Case Studies in Teaching Evolution: The Intersection of Dilemmas in Practice

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Abstract

Despite recent science education reform documents citing evolution as a core concept to be taught in grades K-12, research shows problems with how it is currently taught. Evolution is often avoided, teachers minimize its importance within biology, infuse misconceptions, and/or interject non-scientific ideologies into lessons. My research focused on how teachers in two geographically and culturally distinct school districts in the southwestern U.S. negotiate dilemmas during an evolution unit. One school district was rural and had a large population of Mormon students, while the other district was urban, with a large majority Mexican/Mexican-American students. Using a case study approach, I observed three biology teachers during their evolution lessons, interviewed them throughout the unit, co-planned lessons with them, and collected artifacts from this unit, including anonymous student work. Findings showed teachers' backgrounds and comfort levels with evolution, in addition to their perception of the community context, affected how they negotiated pedagogical, conceptual, political, and cultural dilemmas. This study's findings will inform in-service and pre-service teachers' future practice and professional development tools to aid with their teaching – this may include methods to negotiate some of the political (e.g. state standards) or cultural (e.g. religious resistance) issues inherent to teaching evolution.

Problem

Evolution is the unifying concept in biology, and as Dobzhansky (1973, p. 125), a distinguished evolutionary geneticist noted, "Nothing in biology makes sense except in the light of evolution." Despite the *lack* of controversy among scientists regarding the validity of evolutionary theory, a social controversy exists that affects how and if this topic is currently taught in science classrooms in the United States. The importance of teaching evolution has been reflected in recent educational reform documents including the *Next Generation Science Standards* (NGSS), which emphasize evolution as a core concept throughout grades K-12 (National Research Council, 2011). These comprehensive new standards were developed to reflect the profound need for change in science education due to recent advances in scientific research and a better understanding of how students learn science (National Research Council, 2012).

Despite reform documents' focus on teaching evolution, recent research has shown problems with how (or if) it is taught in science classrooms. Many teachers avoid the topic, only teach tested concepts within evolution, minimize the importance of its role in biology (Berkman & Plutzer, 2010), and/or infuse misconceptions into lessons (Smith, 2010). Teachers' personal beliefs not only influence instruction, but also have a stronger impact than other factors examined (e.g. certification to teach, credit hours in biology) (Berkman & Plutzer, 2010). As such, some teachers inject non-scientific concepts, such as intelligent design and/or creationism, into science instruction. Similarly, Goldston and Kyzer (2009) found that how evolution is taught in high school classrooms often depends upon teachers' and students' religious beliefs, teachers' acceptance of evolution, and how teachers viewed issues that could arise in their community as a result of teaching evolution.

Clearly, there are issues with how evolution is taught in the U.S. However, most studies that have examined the teaching of evolution have done so through interviews and surveys, rather than an in-depth case study approach where researchers spend significant time in classrooms. Additionally, little research has been done on this topic specifically in the southwestern U.S., and no studies exist on Mexican/Mexican American and Latter Day Saints (LDS, or Mormon) communities within this part of the country. A recent Pew Survey (2014) showed that Latinos have moved away from Catholicism, and toward evangelical Protestantism, members of which have traditionally opposed evolution. As for the LDS community, they have historically espoused conservative values, but their position (as a demographic) on evolution is still undetermined (Anonymous Professor, personal communication, March 2015; Eddington, 2006).

Frameworks

To better understand the complexities of teaching evolution in the southwestern U.S., I viewed it through Lemke's (2001) lens of sociocultural theory. Few studies, other than Goldston and Kyzer's (2009) work on how teachers in the southeastern U.S. approach evolution, have examined this topic from a sociocultural perspective. Lemke (2001) views social interaction as central to learning in a classroom. Human activity is possible since we all live within larger-scale social institutions and organizations – these include, but are not limited to, churches, cities, schools, and families. Living within these institutions and communities provides us tools for sense making in the form of language, belief systems, or specialized discourses and practices that help us better understand our world. When thinking about what matters to the learning of science, one needs to contemplate the socially learned cultural traditions of the discourses and representations that prove useful. We must also consider science education from more than just a learning perspective; instead, we should build on sociocultural theory since science education affects not only individuals, but it has political, economic, and cultural implications as well (Lemke, 2001).

I also drew on Windschitl's (2002) negotiation of dilemmas framework as a conceptual tool to better understand the teaching of evolution. He defined dilemmas as "aspects of *teachers'* intellectual and lived experiences that prevent theoretical ideals of constructivism from being realized in practice in school settings," (Windschitl, 2002, p.132). Although he used this term in the context of constructivism, I applied it to teaching evolution. Windschitl (2002) described the dilemmas in teaching as being of a pedagogical, conceptual, cultural, and political nature.

Design/Procedure

The goal of this study was to gain insight into two unique communities in the southwestern U.S. that have never been studied in the context of teaching evolution – a rural community comprised of LDS families, and an urban community with a Mexican/Mexican American majority. My research questions are: 1) How do high school biology teachers in two different communities in the southwestern U.S. teach a unit on evolution? 2) What dilemmas of practice arise during a unit on evolution? 3) How do teachers negotiate the dilemmas during a unit on evolution? 4) Do the stakeholders in the school community (ex. principals, parents, etc.) influence teachers' negotiation of dilemmas of practice? If so, in what ways? In these questions, 'dilemmas' or 'dilemmas of practice' refer to any obstacles or issues teachers face in the classroom (e.g. religious resistance, teachers' own content knowledge, etc.).

To answer these questions, I used a case study methodology, which means I examined 'cases,' or teachers, during the entirety of their evolution units. This qualitative approach is used when researchers want to understand a particular phenomenon (such as teaching evolution), when context is important (how the community stakeholders affect evolution instruction), and when interactions at a site are important (Yin, 2003), i.e. how teachers interact with students

during this unit. Additionally, multiple sources of evidence, including observations, interviews, and research memos, are used when discussing cases to elucidate the complexity of a given phenomenon.

The 'cases' in my study included one high school biology teacher in a rural district, and two high school biology teachers at the same school in an urban district. The rural teacher's evolution unit lasted from January-March, while the urban teachers' units lasted from March – May. For each of these teachers, I used the same methodology. Every day they taught a class on evolution, I audio/video recorded that lesson, focusing on the teachers' words and actions. I took detailed field notes during each class, and wrote research memos reflecting on the day's observations. Additionally, I interviewed each teacher once before the unit on evolution, once at the end of each week, and once upon completion of the unit. Each interview lasted between 30-60 minutes and focused on understanding the teachers' background and experiences, their reflections on the weekly lessons, and any other thoughts on the interactions/lessons. I transcribed salient components of video recordings that related back to my research questions, and the entirety of the audio interviews. I also collected artifacts relating to this unit including lesson plans, blank student worksheets/labs, science standards, teachers' emails, and anonymous student work – all of which provided a better understanding of how this unit was taught and how students responded. All transcripts and artifacts were coded for emergent themes.

Prior to the evolution unit, I observed four lessons from each of the teachers' genetics units. This latter unit directly preceded evolution for all three teachers. I employed the same methods for conducting observations and interviews, and for collecting artifacts for the genetics unit as I did with the unit on evolution. I included these extra observations of genetics to determine if the issues that arose during evolution were a result of the general practice of the teacher, or if they were unique to evolution.

I also employed a novel methodology in co-planning with the teachers – there are no studies in evolution education that involve the researcher in the lesson planning process during data collection. I co-planned with the rural teacher twice during the evolution unit, and once with one of the urban teachers. The second urban teacher did not make time to lesson plan during this study. The length of each session varied and depended on the time set aside by each teacher. Although the content discussed at each session varied depending on the teacher and where he/she was in the unit, I always asked questions relating back to the research foci. This co-planning method enabled me to dig deeper into the dilemmas teachers face when planning and eventually teaching lessons on evolution. All co-planning sessions were audio recorded, transcribed, and coded for emergent themes.

All data were analyzed and interpreted using an inductive approach; this allowed for "discovering patterns, themes and categories in one's data," (Patton, 2002, p.453), which is in direct contrast to deductive analysis that stipulates categories prior to analysis. I took several steps to ensure the trustworthiness of my findings including triangulating data from several sources (Marshall & Rossman, 2011), spending prolonged time in the field, and documenting all data collection and analysis procedures. I member checked with the teachers by discussing my findings with them, and allowing them to determine the accuracy of my representation of "their worlds," (Marshall & Rossman, 2011, p.42). The teachers were allowed to comment on these findings; if there were any discrepancies, I discussed them in the results.

Analysis and Findings

In this section, I discuss my findings from each of the cases, or teachers, in this study. Within each case, I mention the teachers' backgrounds, and the context of the school community.

I detail the two major themes for each teacher that I discussed at the conference, even though each teacher had between four-six themes. This was done for brevity purposes.

Case 1: Jane

Jane is a high school biology teacher and science department chair in a large public school in the southwestern U.S. She grew up in the southwest, and comes from a long line of teachers. Jane received a Bachelor's degree in Community Health due to her goal of entering the field of social work, which she did for several years prior to switching to teaching. Part of her job as a social worker involved classroom work with kids, which she loved. As a result, Jane went back to school and received a Master's degree in 2002 in elementary education. She is certified to teach cross categorical special education, secondary education, history, geography, general science and biology. She started teaching at her current school ten years ago, but she has only taught biology the last four years.

Jane teaches General Biology and Human Biology at a large Title I public high school in a rural part of the southwestern U.S. There are students who live on farms, students whose parents work on farms, and then a group considered more middle class, who attend the school. According to the National Center for Educational Statistics (2014), her high school is 62% White, and 30% Hispanic, with 40% of the students receiving free or reduced price lunches. Jane noted that the community surrounding her school is "very conservative," and a large population of students at her school affiliate with the LDS faith. Many of these students are heavily involved in honors classes and the student council. While I was at the school, a few other science teachers voluntarily mentioned how this school has a large LDS population, thereby supporting Jane's comments.

Emphasis on videos/textbooks as pedagogical tools, with little room for student discussion. Jane taught evolution for a total of nineteen days (this does not include two days set aside solely for assessments). During this unit, she taught mainly through the use of videos, textbook-based worksheets, and a few PowerPoint lectures. Videos of varying lengths, ranging from 10-50 minutes, were shown on eight different days of the unit. Jane's reason for including videos was that "kids learn differently….and the videos help reinforce ideas, especially for visual learners." On an almost daily basis, textbook-based worksheets were given to the students either as an in-class activity, or a homework assignment. Providing these types of assignments, "…gets them to read and open the book," according to Jane. When students had questions about content either on worksheets or during a discussion, Jane often responded by referring them to the textbook for an answer. Most of the PowerPoint lectures originated directly from the textbook publisher's web site. One lecture on classification came from an out-of-state teacher's web site.

As Jane noted in an interview, "I do try and keep it as paced and factual as I can because every once in a while you have a kid who kind of tries to argue. I'm like, you can go home and argue with your parents about it but we can't do it in here, sorry, type deal. That's usually how I try and shut it down." This quote reinforced the nature of the discussions during her evolution unit, and one reason for not allowing much room for student discussion. Jane was clearly aware of the potential for resistance, and wanted to avoid it at all costs. By not providing much room for student discussion, this helped prevent any of these interactions in the classroom.

Community religiosity and Jane's views on science/religion impact teaching. Jane lived in the community in which she taught, and has taught at her current school for ten years. As a result, she knew her students and the community quite well. When she described aspects of their faith, she did so in the following manner, "They are taught early on to kind of separate church doctrine from some of the stuff they are taught in school. They are really good at

separating those two things. And they don't even consider that they might intertwine because their church doctrine is always first to them." Jane also made the assumption that they were, "pretty heavy into creationism." Due to the students' religious upbringing, they may not 'agree' with evolution; however, Jane respected the students and their ideologies.

Jane's own views of the science/religion issue also became apparent during my project. She had mentioned that she went to a grade school where creationism was taught, despite her liberal Episcopalian upbringing (her parents sent her to this school solely because the public schools in the area were not good). Although she was taught creationism at this school, she began to question the literal interpretation of the Bible. However, her ideas about science and religion were clarified when she stated the following, "There's a lot of evolution out there in terms of the thinking of evolution in that it actually kind of marries with creationism and there's actually a way to view both of them as intertwined and unified." This shows that she did not view science and religion as two separate entities; rather, they can be complementary.

Jane's knowledge of her students' faith, and her own ideas on science and religion, had an impact on what she taught within evolution. She clearly emphasized microevolution, with a focus on Darwin's adventures, and natural selection. Jane acknowledged not showing a video on human evolution because she was concerned about the controversy it would cause among her students. She admitted to never viewing the video; as such, I asked her how she would determine if she could use it in class, and she responded, "Making sure it's not anti-creationism. As long as it's not trying to stomp on that aspect. I'd rather they completely ignore it or just kind of say, here's the opposing view and be done with it. I just want to make sure it's not stomped on. Because that would create way too much controversy." This quote shows that she did not want to disrespect her students by showing them anything that might offend them, such as a video that discusses anti-creationism (even though this information would not be scientific).

Case 2: Ben

Ben is a high school biology teacher in a large public school in the southwestern U.S. He grew up in the Midwest, where he attended a small, secular college preparatory private school from grades 5-12. Upon graduating from high school, he enrolled in a large public university in the Midwest, where he received a degree in molecular biology (with honors). After taking a year off, he attended medical school, and left after one year. While Ben enjoyed the knowledge he gained in medical school, he did not like the idea of becoming a doctor. Shortly thereafter, Ben realized that he wanted to study evolution; as a result, he started a Master's program in Ecology and Evolutionary Biology at a large public university in the southwest a year later. In 2012, he graduated with a MS degree focused on bioinformatics and computational biology. Soon after his graduation, he started a one-year intensive teacher preparation program at the same college where he received his Master's degree. Through this program, he also received a license to teach Biology.

Ben teaches both General Biology and AP Biology at a large Title I urban public school in the southwestern U.S. Approximately 57% of the student population is Hispanic, while 37% is White. Ben described the students at his school as belonging to one of two populations – one group that is not as affluent and lives within a 2.5 mile radius of the school; the other group lives farther north, and is wealthier. Despite the income disparity, Ben explained how the two groups of students intermingle at school. He believes that the class divide between students 'melts' when they get to school. Most of the students in his regular biology class (about 70% of each class) live in the less well-to-do area near the school. Overall, he feels very safe at his school, and everyone (students, staff, etc.) is very considerate of one another.

In-depth content knowledge as a resource for his teaching and a source of internal struggle. Ben's in-depth content knowledge from his undergraduate and graduate training helped him teach evolution. Ben paid careful attention to the scientific meaning of words he used during class; for example, he spent an ample amount of class time discussing the scientific term 'theory.' Although concepts on PowerPoint slides loosely guided his lessons, he provided a greater explanation of ideas during most classes I observed. He rarely addressed concepts solely by reading the definitions on the slides. Throughout the evolution unit, during bell work and other activities, Ben asked his students higher-level questions that required more than just factual recall. For example, after the students had learned about Lamarck's idea of inheritance of acquired characteristics, he had them devise an experiment that would prove that Lamarck was wrong.

Although Ben's content knowledge proved useful in his teaching, it also became a source of internal stress. As Ben stated in an interview, "I think the difficulty there is that I understand it at such a deep level, and sometimes I feel like that deep level is essential to seeing something in a certain way. And so I often get personally frustrated, not with my kids, but kind of just with the nature of it, that I can't fully convey how I see things to them…So I think that's one of the difficult things, especially with evolution, again, because I care about it so much. And I get so excited about it." Ben's tone of voice during this conversation showed that he cared deeply about evolution, and was frustrated that his students did not always see the content the same way he did. He clearly let students talk through ideas in class to have them answer his questions, but it was evident he felt frustrated at times when they could not get the answer. Later in this same interview, Ben clarified how he was still working through how to set his expectations, and he acknowledged this as something he would have to deal with for some time.

Frontloading to avoid the controversy. On the first day of the evolution unit, Ben asked the students the following question in a bell work assignment – "What have you heard, good or bad, about evolution?" In an interview, I had asked him why he chose to start the unit with this question. Ben responded, "I feel like I just want to pull it out in the beginning so that we can talk about it and we can move on." During this interview, Ben appeared uncomfortable discussing the issue. This quote also acknowledged his awareness of issues that surround the teaching of evolution, and instead of guessing when or if a student might resist the content, he chose to control the timing of the conversation.

After students responded to the bell work question, Ben stated the following to them, "We are going to learn about evolution, but there are some facts about evolution that contradict certain other facts that people very, hold onto, very strongly…. I don't think, I think that if you can get beyond some of those factoids, there's really no issue there. So I really wouldn't worry about it. But, if there is an issue, just know, that in this class, we are learning evolution. That's what we are going with. You have to learn it. You have to understand it for the test. And that's all there really is to it." Ben showed how he clearly separated religion from science, and made it apparent that the former would not be a part of his instruction. This quote also provides evidence of how Ben controlled the timing and content of this seemingly uncomfortable topic for himself - he accomplished this by stating his definite thoughts on this matter and informing his students, albeit indirectly, there should be no further discussion about this issue. Ultimately, he wanted his students to learn the scientific content, despite one's belief system or discomfort during the unit.

Case 3: Diane

Diane is a high school science teacher at the same public school as Ben. She is from the southwest, where she attended an all-girls Catholic college preparatory high school. Diane knew

she wanted to teach science – she had always loved the outdoors and the natural world, and she really enjoyed, "putting information together and explaining information," and liked to "…come up with creative ways to have people engage in that information." Upon graduating from high school, Diane enrolled in an undergraduate program at a large public university in the southwestern U.S. that focused on secondary science teacher preparation. This program was housed in a college of science, so she received a Bachelor's of Science degree, with a focus in biology, along with a teaching certification. Her content focus was more on ecology, and some evolutionary biology, rather than microbiology. During her undergraduate studies, she contemplated teaching earth science, and earning a geology degree, but she chose biology instead. Diane also received a second degree simultaneously – a Bachelor's of Art degree in painting.

Diane taught Environmental Science and Biology at the large, urban, Title I public high school, whose demographics were described above. She described her students in the following way, "We've got a really big Hispanic population, of course. And then we have a pretty significant portion of our students that are coming from housing which is not the best. I don't know how to say it. Not...how do they call it? Trailer homes?... And I think a lot of them grow up in situations which are, their parents are struggling financially, mentally, mental health issues." Diane recognized that her students came from very difficult home lives. This was a viewpoint she acknowledged at multiple times throughout my project.

A focus on addressing misconceptions. Diane mentioned in an interview that one of her main goals for the evolution unit was to address misconceptions. She felt that, "some people want to polarize the issue more than I believe it really is by misusing vocabulary and trying to confuse people." As such, Diane acknowledged the issues relating to evolution, and wanted to approach them directly with her students. She followed up by stating, "I would like them to be able to go out and debunk the myths…I'm hoping that the kids will come away with an understanding of what evolution is. The science behind it, I don't feel like, is a stretch in the least."

Diane introduced the term evolution to the students at the beginning of the unit by stating the following, "We are talking about evolution, which is very special…So our objective is to define and figure out what is evolution. Probably you've heard about it in the past. You have some idea. But we'll try to dispel a few misconceptions." Diane showed how she viewed evolution in a positive way, by describing it as 'special,' and she acknowledged that her students have likely heard misinformation about evolution in the past. Following this lesson, Diane regularly addressed misconceptions throughout the unit, specifically as they related to the terms 'adaptation' and 'fitness,' with a focus on the former. When she heard students using one of these terms incorrectly, she stopped them, and helped scaffold their learning by directing them back to the scientific definitions of the words.

It also became clear that how Diane addressed misconceptions was not affected by her students' cultural backgrounds. This was verified when I asked, more generally, if the student cultural context affected how or what she taught about evolution. Her response was placed in context of one of her major goals for the unit – addressing misconceptions. In this email, Diane stated the following, "I generally assume that all students (not just at my current school, but at a more affluent school I student taught at) have experienced some pushback/misconceptions about evolution in social media or with an older relative, so I think it's important to have our 'facts straight' about what evolution is and is not, what science is and is not, and what certain vocabulary words mean in order to make sure we are on the same page." Diane clearly viewed

her current students as coming from a lower socioeconomic status than previous students she has taught. However, she did not believe that her current students were different in terms of what they need to be taught with regard to evolution. All students, according to Diane, have likely been exposed to the same misconceptions, and thus, she addressed them in the same way to all students. This approach does not take into account the cultural context of her current students, and how they might differ from other students she has taught.

Informal mentor as an important source of pedagogical and conceptual insight. Throughout my research project, in the context of planning and curriculum decisions for her biology course, Diane often mentioned another biology teacher at her school. I will use the term 'mentor' in this theme instead of 'other teacher' for succinctness and the sake of clarity. She discussed her mentor's influence in the following way, "And I got a lot of resources from (teacher) upstairs. Because she's been teaching it for many, many years. And so, basically whatever she has I take and use. Because this is my second prep so it's like, huh…I only have two classes of biology and, so, yeah." To clarify, Diane only taught environmental science her first year teaching. The year I observed was her second year teaching biology, of which, she only had two class periods (out of six). As a result, she made the decision to spend more time preparing for her environmental science class, and therefore relied heavily on her mentor for biology resources.

In addition to providing Diane with PowerPoints, labs, and other activities, her mentor helped Diane consider new ways of teaching. Diane provided evidence of this by stating, "But I also really like, because it forces me to get into the lab more. And she has more lab experience then I do." Diane has clearly reflected on her own teaching style, and is constantly looking to improve her teaching, even it means going beyond a certain comfort level with her pedagogy. Diane spent almost an entire week on a lab during the evolution unit, something she would not have done without the influence of her mentor.

Diane's mentor also helped her negotiate a political dilemma during the evolution unit. The administration announced that the entire school would be giving a new state standardized test (they gave the teachers a few weeks' notice). This testing would occur for two weeks during Diane's evolution unit. All of the teachers were told that since students would be leaving their classes at various times to take these tests over this two week period of time, they could not teach anything during this time that would be tested. As a result, Diane would have to take a 'break' with her evolution unit. During our discussions, Diane seemed frustrated and unsure about what she would do during this two week 'break.' However, she and her mentor met and came up with a good plan for this time period. Diane described this discussion by stating, "So what she and I came up with was, which is actually what I really like, because I had these from last year, that she had developed, which is a lab where the kids look at different organisms under the microscope." They appeared to have developed a plan together, based on the mentor's previous experience and Diane's agreement with her mentor's approach to the stations. Diane's mentor helped her negotiate this sudden political dilemma that initially complicated her schedule for the unit.

Conclusions and Implications

This study underscores the importance of utilizing a sociocultural lens in conjunction with an in-depth case study approach to understand the complexities of teaching evolution. Similar to Goldston and Kyzer's (2009) work, the findings presented here showed how a teacher's approach to evolution was at least partially based on her views of her students' beliefs. Jane's perceptions of her students' LDS faith and her own beliefs impacted pedagogical

decisions during her evolution unit. Jane also relied heavily on the textbook as a 'safety net,' and modified her teaching during evolution to not allow for much student talk, similar to Goldson & Kyzer's (2009) findings.

Many of the conclusions add to our current knowledge base of evolution education. Much research has shown how teachers inadvertently introduce misconceptions during evolution (Smith, 2010). In the current study, Diane purposefully addressed misconceptions as one of her main goals, making sure to correct students when they used terms such as 'adaptation' in the colloquial rather than scientific context. Additionally, research has focused on how the teaching of evolution is inadequately taught due to the teachers' deficient content knowledge (Berkman & Plutzer, 2010). The current study's results showed how teachers with an in-depth knowledge of evolution face dilemmas as well – the passion for and content knowledge of evolution ran so deep with Ben that he struggled with expectation management for his students. This underscores the need for further research on how we can support teachers who have excellent content knowledge, but deal with internal stressors and potential external pressures such as those relating to standards and/or tests.

This research has the potential to contribute to the further development of science teacher preparation programs in the southwestern U.S. and the rest of the country. Given the increase in cultural diversity of students in our public school classrooms, teachers and administrators can use the results to reflect on how they navigate potential complexities of teaching evolution. These findings also highlight the need for further work in evolution education that utilizes a sociocultural framework. Examining a larger number of teachers in these same communities through a case study approach would prove useful for the overall understanding of evolution education.

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