Without the light of evolution: A case study of resistance and avoidance in learning to teach high school biology

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Abstract: In this article we present the case of Michael, a prospective high school biology teacher, in order to explore the implications of teacher resistance and avoidance to the topic of evolution. This case is drawn from a year-long qualitative research study that examined Michael’s process of learning to teach high school biology, and describes how his avoidance of evolution in his own education led to further disengagement with evolution in his methods coursework and in his student teaching practice. Paradoxically, his high academic abilities obscured substantive knowledge gaps about evolution, and his content knowledge regarding evolution did not appear to improve as a result of his student teaching experience. Kohl’s concept of “not-learning” is useful in understanding Michael’s avoidance of learning evolution. His use of the discourse of evolution in coursework and in student teaching activities also helped to obscure his opposition to learning evolution. The authors present an argument that proficiency for teaching biology means not only tolerating evolution as a topic to be covered in class, but also advocating for evolution as a foundational theme in the discipline. This research has implications for both the admissions process and curriculum of biology teacher preparation programs.

Keywords: science teacher education, evolution, evolution education, conceptual change, biology teaching

Recent publications have brought attention to the fact that many new teachers certified to teach biology each year still hold only a limited understanding of the key concepts of evolution (Berkman, Pacheco, & Plutzer, 2008; Ha, Haury, & Nehm, 2012). In one respect these new biology teachers are hardly different from their peers in other science teaching disciplines, who often find that their own academic successes in high school and college-level science courses do not necessarily translate into a facility to teach the fundamental ideas of their subject to students (Abell, 2007). These new teachers certainly face the challenge of strengthening their content knowledge over time (Davis, Petish, & Smithey, 2006), but another issue complicates the teaching of evolution beyond its conceptual complexity.

In a 2008 report examining the perspectives of U.S. high school biology teachers on evolution, researchers found that 48% of the biology teachers surveyed agreed or strongly agreed that creationism or intelligent design was “a valid, scientific alternative to Darwinian


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explanations for the origin of species,” (Berkman et al., 2008). Further, 16% of the high school biology teachers surveyed agreed that “God created human beings in pretty much their present form sometime in the last 10,000 years or so,” as did nearly half of the non-teaching population. The general public’s attitudes and understanding of evolution is troubling enough, but it is even more disconcerting to consider that nearly a sixth of all high school biology teachers reject one of the central tenets that holds their discipline together. One is hard-pressed to imagine a similar number of chemistry teachers rejecting atomic theory. As Dobzansky (1973) remarked, the discipline of biology will inevitably be represented as “a pile of sundry facts,” (p. 129) in such teachers’ classrooms.

In terms of teacher preparation, it is reasonable to ask how such a state of affairs is possible. After all, regardless of the duration, components, and pathways into teaching, teacher preparation programs all share the common attribute of ensuring that prospective teachers have attained the knowledge and skills to be a teacher in their discipline. There are a number of ways that teacher preparation programs and state certification officials are supposed to ensure this level of competence. Certainly one’s grades in undergraduate biology courses are an important indicator for determining if an individual knows the content well enough to teach it. Therefore teacher education programs routinely examine applicant transcripts, and the grade point average in one’s major is taken as strong evidence of one’s subject matter knowledge. Standardized tests such as the PRAXIS II represent a more direct measure of subject matter knowledge for teaching, and are currently mandated in most states as a prerequisite to being permitted to enter the classroom either as a student teacher or a teacher of record (National Council on Teacher Quality, 2010).

For those in university-based or clinical preservice teacher preparation programs, another indicator of prospective biology teacher quality is one’s performance during student teaching, residency, or other probationary period. These programs regularly require classroom evaluations by both school and program personnel to assess and document individuals’ competence and progress in several areas of practice, including subject matter knowledge (Clift & Brady, 2005). Prospective teachers who can demonstrate knowledge in their subject area, along with competence and professionalism during student teaching, will very likely receive teacher certification upon the completion of their program’s requirements.

There is little doubt that gaps in certain areas of novice teachers’ subject matter knowledge are a common and normal occurrence in learning to teach (Abell, 2007; Oxford, 1997). Some studies show that new science teachers are able to better integrate their content knowledge during their first years of teaching (Davis et al., 2006), while other researchers suggest that new teachers’ self-reports of subject matter knowledge gains are more readily attributed to increased confidence (Lemberger, Hewson, & Park, 1999), even if the common wisdom that “teaching a topic is an excellent way to learn it” remains true (Hewson, 2006, p. 123). In either case, it is not clear that such findings hold true for knowledge and teaching in regard to evolution. Therefore, it remains a matter of great concern that many prospective teachers see creationism and intelligent design as plausible alternate explanations for the history of life on Earth and hold regressive views about evolution.

Accepting the findings of studies such as Berkman et al. (2008) and Ha et al. (2012) implies recognizing that a substantial number of preservice biology teachers are acquiring teacher certification each year without an understanding of evolution as the explanatory framework for the diversity of life. Much of the existing research on teacher understanding of evolution has been survey-based, a methodology that has proven more than adequate in
portraying the overall knowledge, skills, and beliefs of biology teachers. Yet we remain ill-informed as a field when it comes to understanding how individual teachers navigate the task of becoming credentialed to teach biology despite demonstrating only a limited understanding of the key concepts of evolution. It has been claimed that teacher education programs are a weak intervention that contribute little to one’s development as a teacher (Ballou & Podgursky, 1998), but this is not a credible argument for critiquing subject matter knowledge gaps, given the fact that more than 16% of science teachers did not major in their main teaching assignment subject area (Aud, Fox, & KewalRamani, 2010). If anything, teacher education programs offer an additional opportunity to ensure that prospective biology teachers have the requisite knowledge to teach evolution. An in-depth understanding of how biology teacher preparation falls short in this regard is clearly necessary in efforts to improve the teaching of evolution in schools and expand the research base on learning to teach evolution.

In this study, we explore the idea that assenting to learn evolution is a crucial and previously overlooked aspect of biology teacher preparation. Indeed, the vigorous opposition to learning evolution among certain segments of the population in the United States and Canada had led to a movement to allow parents to “opt out” of evolution education for their children (Pennock, 2010). The idea that some preservice biology teachers may similarly opt out of learning evolution themselves seems a plausible explanation for the findings of Berkman et al. (2008) discussed above, though the pathway to becoming a certified biology teacher would appear to be more difficult in such cases.

Consequently, the research question addressed in this study is: What is the role of one’s “assent to learn” evolution in the development of a preservice biology teacher? More specifically, we investigate how an academically successful individual is able to progress through a high school biology teacher preparation program without developing an understanding of evolution as the explanatory framework for the diversity of life.

To this end, we have identified such a teacher who fits this description, and further, appears to have done so in a manner that was undetected by his instructors. We present the case of Michael, an undergraduate biology major enrolled in a teacher certification program, whose academic work and teaching was considered to be exemplary by both his university professors and his cooperating teacher. Yet an examination of his thinking about teaching and learning biology over the final year in his teacher certification program shows how he successfully avoided learning evolution as an organizing concept in biology.

We wish to be clear on one point at the outset: this work is both an empirical case study and a theoretical exploration. To say the least, the identification of multiple individuals like Michael would be a tremendous logistical challenge—imagine the process of finding participants for a research study who are both highly regarded by their biology teacher preparation program yet willing to admit that they do not accept evolution—and in many ways the present case takes advantage of serendipitous opportunity to learn from a unique situation. The overarching purpose of this article is less about portraying each and every aspect of Michael’s experiences for the sake of mapping causality in his learning to teach, and more about trying to understand what implications a case like his has for the role of teacher education in the preparation of biology

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4 However, all high school teachers in the United States are required by their state credentialing office to possess at least a Bachelor’s Degree (United States Department of Education, 2002).
5 At this writing, four U.S. states (Missouri, Oklahoma, South Dakota and Virginia) have introduced legislation that seeks to provide a legal basis for parents to opt their children out of evolution education. To date, these efforts have not been successful.
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teachers for U.S. schools. Given the large numbers of biology teachers who avoid or minimize the topic of evolution in their teaching (Berkman et al., 2008), as well as what we as a field have come to know about the continuum of teacher learning (Feiman-Nemser, 2001), these implications may be more significant than has previously been realized.

Background

Understanding vs. accepting evolution

For the purposes of this article, it is important to make clear the differences between understanding evolution and accepting that evolution represents a true and valid explanation of speciation (Nehm & Schonfeld, 2007; Smith, 2010a; Smith & Siegel, 2004). In the following section, we aim to define these terms operationally, and also link them to the conceptual change model of learning as it has been deployed in science teaching and learning (Hewson, Beeth, & Thorley, 1998; Larkin, 2012b; Posner, Strike, Hewson, & Gertzog, 1982). As will be detailed below, it is helpful to consider the construct of “understanding of evolution” mapped to the conceptual change status criteria of intelligibility, and “acceptance of evolution” as correlated with the status criteria of plausibility.

Understanding evolution. In a recent study exploring the validity of assessments of evolution, Nehm and Ha (2011) put forth three key concepts underpinning an understanding of evolution: “(1) The presence and causes of variation (mutation, recombination, sex); (2) The heritability of variation; and (3) The differential reproduction and/or survival of individuals.” Perkins (1998) suggests that evidence for understanding a concept rests in the ability of an individual to “to think and act flexibly with what one knows,” (p. 40), a perspective echoed in recent syntheses about human learning (Bransford & Donovan, 2005; Donovan, Bransford, & Pelligrino, 1999). Therefore, for the purpose of definitional clarity in this article, an individual with the ability to engage in evolutionary reasoning using Nehm & Ha’s (2011) three key concepts would be considered to have an adequate understanding of evolution.

Scholars have questioned whether individuals’ evolutionary reasoning operates differently depending on the time scales under consideration, commonly separated into the broad categories of micro- and macroevolution (Nadelson & Southerland, 2009). Microevolution refers to processes occurring at the organismal level that act on genomes, individuals or populations. Natural selection is perhaps the most vivid example of microevolution. In contrast, macroevolution concerns “processes that occur at the level of species (e.g., blue whale) and above (e.g., cetaceans, mammals, vertebrates), resulting in the formation, radiation, and extinction of higher groups of taxa,” (Novick & Catley, 2013, p.140). In the present study, we remain cognizant of this distinction while seeking evidence of understanding evolution at either scale.

Ascertaining an individual’s understanding of evolution can also be informed by drawing upon the decades of work on the development of a conceptual change model of learning in science. Of interest in the present study is the construct of status, which is measure of an idea in the mind of the holder that permits consideration of its explanatory power in comparison to other ideas. The status of an idea “is an indication of the degree to which the person holding it knows it, accepts it, and finds it useful,” (Hewson et al., 1998, p. 207), and it commonly indicated by three measures when under consideration: intelligibility, plausibility, and fruitfulness. This first component of intelligibility is closely linked to our earlier definition of understanding:

Intelligibility at a superficial level requires an understanding of the component terms and symbols used and the syntax of the mode of expression…Intelligibility
also requires constructing or identifying a coherent representation of what a passage or theory is saying (Bransford & Johnson, 1973). In fact, we would claim that no theory can function psychologically at all unless it is internally represented by the individual. (Posner et al., 1982, p.216).

Clearly, an understanding of evolution must be grounded in intelligibility of its component terms and concepts, and engaging in evolutionary reasoning would seem dependent on access to an internal model of evolution to draw upon—even if this model is not completely congruent with scientifically accepted knowledge.

**Acceptance of evolution.** The notion of acceptance is deeply intertwined with the construct of “belief,” and though it is not our intention to make fine philosophical distinctions between belief and acceptance here, it is worth noting that beliefs act as a perceptual filter for interpreting new phenomena (Pajares, 1992), and the subject matter of evolution is certainly ripe for such filtering. We define acceptance of evolution here broadly as being in agreement with the proposition that the theory of evolution—writ large—is true.

In many ways, this definition is consistent with the construct of plausibility in the conceptual change model of learning. Returning once more to the foundational work by Posner et al (1982), the criteria they set forth for initial plausibility of an idea can be applied quite well to an individual’s acceptance of evolution:

- There appear to be at least five ways by which a conception can become initially plausible. 1) One finds it consistent with one’s current metaphysical beliefs and epistemological commitments, i.e., one’s fundamental assumptions. 2) One finds the conception to be consistent with other theories or knowledge. 3) One finds the conception to be consistent with past experience. 4) One finds or can create images for the conception, which match one’s sense of what the world is or could be like. 5) One finds the new conception capable of solving problems of which one is aware (i.e. resolving anomalies). (p. 218)

The first factor would seem to be the most salient in the present discussion, given that one of the major barriers to individuals’ acceptance of evolution appears to be a conflict with religious beliefs (e.g. Meadows, Doster, & Jackson, 2000). The fourth becomes important as the sense of “what the world is or could be like” is applied to one’s own identity, as discussed below.

Note that in Posner et al., the intelligibility of an idea is not mentioned as an aspect of plausibility. While it would seem logical that one must first understand an idea first before finding it useful, we demonstrate in the following section that this need not be the case in regard to evolution.6

**Linkages between understanding and acceptance of evolution.** It is quite possible for an individual to demonstrate an understanding of evolution’s central concepts, yet not accept that evolution is true (Meadows et al., 2000; Sinatra, Southerland, McConaughy, & Demastes, 2003). Conversely, it is also quite possible for someone to hold dogmatic beliefs about evolution without a firm understanding of the ways in which concepts such as variation within species, the molecular basis for inheritance, and natural selection form a coherent explanation for the history of the diversity of life on Earth. While accepting or understanding is neither “a prerequisite nor

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6 While it would appear that an idea must first be intelligible to be plausible, and plausible to be fruitful, there are exceptions. Hewson (personal communication) points out that quantum mechanics has been found to have strong explanatory power (i.e. it is fruitful), despite it being rather implausible to many of those who still find it useful. Similarly, evolution may seem quite plausible to some people who are unable to meet the criteria for the idea’s intelligibility.
necessary condition of the other” (Ingram & Nelson, 2006, p.10), research does support a positive correlation between understanding evolution and acceptance of the belief that evolution is true, even though there is little evidence either way on the direction of causation between the two (Smith, 2010a). Smith and Siegel (2004) suggest that belief typically follows understanding in cases when individuals do not hold extra-scientific convictions concerning the topic. Research clearly demonstrates that people are able to articulate the relationships between their beliefs about evolution and their religious beliefs (Colburn & Henriques, 2006; Meadows et al., 2000; Winslow, Staver, & Scharmann, 2011).

In a comprehensive review of the philosophical and epistemological issues arising in the teaching and learning of evolution, Smith (2010a) notes that religious beliefs, particularly fundamentalism, are commonly a negative predictor of understanding and acceptance of evolution. He also suggests that desirable goals for evolution instruction include, “understanding of evolutionary content, acceptance of evolution as the best scientific explanation of species change and belief in the validity of evolutionary theory as an effective basis for decision making in the real world,” (p.526). Yet Smith further cautions, “changes in beliefs are inappropriate goals on which students are to be evaluated,” (p.526).

Studies suggest that many biology teachers are either undecided about or do not accept evolutionary theory (Berkman et al., 2008; Rutledge & Warden, 2000). From a national survey of high school biology teachers, Berkman and Plutzer (2008) noted that a majority of biology teachers in the United States “either avoid human evolution altogether or devote only one or two class periods to the topic,” (p. 923). For example, one study showed that 43% of biology teachers in Indiana avoided or all too briefly addressed evolution in their classrooms as a result of religious beliefs that appeared to constrain their understanding of the scientific validity of evolution (Rutledge & Mitchell, 2002). Other research similarly details the ways in which teachers display a less than informed approach to the teaching of evolution in their classrooms, or even avoid it altogether (Blackwell, Powell, & Dukes, 2003; Rutledge & Warden, 2000; Smith, 2010b).

There is evidence that despite the existence of both science-education standards and legal mandates in several states that support the teaching of evolution, many teachers—depending upon their knowledge of evolutionary science, attitudes toward the standards, or understanding of the legal issues associated with the teaching of evolution and creationism—advocate neither evolutionary biology nor alternate viewpoints in their classrooms (Aguillard, 1999; Berkman & Plutzer, 2011; Donnelly & Boone, 2007; Moore, 2002, 2004). One case study of New York City biology teachers revealed that 45% of biology teachers in the study preferred that students be taught at least some creationism in the classroom (Nehm, Kim, & Sheppard, 2009).

Other studies report the ways in which creationism continues to be given equal attention to evolution in science classrooms (Moore, 2007). Findings from a study of 10th grade teachers’ professional goals, practices, and pedagogical thinking concerning evolution revealed the significant impact of social and professional identity, lived experiences, and state mandates on those teachers’ decisions about whether to teach evolution (Goldston & Kyzer, 2009).

Preservice teachers’ understanding and acceptance of evolution

As a group, secondary preservice teachers (Deniz & Donnelly, 2011) and elementary preservice teachers (Rice & Kaya, 2012), as well as non-biology teachers (Nehm et al., 2009) do not appear to be markedly different from biology teachers as a whole in their acceptance of evolution. A study examining the evolutionary reasoning patterns of 167 pre-service biology
teachers and pre-service non-biology teachers revealed that both had “mixed” and “novice naturalistic” evolutionary reasoning patterns (Nehm et al., 2009). Teachers in both groups exhibited significant misconceptions about evolution and the nature of science, displayed antievolutionary positions, demonstrated weak connections between knowledge and belief variables, and showed no change in preference for teaching evolution over creationism even after having taken coursework in evolution.

Pre-service biology teachers’ entering beliefs about creationism and evolution often persist beyond academic preparation for science teaching and into their classroom teaching (Kim & Nehm, 2011; Moore, 2008). Teachers’ and pre-service teachers’ comfort with teaching evolution is also related to their position in their respective professional communities, and their awareness of the importance of evolution to their constituencies (Dotger, Dotger, & Tillotson, 2010; Lazarowitz & Bloch, 2005; McGinnis & Simmons, 1999). Certainly, the wide range of orientations toward the teaching of evolution described in the previous section influences the school and departmental contexts into which preservice and novice biology teachers are ultimately socialized.

Ha et al. (2012) articulate a construct that they call “feeling of certainty” that they report to hold some predictive power in terms of pre-service biology teachers’ acceptance of evolution, though as in the case of “understanding,” ascertaining the direction of causality is difficult at best. One insight from this line of research concerns the importance of “intuitive cognitions” in the learning of evolution, and that resistance may be rooted in the feeling that one is correct about a particular worldview. These results align nicely with the body of “warm conceptual change” research (Pintrich, Marx, & Boyle, 1993; Sinatra, 2005; Strike & Posner, 1992), which points to the necessity of including affective considerations in any model of conceptual change.

Theoretical Framework

Withholding Assent to Learn

There can be many explanations as to why a learner may choose not to engage in an act of learning (e.g. physical discomfort or fatigue, an inhospitable environment, a perception of extraordinary difficulty, etc.) but the focus in this section are those reasons connected with a rational intention not to learn. In this study, we frame such a position as withholding assent to learn, and see such a choice as intimately connected with the protection of the image of oneself.

In a classic essay on the topic of face, a construct that has become closely recognized as an aspect of identity half a century later, Goffman (1967) writes, “The surest way for a person to prevent threats to his face is to avoid contacts in which these threats are likely to occur,” (p. 15). If learning is considered a threat to one’s face/identity, then certainly avoiding opportunities to learn is a way to save face. Yet such a position is difficult to maintain if one is to live in the world, and encounters with threats to one’s identity often cannot be avoided completely.

Goffman notes that in situations such as these, “other kinds of avoidance practices come into play. As defensive measures, he keeps off topics and away from activities that would lead to the expression of information that is inconsistent with the line he is maintaining,” (p. 16).

In discussing the everyday circumstances of students either granting or withholding assent to learn, Erickson et al. (2008) note: “No classroom system of surveillance and/or

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7 Goffman states that: “Face is an image of self delineated in terms of approved social attributes—albeit an image that others may share, as when a person makes a good showing for his profession or religion by making a good showing for himself.” (p. 2)
surveillance-linked distribution of rewards and punishments can prevent the withholding of student assent to learn when the risks of face threat for learners is high,” (p.205).

In a classic essay in which he uses his own childhood refusal to learn Yiddish as an example, Kohl (1994) discusses the phenomenon of capable students who make a conscious choice not to learn certain things. He calls this intentional and active refusal to learn “not-learning” to distinguish it from an inability to learn, and notes:

Failure is characterized by the frustrated will to know, whereas not-learning involves the will to refuse knowledge. Failure results in a mismatch between what the learner wants to do and is able to do. The reasons for failure may be personal, social, or cultural, but whatever they are, the results of failure are most often a loss of self-confidence accompanied by a sense of inferiority and inadequacy. Not-learning produces thoroughly different effects. It tends to strengthen the will, clarify one’s definition of self, reinforce self-discipline, and provide inner satisfaction. Not-learning can also get one in trouble if it results in defiance or a refusal to become socialized in ways that are sanctioned by the dominant authority. (p. 6)

“Not-Learning” Evolution

In the present study, we propose that it is possible to make sense of a preservice biology teacher’s degree of understanding and acceptance of evolution through this lens of not-learning. Meadows et al. (2000), explored a similar notion in the interpretation of their study’s findings:

For teachers who may think their students' religious beliefs are not conducive to learning about evolution, a majority of participants in the study sent a clear message that simply increasing their understanding of evolution did not change their personal beliefs about it. In particular, students…may actively resist learning about evolution. When they perceive a conflict between their religious beliefs and new lessons about evolution, students may choose to hold on to their religious beliefs. These students do not fail to learn about evolution as teachers often think; instead, they actively choose not to learn about evolution. (p. 106)

We work from the assumption that people wishing to become biology teachers are educable agents of their own learning, and that not-learning as depicted by Kohl (1994) is an individual and autonomous act of human agency. Like other well-known forms of school resistance described in the literature (e.g. Abowitz, 2000; Fordham & Ogbu, 1986; Willis, 1981), not-learning can be individualistic and/or sociocultural in nature, with the aim of preserving one’s sense of self and/or cultural identity. From this perspective, acquiescing to learning evolution will only widen the gap between an individual’s self-conception and who she/he really wishes to be; Sfard and Prusak (2005) helpfully term these the actual identity and the designated identity. Actual identities are the stories people tell about themselves in the present tense, while designated identities are “stories believed to have the potential to become a part of one’s actual identity,” (p. 19). Narratives such as “I want to be a good Christian” or “I have to be better prepared as a teacher” are representative of designated identities, which often use the future tense to express commitment, obligation, wishes, or necessity.
The connection of designated identities to the act of not-learning is in the resistance to becoming the type of person one does not wish to be, such as an “evolutionist.” Other examples are not difficult to imagine, such as the case of a person who does not wish to learn how to aim and fire a rifle at a shooting range out of a wish not to think of oneself as someone who uses guns. Simply put, the designated identity serves as a beacon for action on the part of a learner, and the avoidance of learning particular knowledge actually serves to further an individual’s desired goal of closing the gap between actual and designated identities.

In the present study, we use Kohl’s notion of not-learning as an explanatory framework for analyzing the case of a preservice biology teacher who successfully avoided learning how to teach evolution, while simultaneously reinforcing his designated identity as an excellent college student, a professional and effective student teacher, and a faithful Christian.

Learning to teach as a process of conceptual change.

The conceptual change theory of learning serves as a useful theoretical framework here, given this article’s focus on the question of understanding how an individual can go through a biology teacher certification program without developing an understanding of evolution concepts. At issue is the question of why conceptual change does not occur in the direction of an improved understanding of evolution. There is a robust literature on teaching for conceptual change in science (Anderson, 2007; Hewson et al., 1998; Posner et al., 1982), the conceptual change process regarding learning evolution specifically (Evans, 2008; Kalchman & Koedinger, 2005; Sinatra et al., 2003), and even in science teacher education (Hewson, 1992; Hewson et al., 1999; Russell & Martin, 2007). A subset of this literature emphasizes the intentional nature of conceptual change and the role that affective considerations play in learning (Sinatra, 2005; Sinatra & Pintrich, 2003).

In teaching for conceptual change, a central principle is that learners’ ideas are themselves the objects of cognition, and that the status of ideas is explicitly compared, and justification is offered for one’s decisions for an idea’s status. Another is the role of the learner’s conceptual ecology that underscores the relationships between knowledge, beliefs, affective considerations, and epistemological commitments (Hewson et al., 1998). In the analysis of the present study, we deploy conceptual change theory primarily to describe the conceptions about teaching evolution under the participant’s consideration. In the final section of the paper we will return to the framework of teaching for conceptual change in order to identify some of the implications for science teacher educators.

Method

Identification of the participant. This research is framed as an instrumental case study (Stake, 1995, 2005), the purpose of which is to gain insight into the issue of why some biology teachers do not possess an adequate knowledge of evolution, even after graduating with an undergraduate biology degree and obtaining teacher certification. The case of a single individual cannot purport to uncover broadly generalizable findings, but qualitative research of this sort does offer the potential to help make sense of puzzling phenomena and suggest avenues of inquiry for future investigations.

The boundaries of the case are the experiences of a preservice teacher named Michael, who was learning to teach biology in a teacher education program over the course of this study. Michael was an undergraduate biology major at Central State College, a mid-sized public
university in the Midwest United States, and was enrolled in the final year of his science teacher education program during the 2008-2009 academic year when this study took place. A White male in his mid-20s, Michael voluntarily identified himself as a Christian during the interviews.

This case is drawn from a more-expansive research study (Larkin, 2012a, 2013) that examined the process of learning to teach high school science for understanding and equity. Participants in the larger study included 14 preservice secondary science teachers in four different teacher preparation programs in the United States, each of whom provided multifaceted data on their conceptions about teaching science during both coursework and fieldwork semesters. Participants for the study were recruited with the aid of their science teacher education programs, and Michael was one of three participants from Central State College. Stake (1995) suggests the selection of cases be based upon the opportunity each offers for learning. Given the larger project’s focus on conceptions about teaching and the emergence of Michael’s struggles with evolution as a central theme in his case, the prospect of an in-depth examination of preservice teacher resistance toward learning to teach evolution seemed worthwhile to pursue.

Sources of data. Data were collected from multiple sources throughout Michael’s final year in his teacher education program, and included pre- and post-student teaching interviews, questionnaires, and two observations of student teaching. Michael also provided a USB drive at the end of the school year containing electronic copies of all of his university course work assignments, lesson plans, and teaching materials, such as worksheets and slide presentations. The interview protocols and questionnaires for this study were developed by employing the structures used in the Teacher Education and Learning to Teach (TELT) Study (Kennedy, Ball, & McDiarmid, 1993; NCRTE, 1991), which were then adapted to incorporate biology content. The TELT teacher educator interview protocol was also used to interview the university faculty member who served as Michael’s Methods of Teaching Science instructor and director of the secondary science teacher education program at Central State College. All of the protocols are available in Larkin (2010).

The first author conducted two formal 90-minute interviews with Michael, the first in the early fall during his last semester of coursework, (which included a Methods of Teaching Science class) and the second in the early days of June at the end of his student teaching experience. In this semi-structured interview, there was one question in particular (see Figure 1) that served as a catalyst for our discussions about evolution, and in both interviews a substantial amount of time was spent discussing the topic. The question was adapted from the TELT protocols as a probe how respondents would respond pedagogically to student difficulties with a particular concept. This question was designed purposefully to remove the issue of the origin of life on Earth from the assessment of an individual’s understanding of evolution, a common error in evolution assessments (Smith, 2010b).

(figure approximate placement of Figure 1.)

Analysis. In Michael’s case, data from all of the sources were coded and analyzed for themes pertaining to learning to teach evolution, and then systematically examined for how the participant’s knowledge of evolution impacted his writing and teaching practice from the time of

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8 All names of institutions and individuals in this research are pseudonyms
9 In the mathematics version of the TELT instruments (Kennedy et al., 1993), place value was the issue used to examine pedagogical responses to student difficulties. In the version that probed knowledge of teaching writing, the issue was possessives and the use of apostrophes.
his coursework through his full time student teaching. The goal of any case study is to understand the case itself, and in the progressive focusing process (Stake, 1995), the theme of resistance and identity preservation became apparent. At that point, the theoretical framework of not-learning (Erickson et al., 2008; Kohl, 1994) discussed above appeared to offer the most explanatory power for Michael’s case, and was used to analyze the findings into the three emergent themes presented below. The case narrative, findings, and discussion were shared with the individual who was Michael’s university supervisor and program director. While she found the details of the case somewhat surprising, she assented to its findings. She also noted that other biology teachers in the district where Michael did his student teaching—even others with an in-depth understanding of evolution—simply choose not to teach evolution in order to avoid conflict with the community.

Member Check. The first author remained in contact with Michael, and in the spring of 2014 sent him a draft of the manuscript to read and comment upon. As a result, minor changes were made in some of the factual details of the case, and he provided feedback on the authenticity of the manuscript’s depiction of his learning to teach biology. To be clear, Michael wrote in response to reading the case: “I agree that it is an accurate representation of my experiences,” (Michael, personal communication, 27 April 2014). His comments on our interpretations of his thinking and actions are woven into the narrative of case below.

Limitations. There are a number of limitations of this study, rooted primarily in the fact that the larger study from which the case of Michael is drawn was not specifically designed to investigate preservice teacher learning of evolution, even though in his case it was an issue that emerged rather readily. As a result, many of the instruments used to investigate evolutionary understanding and acceptance in other research studies were not used here. While there was an effort to probe Michael’s broader understandings of the nature of science using the questionnaire, the tool used proved far too coarse to gain a clear sense of the relationship between his views on science and his resistance to learning evolution.

Another important limitation to this study is that it did not commence until the completion of Michael’s biology course-taking for his major (a requirement for student teaching at his university). Therefore all of the information about his coursework is based on self-report data, and though his 4.0 GPA was independently confirmed through the university website announcing the Dean’s List students for the semester, this study did not independently attempt to assess his biology content knowledge. Understanding how an individual such as Michael actually navigates the weekly readings and assignments of an undergraduate evolutionary biology course would be a valuable addition to a study such as this one.

The case of Michael

Michael recalled that he had shown an interest in biology since his experiences in middle school, when one of his teachers taught in what he now recognizes as an “inquiry-based” manner. His mother was a teacher, and he reported being aware of the emotional satisfaction she

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10 In one sense this analysis was similar to that undertaken for the six cases described in Larkin (2013), with the exception that the focus of analysis in those cases was on teacher learning regarding the pedagogical implications of student diversity, rather than on learning to teach evolution. In Larkin (2012a), the focus of the analysis was on preservice teacher conceptions regarding the elicitation of student ideas.

11 In both administrations of the questionnaire, he agreed with a view of science as a creative endeavor that produced knowledge by following experimentation and the scientific method, and agreed that controversies in science were usually based upon differing interpretations of data.
received from helping children learn, and his decision to pursue teaching as a career was ultimately influenced by his work with youth in his church. He spent two and a half years at a local community college before being accepted as a biology major into Central State College, where he spent an additional four years. He began in the two-year teacher education program during the fall of his junior year.

In the fall of his senior year, Michael was enrolled in a Methods of Teaching Science course, and completed a 100-hour practicum in a middle school science and math classroom. His program coordinator described him as a “star student,” and he had been recognized for his academic achievement on the Dean’s list with a 4.0 grade point average. While most teacher education students at his institution took five years to complete their degree and certification, Michael took an overload on his classes in order to finish at Central State in four years.

In the spring of his senior year, he was assigned a student teaching placement in a large comprehensive high school not far from his rural hometown. The community in which the school was located had just undergone a high-profile automobile plant closing, but the completion of construction on the school’s new science wing appeared to keep spirits high among the teachers. Michael’s cooperating teacher taught three sections of Biology as well as two Anatomy & Physiology classes. This cooperating teacher had worked in the district for more than ten years, and had served as a reliable placement for Central State’s biology student teachers many times in the past. By all accounts Michael’s student teaching was well-regarded. In fact, by the beginning of May he had accepted a biology teaching position in a neighboring community for the following fall.

Michael began his teacher preparation program wrestling with not only the concepts of evolution, but with the teaching of evolution as well. As a prospective biology teacher, he knew that he would ultimately be expected to teach evolution. Yet some of the key concepts of evolution—though not all, as will be shown—conflicted with his own personal beliefs about the origins and descent of life on Earth. This led to three distinct issues for him in learning to teach. The first was the matter of his fragmented content knowledge concerning evolution, and how such a view contrasted with the scientifically accepted view of evolution as a coherent organizing principle in biology. Second, his choice to “not-learn” evolution while seeking teacher certification meant that he had to navigate around the topic in a way that did not cause conflict with his program. His third challenge lay in the prospect of addressing evolutionary topics in the curriculum during student teaching. I describe each of these issues below before discussing his case more generally.

A fragmented understanding of evolution

Michael’s first challenge was learning the concepts of evolution from the perspective of an undergraduate biology major. This in itself appeared to pose little problem for Michael, who had clearly learned how to navigate his way to academic excellence in nearly every course he ever took. Yet, as demonstrated below, his knowledge of biology as applied to evolution appears to fit the knowledge-in-pieces description as characterized by diSessa (1988): "...a fragmented collection of ideas, loosely connected and reinforcing, having none of the commitment or systematicity that one attributes to theories." (p. 50)

The prospect of learning evolution deeply enough to represent the perspective of an “evolutionist” turned out to be more difficult than he anticipated in his undergraduate courses:
If you believe in creation, it’s still important for you to know the points of an evolutionist if you’re going to have a discussion with somebody….At first, when they brought it up, I was like, I told myself I really want to understand why they believe the way they do. And so I really tried to learn pretty hard, but then the longer it went, the more I found myself becoming disengaged. It seemed like there were too many “ifs” in there. You know, if this happened, and if that happened, and recreating all that. It sort of made sense but I couldn’t be 100% sure so I sort of became disengaged and let it go.

Through the lens of conceptual change theory, it appears that the concept of evolution was neither intelligible nor plausible to Michael and was therefore limited in its ability to offer explanatory power.

It appears that Michael’s academic grades did not accurately reflect his substantive knowledge of biology—at least concerning evolution—yet this situation not unknown in undergraduate science education (Lord & Rauscher, 1991; Medina, Ortlieb, & Metoyer, 2014). In fact, his experiences in learning evolution appear to have further reinforced his earlier metaphysical commitments, which Long (2012) refers to as the “backfire effect” in evolution education. The evidence from Michael’s interviews further indicates that his content knowledge regarding evolution did not improve as a result of his student teaching experience. Consider the following exchange prior to Michael’s field work and student teaching:

**Interviewer:** Suppose a student asks you how it is possible for all life on earth to have come from common single-celled ancestors?

**Michael:** I would say…are we talking about evolution?

**Interviewer:** Sure.

**Michael:** [laughs.] That’s very interesting. I was just reading this book [reaches into his backpack and pulls out “The Case for a Creator” by Lee Strobel].

**Interviewer:** Well, what are you thinking about in trying to think about how to respond to that student?

**Michael:** I guess I’m thinking, I’d kind of encourage the student to look up information on their own, because I don’t want to say, this is the way it is and this is fact because…we don’t know for sure what….exactly how life was formed I guess….I’d want them to do their own research and come up…say there’s….a side…you can use, you know, the model of…well, first there was the materials and chemicals that were available on earth, and then you have the lightning or electricity that formed amino acids which formed proteins which formed the cell. (Interview, 8 Oct. 2008)

Despite his impressive academic record, Michael was unable to articulate a response to the hypothetical student, and the best he was able to do was to recall random facts about the Miller and Urey (1959) experiment that are unrelated to the evolution of modern life from single-celled organisms. At the conclusion of student teaching nine months later, the same question presented similar difficulties:
**Interviewer:** Suppose you have a pupil who asks you how it is possible for all life on earth to have come from single-celled common ancestors. How would you respond?

**Michael:** I guess I would just explain to that student that that’s one of the widely accepted scientific theories that scientists approve of…

**Interviewer:** What if this didn’t seem to make sense to the student? Is there something else that you would try?

**Michael:** Well, I mean, you could always have them do their own research. Or I could provide them with resources that explain the theory… I guess what I would do is give them an example of an amoeba…and show how that engulfs its food particles. And then explain how some single celled organisms use similar concepts to engulf things like mitochondria, and then I’d have to explain what mitochondria do, and show how those organelles get into a cell, and then explain the process of cellular division to the student if they don’t know that already. I guess that’s how I would go about doing that. (2 June 2009).

Like the earlier interview, he gives an example that does not address the evolution of diverse forms of modern life from single-celled organisms. Instead he offers a basic (and perhaps Lamarckian) description of endosymbiotic theory. It appears that Michael’s “pieces” of knowledge (diSessa, 2008, 1988) about evolution are only vaguely related to one another.

However, Michael was able to find a rationale for learning evolution that fit with his beliefs, and he did so by making a distinction between macro- and microevolution. Such a cognitive accommodation has been previously noted in studies describing creationist reasoning (Evans, 2008). Prior to student teaching he said, “A lot of people feel that it’s either evolution or there’s creation, there’s no in between. I’ve read some stuff that there can still be creation and some micro-evolution, but not evolution from single celled organisms.” By the end of student teaching his assessment of evolution was more blunt, and he was clear about his reasons for not accepting macroevolution: “Personally I don’t believe we came from single celled organisms. So I guess what I would want to make sure that my students understood is that evolution means changes in a gene pool, and those genes result in physical characteristics that change.” He provided an example of the genetics of dog breeding to support this notion of variability in the gene pool, but he did not think that these small changes could possibly rise to the level of species change over time.

In reading a draft of this case, Michael commented upon his understanding of evolution at the time, as well as his developing perspectives on his struggle to reconcile his faith and evolution:

As I was reading your document, I began to really look at how well I understand evolution. After having taught for 5 years now, I have begun to realize just how much information on evolution I had not learned while in college. Based on my grades, I thought that I did have a solid understanding of evolution. At that time in my life, I was struggling to figure out what I believed to be true, and I was weighing my faith and the evidence presented for evolution. I agree that I was trying to find ways to fit them both together. However, I don't think I was "avoiding" parts of evolution on purpose. I think I was able to fit the evidence for evolution and my faith together at that time fairly easily in my mind because the curriculum in college was not as rigorous as it could have been. While in college,
I felt like I learned the information that my professors wanted me to learn, but since then I have had to go back and further my understanding. (Michael, personal communication, 27 April 2014).

**Navigating around evolution in teacher education**

The second problem for Michael was how to navigate his teacher education program in regard to the issue of evolution. His perspective on the rationale for learning evolution is instructive in making sense of his approach to the topic as a prospective teacher in a teacher education program. In a position statement on the teaching of evolution, the National Association of Biology Teachers offers an argument grounded in fostering scientific literacy, stating that evolution occupies a central place in biology curricula because of “its unifying properties and predictive features, the clear empirical testability of its integral models and the richness of new scientific research it fosters,” (National Center for Science Education, 2008, p. 155). Hence, the rationale for teaching evolution in high school biology from this perspective echoes Dobzansky (1973), and might be characterized by master science teachers as: *evolution has explanatory power for understanding the diversity and processes of life.* As will be shown below, it is not clear that Michael had a deep enough understanding of evolution to articulate this as a rationale. Yet he could still talk about evolution in ways that were acceptable to his professors, university supervisors, and cooperating teacher by refocusing his rationale for teaching evolution as *providing information so that students can make up their minds.*

In a written reflection describing a methods class meeting in which teaching evolution was discussed, he takes the position of a teacher who recognizes the topic’s importance, and expresses concern about students who might hold anti-evolutionary beliefs and argues that such students can still understand evolution:

> Of all the topics that we discussed in class, I believe that our discussion of how to teach evolution had the greatest impact on me. It is important for science teachers to think about the topic of evolution and educate themselves on ways of dealing with students who refuse to learn about this theory…I have realized that there are ways of showing students, especially those who believe that evolution doesn’t exist, that it is important to know and understand the process of evolution. (Portfolio, June 2009)

It is a compelling proposition to think that Michael is actually referencing himself when he describes “students who refuse to learn about this theory.” Later in the same reflection, Michael states, “…in order for a person to dispute evolution they must know its shortcomings. Therefore students who don’t believe in evolution must learn about evolution in order to have an intelligent conversation with someone who does believe in evolution.” For Michael then, one rationale for learning evolution can be characterized as *opposition research,* in that the process allows for one to gather evidence about a topic in order to better argue against it.

Like many other prospective science teachers (Davis et al., 2006), Michael was apprehensive about causing disruptions of any kind, and sought to minimize opportunities for conflict to occur. This was as true for his classroom as it was for his interactions with teacher education program, and his affable nature made it easy to avoid such conflict. Michael recognized that conversations and debates concerning student beliefs about creationism do not
belong in a science classroom. From a certain perspective, this is consistent with positions taken by organizations such as the National Center for Science Education (NCSE) and other professional scientific and educational association because, as the 2002 AAAS position statement on this matter states that along with creationism “the lack of scientific warrant for so-called ‘intelligent design theory’ makes it improper to include as a part of science education (National Center for Science Education, 2008, p. 22). Yet Michael’s reasons for doing so, however, had little to do with the non-scientific basis for this position, and more to do with avoiding conflict. After reading an article titled “Religion or Science: Revisiting the Scopes Trial In 7th Grade” by Conti and Pate (in Koballa & Tippins, 2004), Michael wrote the following reflection that effectively captures his approach to “not-learning” evolution in this activity:

Through reading the article, I have learned that this intelligent conversation must be done outside of class because this conversation may turn into a debate that will more than likely erupt into a heated argument and eventually tear the class apart. (Reflective essay, 10 Dec. 2008)

Michael’s affirmation of keeping the debate out of the classroom positioned him in a positive light with his teacher education program. Yet, it also allowed him to successfully avoid discussion of the pedagogy of actually teaching evolution.

**The avoidance of evolutionary topics during student teaching**

Michael was in his student teaching classroom from the end of January through the second week of June, as per the requirements for teacher certification in his state. The tenth-grade biology class in which he worked covered topics in cellular biology, genetics, and taxonomy during this time. There is no evidence in any of his lesson plans or teaching materials that Michael addressed evolution at all during his student teaching, and in our discussions at the conclusion of the semester he expressed relief that it had not been part of the second semester curriculum. To a biologist with a robust understanding of evolution, such a statement might seem patently absurd, so an example is in order.

I observed one lesson of the taxonomy unit in which Michael designed an Internet search activity for his students. Prior to the lesson, I talked with Michael’s cooperating teacher, who had very positive things to say about him. Michael began the lesson by stating, “Yesterday we started talking about the order [sic] chordates and the sub-order [sic] vertebrates. Which one looked like sponges?” A student responded with “tunicates,” and the review of the lesson continued. Michael them presented the task for students in that day’s class. “Today we’re going to look for the

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12 Though not the focus of this research, it is important to state that Michael’s student teaching experience was challenging for him in many ways, and the limitation of the analysis to only the aspects of student teaching related to evolution in this case study are not intended to present a simplistic portrayal of the student teaching experience. For example, in a reflection written in mid-May, Michael wrote the following passage that demonstrates his own feelings about his content knowledge for teaching:

At the beginning of this week, I was feeling slightly overwhelmed, but by the end of this week, I am pretty comfortable with where I am at in my teaching. I was teaching immunology this week and wasn’t really comfortable with the content at first. I felt like I was just keeping ahead of the students, and many times students would ask questions that I should have known and didn’t. This was really frustrating for me because I feel like I’m not doing my job if I am not able to answer many of the questions that students ask. I know that I’m never going to have all the answers, but I do think that I will be able to know the types of questions that students tend to answer the more I teach.” (Weekly reflection, 15 May 2009)
fastest vertebrates on land, air and water.” He handed out a graphic organizer for students to guide them in recording their findings, and the task required students to research the five fastest animals in each category and record the characteristics of each.

The class then moved to one of the recently completed science lab rooms to use the computers for this research. Students spent the majority of the period on this activity, and at the end of the class Michael led the class in a discussion in which he listed students’ findings about the shared characteristics of the fastest land animals on the board. After some discussion, he led the class to consensus that three important traits for speed included a flexible spinal column, fast contracting muscles, and four legs. “That’s pretty much what I wanted you to find,” he concluded as he collected the handout and the previous day’s homework at the bell. In this lesson on vertebrates there had been a complete absence of phylogeny; instead the focus had remained on the common characteristics that ensured continued survival of a particular species. Such an approach allowed Michael to address the curriculum without venturing into areas that were uncomfortable for him personally.

Michael recounted another lesson that further illuminated his approach to avoiding evolution in biology teaching. In an interview at the conclusion of his student teaching, he expressed an admiration of the “hands-on” activities his cooperating teacher had developed because he observed that they forced students to “think critically.” He then went on to describe one attempt to replicate this practice in his own teaching, in which he made modifications to a commonly used high school biology activity on evolutionary adaptation called “Battle of the Beaks,” (Scotchmoor, 2003). Michael recounted how the lesson unfolded in class, framing the goals of the activity in a way that were detached from concepts in natural selection:

We were learning about birds, so we were talking about their beaks and how they have different adaptations in their beaks for feeding on different types of food. So what I decided to do was to come up with different eating utensils, so I had a toothpick, a fork, a spoon, a knife—it was a plastic knife—and a pair of chopsticks. And so I had Skittles, and Cheerios, and pretzels, the stick pretzels, and so they each had to get a certain number of pieces of food in a certain amount of time, and if they didn’t get the required number of pieces of food, then they would go extinct. Then we had three pieces of food, and then six pieces of food, and so then you get into the competition, where, there’s not enough food for everyone to get six pieces of food, so we figure out who has the most efficient beak, things like that. (Michael interview, 2 June 2009)

He then went on to describe how students’ excitement with the competition aspect of the activity took them off-task, and he felt that they hadn’t understood the “gist of the activity.” His weekly journal similarly reflects his frustration with this lesson:

Again the students did not follow the directions even though we were going through the lab step by step as a class. At this point I became frustrated partly because I had spent a fair amount of time creating this activity and partly because the students were not following directions. Since the activity did not go according to plan, I explained to this group what the results should have been so they could answer the analysis questions that followed. (Weekly reflection, 29 May 2009)

Like many new science teachers, Michael’s tendency toward material activity rather than intellectual work led him to focus attention primarily on the management of his students and the
lesson materials, rather than on student learning goals (Windschitl, Thompson, & Braaten, 2011). When asked what he had wanted his students to learn from doing the activity, Michael replied:

What I wanted them to learn was how animals adapt, have made adaptations to their surroundings, so the different adaptations in the beak shapes and the sizes of the beaks to the type of food that they’re eating, and for competition. Each student kept the same utensil but then during each round I increased the number of pieces of food they needed, so then there wasn’t enough food for everybody, so somebody was going to go extinct. (Michael interview, 2 June 2009)

Presented in the context of evolution, such an activity may have developed students’ understandings of the relationships between form and function, particularly in how forms change over time in response to different environmental pressures. However, in Michael’s class, the activity highlighted the relationship of form to function devoid of any evolutionary or ecological context. To Michael, the lesson remained more about the characteristics of birds than evolutionary adaptation.

It is important to note a number of other features of this lesson. First, the original lab activity stated the learning goal for students as being: “Animals that are better adapted to take advantage of available foods will fare better than those who are less well adapted, and thus live to pass on their genes to the next generation.” Yet from Michael’s perspective, the word “adaptation” is used as a synonym for “design,” and there is little to no indication in his lessons of the dynamic evolutionary processes that lead to adaptations. While Michael invoked two key concepts of natural selection—that of competition and limited resources—the only outcomes possible in his activity are either extinction or survival of the individual. Neither differential reproduction nor changes in phenotypic variations of generations were part of the simulation activity. As a model, Michael’s activity could only explain extinction as a result of limited resources, an aspect of the life on earth story that is uncontested (at least in the post-diluvian narrative) by opponents of teaching evolution.

Finally, it is important to note that just as in the examples from his undergraduate and teacher education experiences, Michael gives the appearance of attending to evolutionary ideas while completely avoiding them. In his teaching and coursework, he employed evolutionary language (e.g. “adaptation,” “competition”) while subtly redefining these terms to fit his worldview. In a similar manner, activities intended to teach evolution (including another population ecology activity not detailed here) were repurposed to focus primarily on discrete biology knowledge that remained unscaffolded by the overarching theme of evolution.

In responding to a draft of the written case, Michael points out how much more he engages with these same topics in his current teaching:

As I began to teach evolution in my own classroom, I decided up front that I needed to make sure that I separated my religious beliefs from the evidence that supports the theory of evolution. For example, I have made it a point to explain in

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13 In providing feedback on this case five years later, Michael stated, “As I read the part about the bird beak lab, I was wondering how/why I didn't go more in depth. My guess is that I was so focused on learning how to manage a classroom and prepare lessons that I was already trying to think about the next topic. As a new teacher at the time, student engagement and classroom management was one of my priorities, and I don't think that that is unnatural for a new teacher.”
my biology classes that science (which includes evolution) is made up of explanations based on observable and testable evidence and not based on faith. This allows me and my religious students to have discussions that may differ from their religious beliefs because I require my students to keep the discussions in class based on the evidence that we have. I make a big deal [now] about what a theory is and the enormous amount of evidence that must be collected from observations and experiments in order to create a theory. I then proceed to list evidence for evolution which includes but is not limited to mutations in DNA and how they form, how changes in DNA result in changes in physical characteristics, similarities in embryo development, fossil evidence, and how changes in the environment cause changes in gene pools. I am now much more comfortable having discussions with students about evolution than I would have been during my student teaching years. In no way would I tell my students now to go research the information on their own. (Michael, personal communication, 27 April 2014).

Discussion

The evidence suggests that during the final year of his teacher education program, Michael’s biology knowledge was strong in some respects and fragmented in others. Though unconfirmed by the sort of detailed assessment offered by Nehm and Ha (2011), it seemed that in Michael’s interviews he had a fairly clear understanding of each of the three central concepts of evolution (variation, heritability, and differential reproduction and/or survival). However well he understood each of these ideas on its own, there is little to no evidence that he had woven them together into a coherent model of natural selection that could explain evolutionary patterns. It is difficult to escape the conclusion that this resulted from either an inability or an unwillingness to deploy the organizing principle of evolution to guide his thinking, or at the very least, there was no perceived need on his part to do so.

From a conceptual change perspective, Michael was forced to make sense of two competing ideas in his own learning about evolution. The first was the idea that evolution has to be real in some sense, because there is variability and change in the gene pool of various organisms. The second idea was simply that the scientific story about macroevolution could not be true. The compromise he eventually settled upon was choosing to accept a version of evolutionary ideas that he felt were not in conflict with his religious beliefs. Features of this version included viewing small changes in species as acceptable, and allowed for the idea that extinction was a natural outcome of such processes. In the language of the conceptual change model, this view of microevolution was both intelligible and plausible to him, but had only limited fruitfulness (i.e. explanatory power). However, Michael did not accept the macro processes described by the theory of evolution—speciation in particular—and felt that a divine hand was responsible for the diversity of life on earth. Non-divine explanations for the origin of species were not only implausible to Michael, from a conceptual change perspective they were hardly intelligible. This led to a fragmented presentation of major themes in biology to his students.

Though he initially expressed a willingness to learn enough about evolution to represent the position of “evolutionists,” his unwillingness to view evolution as a plausible mechanism for speciation was a choice that circumscribed his opportunities to learn. His outstanding academic record and reported competence as a teacher stand in stark contrast to what might at first appear
to be an inability learn evolution. Therefore, the proposition that Michael chose not to learn more about evolution seems a much more plausible interpretation of his case.

Kohl (1994) argues that there is often an assumption of a lack of intelligence, confidence, or lack of opportunity when a person appears not to learn. Such a conclusion, however, shows a lack of respect for that person’s will to choose what they will or will not learn, and also denies that they might have good reason to not do so. In the case of the grandfather of one of Kohl’s students who did not learn to speak English, even after living many years in the United States, his choice not to learn English was rooted in his preserving his identity:

At the end of our conversation he repeated adamantly that nothing could make him learn to speak English, that families and cultures could not survive if the children lost their parents’ language, and finally, that learning what others wanted you to learn can sometimes destroy you. (Kohl, 1994, p. 10)

Michael’s choice—conscious or otherwise—not to learn evolution appears to be similar in character, in that doing so permitted him to preserve his identity as a person of his faith. As Britzman (2003) has noted, resistance in learning to teach is often about resistance to changes in identity, and such an interpretation of the data in the present case has convincing face validity. Michael’s desire to become a teacher required that he navigate around this threat to his identity throughout his teacher education program. In the terms of the identities introduced by Sfard and Prusak (2005) above, his avoidance in learning evolution allowed him to bring his actual identity as a biology teacher in line with his designated identity of being a principled member of his faith. Michael did not see himself at the time as purposely trying to avoid evolution, and even in the present he still views himself as not having done so. Rather, he perceived his actions as more of reconciliation by trying to force conflicting concepts to make sense, at the cost of teaching correct information. Such an approach was aided by his not having a command of the subject matter in regard to evolution. Michael’s strategy in trying to reconcile evolution and creationism still constitutes resistance in our view because his learning about evolution, by his own admission, ceased intentionality.

In teacher education, resistance and avoidance are not unfamiliar areas of concern. For example, the teacher education literature is particularly rich with suggestions for addressing teacher resistance and avoidance of issues of race or racism (e.g. Villegas & Lucas, 2002; Zeichner, 1996). These approaches emphasize the examination of teachers’ beliefs as part of the teacher education curriculum, and stress the necessity of confronting teachers when resistance or avoidance impedes teacher learning in domains considered crucial for programmatic goals.

While a strong argument can be made about the unlikeliness of conceptual change among those resistant to learning about evolution, it also appears that Michael was never directly confronted on the issue during teacher education. This may be the most significant insight from this study. In fact, it may be the case that his apparent high academic achievement and personal qualities created a “halo effect” (Kahneman, 2011; Kennedy, 2010) that led those responsible for his biology teacher credentialing to overlook his inability to engage in evolutionary thinking. To both his instructors and himself, his high grades served as an acceptable indicator of his knowledge of evolution. In short, he was permitted to not-learn.

**Conclusion**
As a case describing only one teacher, this research has important limitations, and caution must be used in any attempt to make generalizations from its findings. Other preservice teachers who do not learn evolution may be very different from the case described in this research, and it seems likely that a choice to “not-learn” evolution will not be a universal explanation for teachers who are either unwilling or unable to be advocates for evolution in their classrooms. The community context is also important, and it may be that the findings of this research would have been very different had Michael been pressed harder to learn evolution as an undergraduate, placed in the classroom of a different cooperating teacher, or had deeper engagement with other individuals in his teacher education program who offered him a rationale for learning evolution that he perceived to not be in conflict with his faith. Michael was clearly a unique individual in a particular context, yet his case offers tantalizing clues for teacher educators who are charged with preparing teachers to teach evolution.

One issue raised by this case is the question of how much responsibility a teacher preparation program ought to assume for realigning a teacher candidate’s disposition toward learning the subject matter of their discipline—even seemingly unbridgeable ones such as those formed by beliefs in creationism. Teachers continue learning to teach throughout their careers (Feiman-Nemser, 2001), and while it is expected that the subject matter knowledge gaps of novice teachers will diminish over time, this can only happen if there is assent to such learning.

The case of Michael also raises the question of whether we are assessing our undergraduates’ biology knowledge effectively in our courses, particularly around the topic of evolution. How is it possible for a student like Michael to do so well academically in biology yet have such a poor understanding of evolution? The findings from Berkman et al (2008) discussed above suggest he is not alone. This case also raises the issue of whether prospective teachers may be performing well enough to pass state-required content knowledge tests for teacher certification (such as the PRAXIS II) despite a poor knowledge of content pertaining to evolution. It seems that Michael was able to complete his teacher education program without being sufficiently challenged on his knowledge of evolution, and this actually represents something of a lost opportunity to both assess and provide formative feedback to him on his knowledge, skills, and disposition for teaching evolution. A new generation of assessments of evolutionary understanding (Nehm & Ha, 2011; Nehm, Ha, & Mayfield, 2012) may make a substantial contribution to addressing this problem, but only if they are purposely deployed to strengthen the population of biology teachers.

A final question raised by this research is whether the process of teacher certification is adequately performing the task that it was designed to accomplish. If the goal of teacher preparation and certification is to ensure that new teachers are expertly qualified to teach in their subject area, then the continued production of large numbers of teachers being certified who are either unwilling or unable to teach evolution functions in opposition to that goal.14 Given that there is a greater need for teachers who can accurately and even enthusiastically teach evolution, an argument could be made that preservice interventions should focus more on challenging knowledge structures that are inconsistent with scientific knowledge and practice, and on modeling good teaching practices for evolution despite potential lingering presence of

14 Of course, if the purpose of teacher preparation is to produce teachers who are at the beginning of a well-articulated learning trajectory towards becoming a master teacher (Feiman-Nemser, 2001; Luß, Wong, & Semken, 2011; Thompson, Braaten, & Windschitl, 2009) then the implication is that the necessary career supports and resources for this a task are provided, especially during the initial years of teaching. One can reasonably question whether U.S. schools are currently organized to accomplish this goal.
prospective teachers’ inner conflict about the topic. In approaching biology teacher preparation in this manner, teacher educators may adopt a “not on my watch” (Ladson-Billings, 2001, p. 125) strategy towards the teachers they prepare, with an eye toward ensuring that they will be strong advocates for the explanatory power of evolution. But how realistic is it to expect resistant students to become advocates?

Some prior research on the use of constructivism (i.e. eliciting prior knowledge, fostering metacognition) in changing teachers’ professional knowledge and beliefs during in-service training has shown that conceptual change comes from directly confronting pre-existing dispositions and orientations rather than relying on an incremental training approach aimed at gradual acceptance of new knowledge structures (e.g. Oxford, 1997) while others highlight the need for teachers to first identify an aspect of their work as problematic before attempting such confrontation (e.g. Bell & Gilbert, 1996). However, more recent studies call into question the ability of teacher preparation to change student beliefs about the central role of evolution in biology (Nehm et al., 2009; Nehm & Schonfeld, 2007), and the character and structure of possible effective interventions remain an area of future research.

The example of Michael’s “not-learning” of evolution calls for a measured response from the teacher education community. From one perspective, perhaps it is unnecessary to pass judgment on Michael’s individual choice to not-learn evolution when the alternative—from his perspective—is to gain this knowledge at the cost of his own identity. On the other hand, society is under no obligation to sanction Michael’s desire to become certified as a biology teacher in public schools. It is a fair question to ask if Michael was up to the task of teaching evolution as a newly-certified biology teacher and the end of his teacher preparation. Certainly many new teachers face significant challenges (Davis et al., 2006) at the beginning of their careers, and undoubtedly the process of learning to teach continues during this time. Michael’s own depiction of his growth in regard to teaching evolution as quoted above may be representative of others in similar circumstances (though to what extent this growth is authentic and has impacted the biology learning of his students we cannot be sure).

Yet it is also clear from the literature reviewed in the opening section above that many biology teachers do not adequately teach evolution in their classrooms. Given its position as one of the threads that ties the biological sciences together, it does not seem likely that teachers without an understanding of evolution will be able to bring a sense of coherence to their teaching, and that their students will continue to learn biology as a set of disparate and unconnected facts. This is certainly not the 21st century vision of the life sciences as presented in the Next Generation Science Standards (Achieve Inc., 2013).

Implications

An underlying assumption of this study is that the embrace of evolution as an explanatory framework for biology is an indicator of a prospective teacher’s overall proficiency in the discipline. Therefore, the issue of evolutionary understanding is important for what it represents about biology teacher knowledge as a whole, and it is reasonable to compare its role in candidates’ conceptual ecology to that of a keystone species in an ecosystem. It is not the purpose of this paper to investigate analogous concepts in other disciplines, but certainly assessments of teachers’ conceptual understanding of other “keystone” concepts (perhaps kinetic theory in chemistry, Newtonian motion in physics, and plate tectonics and deep time in earth science) may serve a similar roles in indicating the organization of content knowledge for teachers of these subjects.
Certaintly any study of biology teacher education must recognize that there are other equally important aspects of teaching to which preparation programs must attend, in addition to knowledge about the role of evolution in organizing the discipline of biology. Biology teachers, like all teachers, need to be able to teach content to a diverse population of students, diagnose students’ preconceptions then use these ideas to plan and adapt instruction, assess student learning, use effective teaching strategies, and help students focus on the other big ideas of the discipline (e.g. matter and energy transfer in organisms and systems, and the relationship between structure and function). The evolutionary knowledge of prospective biology teachers while important, is not the only consideration for biology teacher educators. Yet teacher educators clearly recognize it as problematic when prospective teachers do not provide their assent to learn about these other areas, and we suggest a similar stance for learning about evolution here.

It is becoming more common in teacher education to address problems in teacher education outcomes by enforcing more stringent selection criteria (Goodwin & Oyler, 2008). For example, a number of teacher education programs and school district human resource departments use screening tools such as the Star Teacher Pre-Screener (Haberman, 1995) to predict success in urban classrooms. Perhaps it is time for teacher education to be equally stringent about who is permitted to be prepared to teach in biology classrooms. Commonly, prospective teachers fulfill a number of requirements before gaining entry into a teacher education program including essays, recommendations, transcripts and interviews. We suggest that a teacher education programs use these tools—and others as they become available—to screen prospective biology teachers to assess their understanding of evolution. Of course, the formative use of such tools in high school and post-secondary biology classrooms (and perhaps even as part of the supports for beginning teachers) may be a more powerful intervention to strengthen the evolutionary knowledge of all prospective teachers. Hindsight suggests such an approach may have been incredibly valuable to Michael.

While we agree with Berkman and Plutzer (2011) that integrating evolution more deeply into preservice biology teacher education is necessary to strengthen the teaching of evolution nationwide, the case of Michael suggests that such a strategy should be reinforced by teacher education admission policies that require at least a minimal understanding of the basic concepts of evolution. While such an approach may prove difficult in the current climate of teacher education deregulation in which even the idea of teacher certification is contested (Zeichner, 2003), the denial of admission into nationally recognized science teacher education programs of students who are unable to teach the central organizing concept of biology is a rational response to the widespread phenomenon of biology teachers who are unwilling to be advocates for evolution. It is important to state that such an approach need not be portrayed as anti-religious in nature. Among scientists, science educators, and the general public there exist a wide range of interpretations rooted in faith about the origins of life. The issue is whether those with strong creationist beliefs will choose to learn the science of evolution well enough to represent the topic correctly in a science classroom.

We are sympathetic to the argument that increasing selection criteria on prospective biology teachers may shrink an already limited pool of applicants. Yet the exhaustive research by Ingersoll and his colleagues on the so-called “shortage” of science teachers (Ingersoll, 2011; Ingersoll & Perda, 2010) demonstrates that it is largely a problem of retention and transfer away from challenging school environments. Ingersoll notes:
Contrary to conventional wisdom, our nation does produce enough qualified math and science teachers to cover both student enrollment and teacher retirement increases. It appears that over the past two decades, efforts to recruit new math and science teachers have been very successful. (2011, p.40)

Consequently, the shortage of biology teachers in high-turnover schools is not likely to be impacted by ensuring that prospective teachers are willing and able to teach evolution. A more narrow pipeline of future biology teachers may complicate the work of science teacher educators, but improvements in teacher preparation (and new teacher induction) that lead to higher retention rates and higher quality science teaching and learning would likely be a worthwhile tradeoff for many.

We conclude with a final example of what such an admissions approach may look like, drawn from an incident arising from informal sharing of the preliminary findings of this study with colleagues. A college sophomore recently applied to a prestigious university-based teacher education program with the intent of becoming certified to teach high school biology. His biology grades from a local community college were outstanding, and during the admissions interview he was able to articulate an admirable rationale for choosing to become a teacher. His reasons were similar to many other prospective biology teachers in that he enjoys the subject of biology and also wants to make a difference in the lives of students. In his admissions essay, he had referenced his strong religious faith a number of times, and his interviewers chose to gently probe how this might impact his future teaching of biology. When asked how he might teach the science behind a topic with which he might disagree, such as embryonic stem-cell research, the candidate responded that as a teacher he would simply follow his school’s curriculum. He was then asked the question from this research, “Suppose you have a student who asks you how it is possible for all life on earth to have come from single-celled common ancestors. How would you respond?” It came as something of a surprise to the interviewers that he was unable to articulate any answer at all. After numerous incredulous probes by the biology department faculty present, he replied simply “I don’t know.” Further questioning showed his biology content knowledge to be fragmented and untethered by any central explanation, evolutionary or otherwise, and he was not accepted into the teacher certification program.

Such fragmentation of biology knowledge may not be uncommon, and likely results from the way in which biology is taught from the earliest grades by teachers who themselves see biology as a set of disconnected facts. This alone can explain the high grades by students who do not appear to know biology very well, as it appears to have done in Michael’s case when he took his high grades as evidence of his own mastery. Yet, the field of biology has grown tremendously from the days when it was slighted by Ernest Rutherford (along with all the other sciences that were not physics) as mere “stamp collecting” (Birks, 1962). Ecology, genetics, physical anthropology, cell biology, biochemistry and many other sub-fields of the life sciences continually draw upon evolutionary models to engage in scientific inquiry, producing new knowledge and posing new questions at an astonishing rate. In such an era, it seems only appropriate that we ensure that the knowledge of the biology teachers we prepare is adequately illuminated by the explanatory power offered by the light of evolution.

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References


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