentiments based on religious beliefs.

Last, there is a strong presence in the literature about whether or not it is an educator's job to help students accept evolution or merely help them understand evolution, and this is still seen by some as an unsettled conflict (Smith, 2010; Sinatra et al., 2003; Nadelson and Southerland, 2010; Shtulman, 2008). A biology educator may believe it is only their duty to help students to understand evolution, and persuading them to accept evolution would be unethical or out of their realm as a science educator. If this is the case, discussing the compatibility of religion and science in the classroom may be seen as unethical to an educator or they might decide the student should have these discussions with their religious leaders, outside of the science class.

In order to understand the potential impact of engaging religious beliefs in an evolution classroom, we must first understand the attitudes and beliefs of the educators who may consider implementing these strategies. If biology educators are unable or

unwilling to engage in such discussions, the likelihood this strategy will be implemented or effective is low. Answering the following questions will give insight into these concerns:

Research Questions:

- What kinds of strategies, related to religion and social identity, are biology professors currently using when teaching evolution?
 - Do they discuss the compatibility of religious beliefs and evolution? Or the spectrum of viewpoints related to religion and evolution?
 - Do they provide students with religious scientist role models, who accept evolution, when teaching evolution?
 - If they do not use these strategies, are they willing to? Why or why not?
- Do biology professors think it is their job to help students to accept evolution? Why or why not? What do professors think acceptance of evolution is?

There is a wide range of biology educators, from elementary school teachers, high school teachers, community college instructors, graduate teaching assistants, to professors in higher education that teach evolution. These groups likely have different opinions based on their differential experience in science education, degrees attained, and religious affiliation because these differences are seen in the general public (Heddy and Nadelson, 2013). A systematic exploration of these groups' beliefs could be useful in determining the viability of the religion-evolution discussion strategy. I started with exploring the attitudes and beliefs of tenured professors. This group is an optimal starting

point for two reasons. First, tenured professors are likely to be most resistant to this strategy given their extensive training in science and the general likelihood that they will be nonreligious, so we can identify the strongest barriers from this group of individuals. Second, tenured professors will be more open to discussing their attitudes about these controversial subjects in interviews with researchers. They have less fear of retaliation from their colleagues given they have reached a relatively secure status in their field. Other instructors in higher education, who feel less secure in their positions, may be less open and honest about their beliefs and experiences.

CHAPTER 4

METHODOLOGY

15 semi-structured interviews were conducted with tenured biology faculty who teach undergraduate introductory biology classes. Participants were recruited by sending individual emails to all faculty, at the institution of interest, who met the criteria (n=40, 37.5% response rate). The email stated that the researcher would like to interview the potential participant about their beliefs and experiences teaching controversial subjects in biology.

The interviews were video recorded. The researcher had a list of talking points and questions that she used for each interview, included here, although the interviews were semi-structured, so questions were not necessarily asked in the same order or format for each interview, and in some interviews the researcher asked additional questions than are on this checklist:

1. What is your experience teaching evolution?
 - a. How many years?
 - b. Which classes?
 - c. Strategies?
 - d. Challenges?
2. What is your perception of student's acceptance? (How many of your students do you think accept evolution?)
3. What is a biology educators' duty- acceptance or understanding?

4. What is your perceptions of student's religiosity? (What proportion of your students do you think are religious?)
5. Importance of public acceptance of evolution? (Do you think it is important for the public to accept evolution?)
6. Do you think you would be willing to address religion in an evolution classroom? (Are you willing to do these things? Have you in the past?)
 - a. Discussing spectrum of viewpoints regarding religion and evolution.
 - b. Religious scientist role models
 - c. Do you think your colleagues feel the same about these topics?
7. What is acceptance of evolution?
 - a. Common ancestry of all of life?
 - b. Natural Selection?
 - c. Other things?
8. What was your experiences learning evolution?
 - a. Any world view conflict?
 - b. Do you remember how you felt learning about evolution?

At the end of each interview each participant was also given a short, closed-ended, paper survey that asked about their professorial status (associate or full), their

level of experience teaching evolution on a 1-10 scale, their current religious affiliation, their childhood household religious affiliation, and their perceptions of how God was involved in evolution, if at all.

Following the interviews, the researcher and a research assistant transcribed all interviews and anonymized any portions of the transcript that might be identifying. Following the transcriptions and using a qualitative analytic processes called “content analysis” (Mayring, 2000) the researcher “coded” each interview by highlighting any excerpt of the interview that either pertained to the research questions being asked, or pertained to a prominent theme that emerged from the interviews, regardless of its relation to the research question. After each excerpt is highlighted, it is given a name for a potential “category”. For instance if a professor said, “I do not really think I am comfortable trying to get students to accept evolution, that is not something I see as a goal of my instruction”, I would highlight this quote and label it “No Acceptance”. Using constant comparison methods (Glesne, et al., 1992) each excerpt is then compared to see if multiple excerpts can be defined under one category. For example, if another professor said, “I don’t think acceptance is my duty as a biology professor” I would place that in the category “No Acceptance” with the previous quotation. Then once all categories have been identified, these categories can be further organized into “themes”. For instance, I would place all the categories “No Acceptance”, “Yes Acceptance” and “Only Understanding” under an overarching theme of “Acceptance versus Understanding”. Then the frequencies, distributions, and weights of each of these excerpts were used to create a narrative aimed at addressing the study’s research questions.

CHAPTER 5

RESULTS

Demographics and Survey Responses

Table 1: Participant pseudonyms, demographics, and survey responses.

Pseudonym	Gender	Self-reported religious affiliation	Childhood religious affiliation	Assc/Full professor	Years teaching undergrads	Experience teaching evolution (1-10)
Frank	Male	Atheist	Catholic	Assc	7	7
Haley	Female	Agnostic	Agnostic	Assc	16	5
Bob	Male	Catholic	Catholic	Full	15	10
William	Male	Jewish	Jewish	Assc	40	9
George	Male	Atheist	Protestant	Full	24	7
Robert	Male	Atheist/Cultural Jew	Jewish	Assc.	11	10
Peter	Male	No Answer	No Answer	Full	17	10
Ernest	Male	Agnostic	Jewish	Full	28	6
Stacey	Female	Atheist	Protestant	Assc.	23	3
Scott	Male	Atheist	Atheist/Catholic	Full	30	2
Jack	Male	Protestant	Protestant	Full	41	5
Devon	Male	Atheist	Catholic	Full	25	9
Tiffany	Female	Agnostic/Animist	Agnostic	Assc.	20	3
Tom	Male	Catholic/Agnostic	Catholic	Assc.	11	6
Evan	Male	Catholic	Catholic	Full	20	9

*Participant reported this view during interview, but did not answer the survey question due to poor wording

**Participant wrote in “Mother nature guided evolution” in survey.

Findings That Represent a Consensus among Interviewed Professors

Finding #1: 14 of 15 professors had never been challenged about evolution in the classroom.

14 of 15 professors say they were never directly challenged in class about evolution. The only professor who had been challenged “Evan”, was one of the professors who encouraged discussions of religion and evolution. But even this professor said he had only been challenged a few times, and in online class discussions rather than in person.

Finding #2: All 15 professors said they had no worldview conflicts when learning about evolution.

In response to a variation of the question, “When learning about evolution, did you ever experience any discomfort or world-view conflict you had to work through?” all 15 professors either simply said “No.” or shook their heads no, including the half of participants who self-reported as belonging to some religious denomination, implying they have somehow reconciled their religious beliefs with evolution.

Finding #3: Professors do not believe God had anything to do with evolution.

When asked what their perception of God’s role in evolution is, with the following options available,

- a. Human beings have evolved over billions of years from older life forms and God guided this process
- b. Human beings have evolved over billions of years from older life forms and God started this process, but did not intervene thereafter.
- c. Human beings have evolved over billions of years from older life forms and God was not involved in this process
- d. Human beings have evolved over billions of years from older life forms and I do not know whether God had anything to do with this process.
- e. God created human beings, more or less, in their current form.

12 of 15 respondents said, “No God involved”, 2 respondents said they were “unsure of God’s role in evolution” and 1 respondent refused to answer the question. It is

important to note that of the 5 participants who self-reported as belonging to some religious group, 4 responded with “No God involved”, and 1 reported Catholic said he was “Unsure of God’s role in evolution”.

Findings that Represent Diverse Viewpoints among Interviewed Professors

Finding #4: Professors did not agree on whether or not it is their job to get students to accept evolution.

When asked whether acceptance is a part of their job as an evolution educator or not, 9 of the 15 professors said they did not consider it a part of their job. Many of them expressed being uncomfortable with “persuading” or “brainwashing” students and thought their goal, as an educator, is to teach students to think for themselves. For instance, one professor, “Tom” expressed the sentiment that it was only his job to teach students critical thinking of biology rather than to get them to accept the content he teaches:

“I guess I don’t really believe in the idea of making people believe. They need to be able to see the facts and make their own judgments, and that’s part of learning at the University is developing into an adult who knows how to make those kind of judgment calls.”

6 of 15 professors were not outwardly opposed to including acceptance of evolution as their job as an evolution educator. Yet among these six, two admitted that they did not actively pursue or think about this aspect of their duties as an evolution educator, as expressed by “Stacey”:

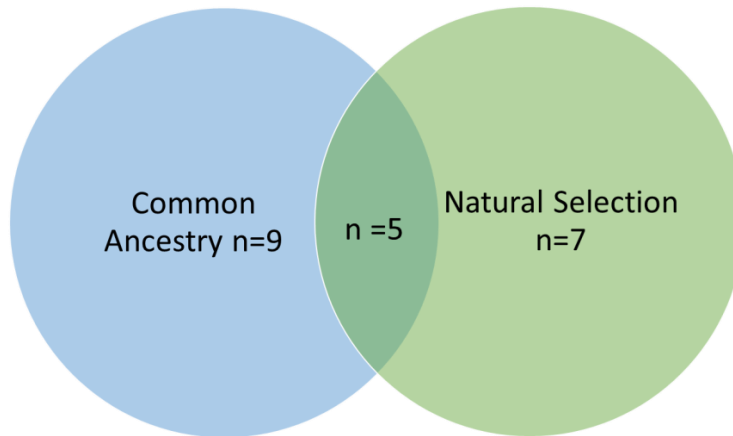
“I really don’t do that as an educator (acceptance of evolution). As I’m thinking now, I’m not in there saying you must believe, but I think that’s the reality. I think that is what I believe, but I’m not doing anything, as an educator (to achieve those means).”

And “Devon”:

“I think part of the job is to get students to accept it, yes. I think that’s a good point. I never, I shouldn’t say never, I don’t necessarily think of it that much...”

Finding #5: Professors did not agree on the definition of “acceptance of evolution”.

When asked “What would a student have to accept, in order for them to “adequately” accept evolution?” professors gave a wide range of varied answers and combinations of concepts that students should accept about evolution. This included accepting that natural selection occurs (n=9), all life shares a common ancestor (n=7), life changes over time (n=5), speciation occurs (n=3), allele frequencies change in a population of organisms over time (n=2), and that there is no purposeful direction to evolution (n=2). Participants often cited more than one concept as important. Below is a Venn diagram, which illustrates participant response rates of common ancestry, natural selection, and a combination of both concepts. 5 participants cited both common ancestry and natural selection as important for acceptance:



Although common ancestry and natural selection were the two most cited concepts important for acceptance of evolution, there was even disagreement about which is important for students to accept. For instance, 3 of the participants espoused the view that acceptance of common ancestry is key to adequate acceptance, but that the mechanism of natural selection is not as important for student acceptance, “Evan” expressed this sentiment clearly:

Evan: I don't think latching onto the mechanism is the most important thing, necessarily. Natural selection is obviously a pretty important driver of that, but even among biologists, there's a lot of discussion (and) debate about how strong selection is driving x, y, and z trait that you might see in an organism in the modern day. Probably not the mechanism, necessarily, but I think just the whole idea that species change over time and diversify. More accepting of the fact that it happens, that it's an observed fact of nature, that adaptation occurs, speciation diversification occurs, and things in the past are not the same as they are now.

Interviewer: And what about the common ancestry of life? Do you think it's important for someone to believe that all of life on earth came from a common ancestor?

Evan: Yes, I guess. That's sort of implicit of accepting there's been diversification.

However, completely contrary to the previous view, 4 participants reported that natural selection, but not common ancestry is important for students to adequately accept evolution, here is an example of that view from "Stacey":

Interviewer: What do you consider acceptance of evolution?

Stacey: To me, it's that mutations are driving, mutations and natural selection, are driving changes in species' populations. I think, personally, that there's enough evidence for the common ancestor, but I could believe somebody saying maybe that all this happened more than once. Clearly it did, just to get that first life, it happened more than once. I could believe more than one common ancestor and being compatible with evolution. I think that's totally compatible, as long as there's not 1 billion common ancestors.

Finding #6: Some professors report addressing religion in the classroom.

Of the 15 professors interviewed, 10 of them said they address religion in their class in some way or another. Most of these professors, 6 of the 10, described talking about what is and what is not science, and indicating that religion is not science.

However, many indicated that this was not an established lesson plan that was systematically applied to every class, such as “George” who said:

“I have occasionally compared religion to science, but not routinely or ever in depth.”

1 professor, “Haley”, said she describes the “different value sets” that influence beliefs about science, but did not indicate she specifically discusses religious viewpoints.

2 professors, “Robert” and “Bob” said they discuss how science cannot address God. However, when addressing this Bob seems to cast a negative light on the idea of God:

“(I describe) how in science we actually set up hypotheses, which are testable whereas any argument coming from the belief in a supernatural being, or God, is just re-emphasizing a fundamental belief that is already there. There is no questioning that we just confirm that... I say science does not make any assumptions. I mean we can say something like “we don’t need to have a supernatural being to explain the existence of life or the evolution of these things” but these are all hypotheses, but we can’t say there’s a God or there’s no God. I mean, this is just not a question that science addresses in that particular case.”

Another professor, “William” describes lambasting creationists in what he called a “sermon” to his students. Although, he meant it to be lighthearted, it could be construed as antagonistic:

William: Okay, let me tell you a little story then, years ago, I used to do a sermon on evolution in class, where I would tell the students that creationists are evil and out to destroy America. I did that because-- I would do the student evaluations of me before I gave that lecture, once they went to the online, they could do it any time, I had to cut that out and so I no longer give a sermon on evolution. My TA's really got annoyed with me because they used to love it-- but there's just no way I can do that with that number of creationists in class.

Interviewer: Can you describe that, the sermon like you said. Can you walk me through it?

William: "There's a terrible wind blowing through America... that is trying to impose religion as science. It is out to destroy America, because it is not simply evolution. Evolution is built on genetics. It's built on chemistry. It's built on physics. It's built on astronomy, all of the sciences. If you believe in creationism, you can't believe in any of the foundations of science and that will destroy America. You will destroy America." Pretty harsh. There is a deathly silence over the classroom-- except for my TA's, which are grinning.

Finding #7: Fewer professors report discussing the spectrum of views regarding religion and evolution.

4 professors reported discussing the spectrum of viewpoints regarding religion and evolution. The first professor, "George", said he previously had students in a class

read a book, which described different views on evolution and religion, but could not recall the specific views or material addressed in the book.

Another professor, “Tom”, stated that he presented evolution and creationism as two ends of a spectrum:

“When I taught it (evolution), I taught creationism as one of the models. I just put it out there as some people believe creationism is the way that species were created, but then that was on one end of the spectrum, and then the other side of the spectrum was sort of like at the end of a continuum, where if we replayed evolution 1,000 times we get humans once or twice, completely atheistic and probabilistic. And to get people to kind of think about it that way, rather than it’s an either/or, I think might have dispelled some. I hope that it dispelled some skepticism.”

The next professor “Jack” said he gave students the option of discussing different religious views on evolution, however he purposefully avoids talking about Christianity:

“Because we only have so much time, (I tell them to) just tell me which theory of creation you want me to talk about and we’ll talk about that next time. There’s the Zuni, there’s the Bon religion from Tibet, there are African tribes, and I list all these potential cultures that have a theory of creation, because it’s a cultural issue. And I say I will talk about any of these, but we all sort of know the Christian story of creation, so let’s just not worry about that one, and just give me one of these other ones, and no one ever comes up with another culture that they want me to talk about. They’ve been neutralized, and so no one has ever brought up talking

about creation science, because I've addressed it myself, and they've had their chance, and then I just talk about the more mechanistic way that we view evolution. That's how I've always handled it."

"Evan" addresses a spectrum of viewpoints between religion and science:

"I used to have this lecture called weird things that people say about evolution, and we tried a few things that people say about evolution that are misleading, in some ways, erroneous. (...) One of them that is explicit that I make sure we deal with is the claim that evolution and science and religion are incompatible with each other, and religious faith and scientific inquiry are incompatible. Because in many ways they're not depending on how far you want to stretch the claims of religion, or what domains. I try to point out that many religious traditions are perfectly fine with scientific investigation (...) I try to point out that there's a broad range of religious teachings about evolution"

However, he then goes on to describe a method that may make students coming from fundamentalist religions uncomfortable with evolution:

"I randomly assign (...) from a list of 12, or so, religious dominations, and I tell them (the students) to go investigate the teachings of that religious tradition about evolution, and then rank that religion on the base on the gradient from, "completely forbidden" or "you're going to heck....you're going to hell if you accept evolution", to "hey that's cool, no problem, evolution's great." And if you do, that you'll see that there are some religious denominations, which are fundamentalists in their viewpoint, and which yes evolution is definitely off the

table, if you believe in evolution you are not in our religion, you're out. That's like Seventh-day Adventist (...) or something like that, Christian fundamentalist groups (...)"

Finding #8: Even fewer professors provide examples of religious scientist role models.

Of 15 professors interviewed, only 2 reported that they provide examples of religious scientist role models.

"Jack" reported discussing religious viewpoints and providing himself as a religious scientist role model.

"I always say I was brought up Presbyterian, I'm a member of my Presbyterian church"

The last professor, "Evan" also espoused an attempt to provide himself and other scientists as religious scientist role models, he says:

"I point out that I'm a Catholic, and I'm an evolutionary biologist, and you go to (a Catholic University), where I went, and they have a whole evolutionary biology department."

Finding #9: There are numerous perceived challenges to engaging student's religious beliefs and social identity among interviewed professors.

There were many concerns over the challenges perceived in discussing religion in a biology classroom. The most prevalent view was that the current class they are teaching would not be an appropriate forum for discussions of religion. 5 of the 15 participants described discussing religion as a strategy that should be used in a philosophy class or a seminar, and not a biology class. For example, "Jack" thought that philosophy is not on the table in a science class:

"Probably one of the reasons (this would be challenging) is that what we are really talking about is the difference between science and philosophy, and because we're really talking about philosophy and this is a science class (...) it's not really on the table."

"Devon" felt similarly:

"Again, the class I teach, this is not what it's all about. Essentially no. The way I teach my classes I talk about scientific facts and what you are bringing up, it's important, it's interesting, it's worth discussing, but this is not based on facts. Creationism is not science-based, this is based on philosophy and things like that, and I have pretty respect for that, but this is not science."

Also prevalent was the concern that classroom sizes and time constraints would hinder this strategy. Robert's answer was characteristic of many of these concerns espoused by participants:

“And the other thing is, we’re teaching a class of over 300 students. It’s very different if I’m in a classroom of 30 students to have a discussion about this then to have me lecture at them about these issues.” He continues later... “there’s only so many things that we can go into and if we spent you know three or four weeks discussing all these different aspects, we would really lose out and I think we would do a disservice to the students to do that.”

3 professors described a lack of training as a barrier to discussing religion and evolution, and “Scott” went as far to say this lack of training might lead to professional repercussions:

Scott: That seems to be too dangerous to me, right now. I don’t want to get into that area, unless we do it in a teamwork. We need to get more advice on it, because these people can be offended, can sue the university, can sue me, for saying something that offends their beliefs.

Interviewer: Do you think more training in the area would be helpful?

Scott: Counseling, yes. If not, there’s no reason I should risk for something that is very unclear. You can get sued for, I don’t want to be in a lawsuit, in all of this controversy.

Interestingly, 2 professors cited their own beliefs as barriers in implementing these strategies. For instance, “George”, who self-reported as an atheist, said it would be hard for him to tell students they could reconcile a belief in a Supreme Being and evolution:

Interviewer: Do you think that evolution and a supreme being are not reconcilable?

George: Certainly, that's the way I think.

Interviewer: And because of that belief, you wouldn't necessarily be comfortable saying that they can believe in a supreme being and believe in evolution?

George: It would be hard for me to be up to say that.

The second professor "William", who self-reported as Jewish, also presented personal beliefs as a barrier. He said it was because he was unsure of his own views on God:

William: I'm not going to get into a major debate over science versus religion. Somebody's religion-- my religion is very personal to me. I don't believe everything that my religion says I should believe." He goes on later... "I don't want to bring God into the equation. I really do not want to do that."

Interviewer: And for what reason?

William: Because I don't know what kind of God I believe in. I do not believe in the God of my Bible or the less threatening God of your Bible. I have my own fuzzy... (belief in what god is).

Finding #10: Most professors reported they are willing to discuss religion when teaching evolution, but ~1/4 said they are not willing.

Only 4 of the 15 participants made no statement that indicated they were willing to engage in student's religious beliefs and social identity. However, only 2 of those 4 were ardently against it. For example, "William" repeatedly expressed this firm view throughout our interview:

Interviewer: If you knew trying these strategies would help students to accept evolution, would you be willing to try them?

William: No. Absolutely not. Nope... nope... nope... nope... no. Absolutely not.

However, regardless of this sentiment held by some participants, most participants (n=11) said they would be willing to try strategies of engaging student's religious beliefs and social identity. In fact, there were a few instances of high enthusiasm and willingness. For instance, when asked if she thought it would be a good idea to engage in students religious beliefs, "Stacy" said:

"That would be awesome. I think that would be really awesome."

Further, when asked if she would be willing to discuss her own religious views and how they relate to evolution, "Tiffany" said:

"Yes, I would. I think that that's the kind of thing that students relate to.

Sometimes personal stories, as a supplement to some data based presentation; your own story can be as compelling as anything."

One professor, “Haley”, expresses a regret from the viewpoint of the scientific community for alienating the religious community in the first place, and desired we aim for a reconciliation:

“I think that in the 70s and 80s the environmental evolution community really did ourselves a disservice by alienating religious groups. It was really tough and we thought that the religious viewpoint was antithetical to what our viewpoint was (...)It has become clear that that was a mistake because you can’t convince people through science; you have to convince people through their values.. We absolutely have to engage in their religious community or who are helping to shape human values, whomever those people are.”

Summary

- Participants are not challenged in the classroom about evolution.
- Participants never experienced any world-view conflicts when learning about evolution.
- Participants do not believe God was involved in evolution, even if they are religiously affiliated.
- Participants do not agree on whether or not it is their job to help students accept evolution.
- Participants did not agree on the definition of “acceptance of evolution”.
- Some participants are addressing religion in the classroom, but only very briefly, and mostly just to describe “what is and what is not science”

- Few participants reported discussing variable viewpoints on religion and evolution.
- Even fewer participants reported providing students with religious scientist role models.
- Classroom size, time constraints, appropriateness of the topic for a science class, and personal beliefs were the most cited barriers to engaging students' religious beliefs.
- The majority of participants are willing to try engaging in students religious beliefs, if this will help them to accept evolution.

CHAPTER 6

DISCUSSION

If a student comes into the classroom with previous belief-based objections to the theory of evolution, then it is unlikely that the presentation of science content alone will be sufficient to persuade the student to accept evolution (Scott & Ecklund, 2013; Sinatra et al., 2003). If our goal as science educators is to help students accept well-established scientific concepts, as outlined by AAAS, NCSE, and NAS (AAAS, 2009; NAS, 2008; NAS, 1998; Petto, 2008), then the results of this study indicate that there may be many barriers to achieving a goal of evolution acceptance in higher education.

Of the barriers identified, the disagreement among participants about their goals as an evolution educator, is the most troublesome. Biology experts should agree on the goals of evolution education in order to be successful in achieving those goals. The results of this study suggest that these participants, who are experts in biology, do not agree on whether or not acceptance should be the goal of their instruction. 9 out of 15 participants said that acceptance of evolution is not their duty as an educator, and even among the remaining 6 participants who do think acceptance is their job, many said they do not actively pursue student acceptance. Their disagreement about their goals as an evolution educator are contrary to the goals of evolution education as outlined by The American Association for the Advancement of Science, the National Academy of Sciences and, the National Center for Science Education who report that acceptance is necessary for the desired outcomes of evolution education.

Further, in order to achieve our goals as educators, it is important that these goals are clear and well defined. However, even AAAS, NAS, and NCSE do not outline exactly what students should *accept* about evolution but only what they should understand. A lack of clearly defined goals regarding acceptance presents a challenge when pursuing acceptance because it leaves too much to interpretation. Professors had very diverse answers to “what is acceptance of evolution?” and this once again may represent disagreement among experts. Although natural selection and common ancestry were the most cited concepts in relation to concepts important for acceptance, this did not represent a consensus, as described in the results, with n=4 who reported natural selection is important for acceptance exclusive from common ancestry, n=3 who reported common ancestry as important for acceptance exclusive of natural selection, and n=5 reporting both concepts as necessary for acceptance.

Given that one of the most widely cited polls on perceptions of evolution measure rejection by eliciting responses regarding belief in common ancestry (Gallup, 2012), it is interesting that nearly half of participants did not think common ancestry was important for acceptance of evolution. If common ancestry is not considered to be necessary for acceptance of evolution by biology faculty, then acceptance is not being measured by Gallup’s biannual poll, which asks respondents whether “humans have developed from less advanced life forms over millions of years” and this poll is widely cited in the media and in research when reporting rejection rates.

Further, it seems that even validated measures of acceptance of evolution do not include questions that evaluate what the participants in this study considered to be

important for acceptance of evolution. A good example is the MATE (Measure of Acceptance of the Theory of Evolution) (Rutledge, 1999) which was developed to objectively measure high school students acceptance of evolution. Interestingly, this measure does not include any questions referring to common ancestry or development from previous life forms. However, the MATE also does not include any questions about natural selection, which was most widely cited by participants as important for acceptance of evolution, above common ancestry. The questions on the MATE address the validity of evolution without actually defining what evolution is, by asking participants about the age of the earth, whether or not evolution is scientifically testable, etc. Although in their paper the authors of the MATE state they constructed questions to gauge students' acceptance of the processes of evolution, in the questionnaire they merely ask whether or not species are the result of "evolutionary processes" without defining what these processes are. This measure was validated by five university professors in Indiana, but does not address either of the concepts that was most cited by the participants as important for acceptance of evolution: natural selection and common ancestry.

Common ancestry and natural selection are arguably, what makes evolution the unifying theory of biology. The first life form was subjected to natural selection, which led to the organism's speciation, and this process was repeated countless times over billions of years. This reiteration of selection and speciation explains the vast diversity and complexity of life we see today (excluding the influence of non-selective forces like genetic drift). So this disconnect between what respondents say is acceptance of evolution and what our polls and instruments are measuring should be disconcerting to

evolution educators and researchers. If we are to pursue acceptance of evolution as a goal of education, then it will be important in the future to establish acceptance as a goal of instruction and construct a clear definition of “acceptance of evolution”.

The Conflation of Acceptance and Understanding

Many participants seemed unable to fully demarcate acceptance from understanding and often conflated the two concepts. For instance, when the researcher asked participants what students should “accept” about evolution, some participants would reply with concepts the instructor would like students to understand. As mentioned before, some even admitted they saw no difference between accepting and understanding, and others admitted they did not think a student can fully understand evolution and reject it. Further, regardless of the fact that professors said helping students to accept evolution was not part of their job, most of them expressed a willingness to try strategies to help students accept evolution. This marks a disconnection between what professors described as their job and what strategies they say they are willing to use when instructing students on evolution. It is not clear why the professors hold these contradictory views. It may be that as scientists, the professors value a students’ ability to independently evaluate evidence and come to their own conclusions, and therefore see “acceptance” as forcing the student to betray their own skeptical evaluation, but have a competing desire to help students’ see what is obviously true to the instructor. It may also be the case, as some participants alluded to, that they think acceptance of evolution is an unrealistic goal, because it is too hard to change students’ minds who have already rejected evolution, and

would therefore be setting themselves up for failure by making acceptance their goal. These reasons are anecdotal, however, and further investigation is needed to identify why professors provided contradictory statements about their goals.

Why are the Participants Omitting a Discussion Addressing Religion while Teaching Evolution?

The confusion and ambiguity of participants' goals as an educator might explain why professors did not report using strategies that may help religious students be more open to evolution, such as discussing the spectrum of viewpoints among religions regarding evolution, or providing students with religious scientist role models with whom students can identify. If understanding of evolution is the only goal of instruction, then it is easy to see why instructors would think discussing religious ideas do not belong in a science class, because supernatural entities cannot be addressed using science. In fact, many participants did indicate that they thought this topic was inappropriate for a science class.

Another factor that may explain why the participants have not been engaging in strategies related to discussing religion is the participant's personal inexperience with a world-view conflict with evolution. All participants reported that they never experienced a world-view conflict with evolution. If they have not experienced the same conflict that many of their students are currently struggling with, they may think the subject is unimportant and that discussions of religion will be unlikely to make an impact. In fact,

some participants said that they thought discussing religion would be unlikely to affect their students' views, even when the researcher cited studies that had shown otherwise.

The professors also may decide this topic is unimportant because they overwhelmingly agree that a creator had no part in evolution, even among professors who reported identifying as religious. This may make them uncomfortable discussing views that include a supernatural component to evolution. As mentioned, one participant explicitly admitted in his interview that he would be uncomfortable telling students they could believe in a “supreme being” and evolution. However, biology educators should be cognizant of their own biases. Philosophically speaking, the processes we use to obtain knowledge in science cannot allude to the presence or absence of any supernatural influence on the material world. So, if a student accepts everything we have observed in evolution, but also believes that a creator started or planned the process, even if they believe a creator intervened and guided evolution for specific purposes, science educators have no reason, based on scientific inquiry, to directly state or imply that this could not be or is likely not the case. It might be hard for biology professors to do this, given that the majority of them do not believe a creator had anything to do with evolution. However, they must recognize that believing a creator was not involved in evolution is just as much of a “belief” as believing that a creator did have something to do with evolution. It is important for educators to help students understand that they can believe in a supernatural influence and accept evolution if our goal is to help the 52% of ASU students who are religious accept evolution (Brem et al., 2003).

Further, it is worth noting that even among the professors who are addressing religion, most are presenting it in ways that are likely ineffective. Of the four professors who said they addressed religion, one assigned a book and couldn't remember what it said about religion, so no inquiry can be made about its possible effects. Another purposefully omitted a discussion of Christianity. This is problematic in that Christianity is the most prevalent religion of Americans, so most students who are religious will likely be looking for ways to reconcile Christianity with evolution. The last professor told students that if you are part of a fundamentalist religion, then you can't believe in evolution. This might persuade some students who come from fundamentalist backgrounds to confirm their disbelief in evolution, rather than help them to be more open to evolution.

Limitations

There are several limitations to this study that warrant further exploration. First, as with most qualitative studies, the results are gathered from a small and homogenous population. In this instance, it was 15 tenured biology faculty members at one institution who teach undergraduate biology classes. It is hard to generalize about biology professors more broadly from the data gathered here. Second, the instructors in this study were to some extent, self-selected. The researcher limited the invitation to a population of certain characteristics, but those that chose to accept the invitation may have characteristics different from the population that chose not to participate. For, instance it could be that those who chose to participate are more interested in evolution education than those who

did not, and would therefore have more nuanced and developed views than the others who chose not to participate.

Also, professors may not always know the reasons for their beliefs. Social psychology has shown that many times one will have an initial gut feeling and then post-hoc, come up with justifications for that intuition (Haidt, 2001). Thus, professors may construct reasons on-the-fly and this may not represent the true nature of their thoughts and beliefs. Further, given the perceived “battle” between “creationists” and “evolutionists” the participants may have been unwilling to say anything that might contradict an orthodox view of evolutionary theory.

In order to achieve inferences about a larger population, it would be helpful to interview more instructors from institutions that vary in religious affiliations, scientific training, and geographic locations, to see if there are obvious differences among groups interviewed. Further, the results of interviews can then be validated in a larger group of people by constructing a survey measure using the various themes that emerged from the interviewed.

CHAPTER 7

CONCLUSION

As previously cited, the rejection of evolution has remained relatively stable in the US for over thirty years (Gallup, 2012), which warrants a change in education strategies if acceptance of evolution is the goal of evolution education. However, given the results of this study, professors might be confused about their goals, which in turn might lead to confusion over which strategies are appropriate. Discussing religious viewpoints in relation to evolution and providing students with examples of religious scientist role models has shown promising results in eliciting acceptance. However, before educators can explore using these strategies, it will be important to help professors understand that acceptance of evolution is a goal of evolution education, to create well-defined goals of what students should accept about evolution, to help professors understand how acceptance is different from understanding, and why the two warrant different educational strategies. Further, it will be imperative to help instructors understand that they have their own belief systems that influence their teaching of evolution, such as their lack of belief in any supernatural influence on the history of life on Earth, and that this belief, if injected into their instructional methods, could be persuading religious students to reject evolution.

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