HOW SCIENCE TEACHERS BALANCE RELIGION AND EVOLUTION IN THE SCIENCE CLASSROOM: A CASE STUDY OF SCIENCE CLASSES IN A FLORIDA PUBLIC SCHOOL DISTRICT

by

Pierre Dominique Willems

Liberty University

A Dissertation Presented in Partial Fulfillment of

the Requirements for the Degree

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ABSTRACT

The purpose of this case study was to research how science teachers balance both religion and evolution in the science classroom with as little controversy as possible. In this study I attempted to provide some insight on how teachers are currently teaching evolution in their science classes in light of the religious beliefs of the students as well as their own. The case study was conducted in a school district in Florida where I attempted to answer the following questions: (a) How do science teachers in the Florida School District (FSD) approach the religion–evolution issue in preparing students for a career in a field of science? (b) How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students? (c) How do science teachers in the FSD reconcile their own religious views with the teaching of evolution? (d) How do science teachers in the FSD perceive the relationship between religion and science? The data was collected through interviews with two high school teachers, and one middle school teacher, by observing each participant teach, by collecting site documents and by administering an exploratory survey to student volunteers. Analysis was conducted by open coding which produced four themes from which the research questions were answered and the survey answers were counted to produce the percentages displayed in the tables in chapter four. The teachers avoided discussion on religiously oriented questions or statements by the students and did not reveal their own religious orientation. The topic of microevolution appeared to reduce stress in the classroom environment, as opposed to addressing macroevolution.

Keywords: microevolution, macroevolution, intelligent design, socio-controversial, nature of science, religiosity

Dedication

I would like to dedicate this dissertation to my Lord and Savior Jesus Christ whose strength and provision allowed me to finish this project.

Acknowledgments

I would like to thank my wife, Dolly, who was always supportive and confident that I could get this project completed. This was a great encouragement to me, as well as her enduring patience in this lengthy trial.

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List of Abbreviations

American Association for the Advancement of Science- AAAS

National Research Council- NRC

National Science Teachers Association- NSTA

National Academy of Sciences- NAS

National Center for Science Education- NCSE

Florida School District- FSD

Next Generation Sunshine State Standards- NGSSS

CHAPTER ONE: INTRODUCTION

Background

This country's leading influential science education organizations, such as the American Association for the Advancement of Science (AAAS, 2007) and the National Center for Science Education (NCSE, 2008), believe that evolution is essential to teach biology and understand the sciences in general. By evolution I am referring to natural processes assumed to have produced life from chemicals and later, by means of mutations and natural selection, *microevolution*, caused species to change into other species, such as reptiles to mammals, *macroevolution*. See the list of definitions on page twelve for a more formal definition. Dr. Theodosius Dobzhansky believed that evolution should be the framework upon which biology is structured (Moore, 2007). Reydon (2013) explains the essential relationship between the biological classification system and the theory of evolution but forgets that Carolus Linnaeus, who originated the classification system from which the present one was developed, was not an evolutionist, but a creationist (Morris, 1984; Kampourakis, 2013). The above organizations believe that knowledge of the nature of science and the knowledge of evolution are essential for effective instruction of the natural sciences (Nadelson & Southerland, 2010), while scientists in various fields of science challenge the presently accepted process of evolution (Mazur, 2009), making it a theory not fully accepted by the scientific community (Ashton, 2001).

It is well accepted in the educational community that evolution is necessary for proper instruction in the natural sciences. The AAAS states that evolution is ". . . a core element in science education. . .," (AAAS, 2006, p. 1) and believes it is necessary for the proper understanding of the natural and physical sciences. This kind of statement is seldom challenged and the concern of researchers is not whether evolution should be taught or accepted but why it

is not more widely accepted and understood by science teachers (Nehm & Schonfeld, 2007).

Quantitative research has been employed to establish a variety of correlational relationships between the acceptance of evolution by teachers and their religious beliefs, their knowledge of evolution, and their knowledge of the nature of science (Nehm & Schonfeld, 2007; Nehm, Kim, & Sheppard, 2009; Smith, 2010b). Little qualitative research has been conducted to attempt to understand how teachers maintain a balance in their classroom between religion and evolution. It is the hope of researchers that increasing the understanding of evolution, that is, its processes of operation, will increase its acceptance by teachers and students (Nehm & Schonfeld, 2007; Stanisavljevic, Papadopoulou, & Djuric, 2013).

Of the approximately two hundred research articles I have found which deal with teaching evolution, though all address the controversy between religion and evolution in the classroom, only a few have been found to be qualitative (Donnelly, Kazempour, & Amirshokoohi, 2009; Reis & Galvao, 2009). The articles consistently make reference to the belief of teachers and students in evolution without making a distinction between microevolution and macroevolution. In this study I went to the participant teachers and found out whether or not they reject or accept evolution as a whole and was able to discover their personal views on the teaching of evolution. This includes their reactions to classroom situations and their personal rejection and acceptance of the teaching of evolution, which included the religiosity factor. According to Fowler, Florida received an "F" on their science standards in a national report from the Thomas B. Fordham Foundation in 2005. In 2010 Fowler introduced a survey to 353 teachers from the Florida public schools, 74% of which felt comfortable with the new Floridian science standards which required teaching principles of evolution. About 62% of the teachers agreed to use the new standards (Fowler, 2010; Gross, Lerner, Goodenougn, Lynch, Schwartz, M.,

Schwartz, R., 2012). Fowler concluded that approximately 20% of Florida's students are taught evolution by teachers not comfortable with teaching the subject or who do not teach evolution at all. In 2012 the Thomas B. Fordham Foundation gave Florida a grade of C on their science standards, requiring the teaching of evolution (Gross, et al., 2012).

Going to teachers in person should help to understand how they are dealing with teaching a controversial subject such as evolution.

Situation to Self

To assume that a better understanding of the nature of science will enhance the ability to understand evolution is philosophical in nature, not scientific. I am a science teacher who has taught creationism and the processes of evolution in apologetics classes for over thirty years, first at the high school level, and for the last ten years, at the college level. The philosophy that it is necessary for evolution to be taught in the science classroom is accepted without question by the leadership of educational organizations in our country who hold the strongest influence in science education. Much research has been conducted on the teaching of evolution, with many disappointing results (Nehm & Schonfeld, 2007; Smith, 2010a, 2010b). According to Nehm and Schonfeld (2007) even after taking a fourteen-week course on evolution which targeted numerous misconceptions teachers have about evolution, the teachers still wanted to have antievolutionary material taught along with evolution in their classroom. The course enhanced their knowledge of evolution and the nature of science and reduced the number of misconceptions but the attitudes of the teachers did not change. When it comes to teaching evolution, teachers have not been doing the job expected of science educators (Nehm & Sheppard, 2009) due, in part, to what some researchers refer to as the *religiosity* factor. Nehm and Schonfeld (2007) and some others use the term *religiosity* in their research to address the

level of commitment to the religious beliefs of the participants. The term is used with the same intent in this study. This study looked into the ways in which science teachers in a school district in the state of Florida deal with this controversial issue.

Problem Statement

The problem is that evolution is a controversial, socio-scientific subject which must be taught in the science classroom in an American culture where 78% of the population believes that God employed some act of creation to bring about the Earth and life on it (Newport, 2012). The problem has been addressed with the use of quantitative research, primarily, with the use of surveys. I believe that if students and teachers are questioned with a more personal approach, in person rather than with surveys, it may provide some insight not otherwise accessible. In quantitative research surveys do not reach the participant on a personal basis and assumptions must be made, such as those mentioned on page thirteen.

Organizations influential in the teaching of science in the U.S. are treating evolution as a framework for teaching the nature of science. A number of scientists, including some established research scientists, are challenging the popular theories concerning the process of evolution because they believe that Darwinism is not a satisfactory process to account for the origin of life (Mazur, 2009; Nadelson & Southerland, 2010). The science education community equates the teaching of evolution with the proper teaching of science, and the teaching of creationism with the teaching of religion (Lovely, 2008). Nehm and Schonfeld's (2007) research indicates that half the research participants, usually high school science teachers are not convinced that the perceived need for evolution in the science curricula has been demonstrated.

Organizations like AAAS, NTSA, NAS, NRC, and NCES (NAS, 1998; NRC, 2012) insist that evolution is necessary for the teaching of science, especially biology, yet many science

teachers have difficulty accepting and teaching evolution. According to Sanders and Ngxola (2009), teachers feel a need for training on how to teach the subject of evolution. This is partly because evolution is a controversial socio-scientific issue and teachers need to believe in the significance of the issue, as well as feel knowledgeable on the topic before addressing the controversial subject in the classroom (Reis & Galvao, 2009).

Purpose Statement

The purpose of this study is to inquire about how science teachers in a school district in Florida reconcile religion and evolution in their classroom. I am attempting to find out how they teach evolution in the science classroom, when, according to research, it is very likely that the teachers, and some of their students, do not accept evolution (Seals, 2010; Moore & Cotner, 2009; Moore et al, 2011). Much quantitative research has been accomplished on the various characteristics necessary for teachers to instruct students in that subject. Little has been done to uncover the reasons behind the disappointing results revealed so far. These results are mostly disappointing to organizations like NRC, AAAS, and others mentioned earlier. After taking a course in evolution, and the nature of science, high school science teachers had more knowledge of the nature of science and evolution, but most of the participants still preferred that students be exposed to some instruction in creationism, as well as evolution (Nehm & Schonfeld, 2007). This discrepancy occurs because the religiosity factor addressed in the studies on this subject overcomes the knowledge factor, an issue addressed by Nehm and Schonfeld and many other researchers mentioned in this study. This conclusion is based on the correlation researchers have discovered between religiosity and knowledge of evolution.

Significance of the Study

The significance of this study is in the investigation of how science teachers are balancing their religious beliefs with those of the students in the science classroom. Research is needed to understand what science teachers are doing to maintain a relatively noncontroversial learning environment, while teaching a controversial subject, evolution, in a state where, only eight years ago, evolution was not mentioned in the science curriculum standards (Fowler, 2010). Religiosity has always been an important factor in the teaching of evolution, the only science subject to which terms like *acceptance, belief, and worldview* have been applied (Nehm, Kim, & Sheppard, 2009).

Throughout the world there are thousands of science teachers who have had evolution introduced into the science curriculum only in recent years (Abrie, 2010). The position of scientific organizations on the necessity for including evolution in the science curriculum implies that school systems throughout the world which have not done so until recently have not taught real science. Yet the U.S. continues to trail behind most of the world in international scholastic competition (Kim & Nehm, 2011; Smith, 2010a).

Research on the subject of the teaching of evolution in the classroom, so far, has provided some disappointing results for the science education community. Most studies show that science teachers with a strong background in the sciences cannot teach evolution to the satisfaction of the education community. It has been demonstrated that knowledge in a non-evolutionary topic will have a positive correlation with belief in that subject, but the same correlational relationship is not necessarily true of knowledge of evolution and belief of evolution (Nehm & Schonfeld, 2007).

I believe the real significance of this study is in its attempt to contribute to research that will help reduce a stressful anti-learning atmosphere in the science classroom.

Research Questions

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?
2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?
3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?
4. How do science teachers in the FSD perceive the relationship between religion and science?

Question #1 addresses the religion-evolution issue, since most Americans have religious beliefs that directly contradict evolution. Some teachers choose to ignore the issue, while others try to confront the religion aspect directly in an attempt to defeat it, and still others approach creation and evolution as two different world views (Levinson, 2006a; Seals, 2010; Reis & Galvao, 2009; Sikkink, 2009). Proponents of evolution believe that the religiosity of teachers will ultimately prevent students from proper preparation in the sciences (NRC, 2012).

Question #2 addresses how teachers deal with the variety of religious beliefs in their classroom. Most students in this country have difficulties accepting evolution in general and struggle with two aspects of evolution in particular: Origin of life and origin of man, both covered under the topic of macroevolution (Levesque & Guillaume, 2010; Nehm et al, 2009).

Question #3 and #4 address how teachers work out their differences, if any, between religiosity and the subject they are required to teach. Research shows consistently that teachers'

religiosity is a substantial factor in the extent to which they desire to teach evolution and how they approach the subject (Nehm & Schonfeld, 2007; Nehm et al, 2009).

Question #4 addresses the perception of the teacher with regard to religion and science, since the literature indicates that some teachers view religion and science as separate entities in conflict with each other, while others do not see a conflict and try to bring the two together by way of theistic evolution, for example (Reis & Galvao, 2009; Seals, 2010).

Research Plan

The case study method is appropriate for this type of research because it seeks to find out how science teachers manage a balance between religion and evolution in their science classrooms in a selected school district in the state of Florida. The school district was selected for my convenience. A state in which the subject of evolution is most likely to be controversial makes it an ideal location to approach this particular socio-scientific subject. Florida went from receiving an "F" by the Thomas B. Fordham Foundation in 2005 for not mentioning evolution in the science standards to requiring that evolution be taught in public schools by 2008 (Fowler, 2010).

Delimitations and Limitations

For convenience of access participants included high school and middle school science teachers in one school district in Florida. These teachers came from the public school system because the literature review indicates that the research is based on the teaching of science in the public schools, and the participants and subjects of the current research are employed by the public schools.

The study was limited to one school district. The study was representative of only one local region of the United States, North Florida. The interview method was limited to my ability

to conduct an interview. There is the possible lack of experience or inability to build trust between interviewer and interviewee. Marshall (1999) and Gall (2007) point out the advantages and limitations of the interviewing process, and the interviewer is probably the one that poses the greatest limitation to the process.

Definitions

1. Evolution-"the descent of modern organisms with modification from preexisting life-forms; strictly speaking, any change in the proportions of different genotypes in a population from one generation to the next" (Audesirk, T., Audesirk, G., & Byers, 2005, p. G9).
2. Microevolution – a term that refers to the rise of adaptations from genetic variation over short periods of time, referred to by some evolutionists as natural selection. Genetic variation within species (Meir, Perry, Herron, & Kingsolver, 2007; Reznick & Ricklefs, 2009).
3. Macroevolution (generally referred to as just 'evolution')– a term that refers to the rise of new species over long periods of time. Microevolution is assumed to cause this process (Meir, Perry, Herron, & Kingsolver, 2007; Reznick & Ricklefs, 2009).
4. Natural selection – in the context of evolution it is the process that causes the survival of species that produce offspring with the necessary characteristics to live in their specified environments (Reznick & Ricklefs, 2009).
5. Species-in its most basic form the word refers to a group of organisms who are able to interbreed.
6. Kind-among creationists refers to an animal within a Family, such as Felids and Canids or an Order, such as Crocodilia (Patterson, 2006).

Summary

Evolution is a controversial socio-scientific subject that is required in public schools in light of the fact that over half of the American population does not accept the process as a whole and about half of the public school teachers would like to teach a form of creationism as a viable alternative. It is also believed that evolution is necessary for proper preparation of students who would like to work in a field of science. This case study was an attempt to find out how science teachers in the public schools in the southeast balance religion and evolution.

CHAPTER TWO: LITERATURE REVIEW

Overview

Research performed by Nehm and Schonfeld (2007) and others (Nehm & Reilly, 2008; Nehm et al, 2009) show positive and negative correlation between certain factors observed in the teaching of evolution. Some of these include negative correlation between a science teacher's religious beliefs and advocacy for teaching evolution; weak positive correlation between knowledge of evolution, religiosity, and understanding of evolution; weak positive to no correlation between understanding of evolution and accepting evolution (Nehm & Schonfeld, 2007). The religiosity of the teacher is not always taken into consideration in research, but the religious view of the student is often the main consideration. Some of the main points of interest in research on the teaching of evolution include: Preparation of the teacher, evolution as a controversial subject, the relationship between religion and science, and acceptance of evolution in foreign countries.

Religiosity refers to the level of commitment of the participants to his or her religious views. This is demonstrated by asking the participant questions about church attendance and other indications of devotion to religion. In this study I am interested in the management of religious beliefs and the teaching of evolution in the science classroom. Most research focuses on the teaching of evolution and its acceptance by the student. Nehm, Schonfeld, Sheppard, Kim, and others have included the religiosity of the teacher and the effect of a teacher's religiosity on his or her willingness to teach evolution. This plays a role in the manner in which the teacher presents the subject. This variable is why one of the research questions asks how the teacher reconciles personal religious preferences with the teaching of evolution. This chapter will review some of that research and consider its results.

Theoretical Framework

This study is seeking to discover how science teachers address religion and evolution in the biology classroom. Several theoretical frameworks should be considered. There is the Piagetian theoretical framework for cognitive development. Applying the cognitivist theories developed by men like Piaget and Tollman, we can conclude that achieving an advanced level of knowledge of evolution will allow students to attain a higher level of development, in the formal operational period, in the area of biology (Hergenhahn, 2001; Miller, 2011). This idea is inferred from cognitivist theories of education and the beliefs of leading educators of biology as well as scientists who conduct research in that area of learning (Alles, 2001).

Cognitive learning theories coincide well with the teaching of science. Science education is designed for students to acquire knowledge which will allow them to proceed to a higher level of understanding. Science educators working at leading organizations believe that the natural sciences cannot truly be understood without evolution, and that evolution must be the framework for the teaching of biology (AAAS, 2006; Alles, 2001; NCSE, 2013, NRC, 2012). If this is true, one can infer that if evolution is taught in the science classroom, a higher level of learning will be achieved, allowing students to make progress in their understanding of the natural sciences. Yet, the problem with the teaching of evolution is that it contradicts the religious beliefs of most Americans (Newport, 2012). This situation puts many students in a position in which they must decide to believe either their teachers or their parents and church. Cognitive theory addresses this situation and attempts to explain how students deal with this new knowledge.

Piaget's framework of cognitive development includes two processes used by children in the learning of new information which must be considered in the instruction of evolution, assimilation and accommodation (Sinatra, Brem, & Evans, 2008). Assimilation is adding new

information to previous information, and accommodation is what the student does when new information does not agree with previous information. Those two processes take place when evolution is taught to science students who have not been raised to believe in evolution. Developmental psychology has made progress since Piaget. We need to jump from his cognitive development framework to a theoretical framework that addresses conceptual change and attempts to explain why it is difficult for students to accept new information, especially related to the learning of evolution (Evans, 2008; Hickling & Wellman, 2001; Sinatra et al, 2008).

Evans and Sinatra both consider the framework of conceptual change from research which reveals that children are born with certain innate abilities called essentialist, teleological, and intentionality constraints, sometimes referred to as naïve theories. Essentialist constraints limit the child to believing that one animal cannot change into another (Sinatra et al, 2008). Teleological constraints cause the child to assign design and purpose to nature, as opposed to the naturalist view of science (Sinatra et al, 2008). Intentionality constraint is the tendency to believe that events are caused by some individual we might refer to as supernatural being (God) or human (Sinatra et al, 2008). Later on, in their development, children can be convinced contrary to these constraints, since they can be taught in evolutionary processes that contradict these constraints. The longer the child is exposed to these viewpoints, the more difficult it becomes to teach information that contradicts them (Evans, 2008; Sinatra et al, 2008; Wellman & Gelman, 1998). But the bottom line is that evolution, a view contrary to what is taught in most American homes, is required to be taught as fact in the science classroom.

Organizations such as the AAAS, NRC, NSTA, NAS, and NCSE believe it is essential that students be taught evolution in science classes and that biology be established on the framework of evolution (AAAS, 2006; NCSE, 2013; NRC, 2012). A workshop summary report

from the NAS explains that an understanding of evolution will allow students to understand the biological sciences. The NCSE calls evolution a fundamental theoretical construct for biology. It is the premise of these organizations and most of the education and scientific community that without the teaching of evolution one cannot truly understand the natural sciences. That, in itself, is a theoretical framework for the teaching of the biological sciences. This framework is not the basis for this study, but one of the principal reasons for it. This evolutionary framework is required in the science standards of most states. Yet it opposes the beliefs of most Americans, including nearly half the science teachers participating in such studies.

The proposed research addresses the classroom management of religion and evolution, which overlap in that they both address, from opposing perspectives, the origin and development of life forms from one form to another: phylogeny. According to Nehm, Kim, and Sheppard (2009), the teaching of evolution in the science classroom is problematic. Their evaluation stems from the fact that evolution is not treated like other topics taught in science education. Outside the scientific method, it addresses the concept of origins, which involves processes that cannot be observed and to which religions hold a position. Since most Americans have a belief of origins that differs from the national science standards, it is not surprising that there is often a conflict between the religious beliefs of the teacher, student, and curriculum, where the teacher does not necessarily agree with the curriculum. When a student is confronted with material that conflicts with previous acquired knowledge, accommodation takes place, and a conceptual change occurs, no matter how minor. If a child is taught that lizards do not change into birds, and the teacher instructs that they do, there must be a new explanation for this apparent contradiction, since children assume their parents do not lie to them and teachers do not lie to their students. The student now has to create an accommodating explanation. The majority of students in the U.S.

are faced with this dilemma with a controversial subject whose instruction is mandated by state curricula.

The theoretical framework which is most applicable to this study is one which addresses controversial socio-scientific topics, the specific application of which is evolution (Levinson, 2006a). Levinson proposes a framework for handling confrontational topics, so that learning can take place under less stressful conditions, which, in itself, should enhance the learning experience when such topics must be addressed in the classroom. A topic is controversial when the teacher has proclaimed it to be the right view, as opposed to another view. Topics such as stem cell research, abortion, childhood vaccinations, environmental issues, and others, also fall to this category because there is always a right and wrong view to consider with such issues. Levinson (2006) and Hermann (2008) have suggested ways to approach these topics in the science classroom. People can react emotionaly towards controversial issues because, by definition, not everyone agrees, and sides are taken. The basis for the disagreement is usually religious or philosophical in nature, and must be handled with consideration for the feelings of all involved.

The teacher must decide how to handle these issues in the classroom to allow the least amount of conflict.The teacher must be able to address conflicting explanations held by large groups of people who do not accept the evidence presented by the opposing side (Levinson, 2006a, 2006b). Disagreement in the classroom discussion must be reasonable, or conflict can follow. Teacher education courses are not created to prepare teachers to deal with controversial subjects in the *science* classroom (Hermann, 2008). Science covers areas of study that are approached empirically, with emphasis on observation and calculations, not beliefs and opinions. The subject of origins, by nature, cannot be addressed empirically, as a whole. Some of the

processes of evolution can be observed, but evolution is presented as an all-or-nothing proposition.

The origins topic falls into a category of controversy in which the validity of entire frameworks are debated. Predominant leaders in the science education community stress that biology classes should be structured on the framework of evolution, which they feel many science teachers do not teach to their satisfaction.

Related Literature

This country's most influential science education organizations believe evolution to be essential to learning biology. For example, Dr. Theodosius Dobzhansky believed that evolution should be the framework upon which biology is structured (Moore, 2007). Many who work in the field of science education are of the same opinion, people like Alles, (2001) and Ayala (2000), for example.

Organizations influential in the field of science education believe that if one understands the nature of science, he or she will most likely accept evolution, and, understand the processes of evolution (Nadelson & Southerland, 2010). Some of the organizations which emphasize the importance of the role of evolution in the science classroom include the National Center for Science Education (NCSE) and the American Association for the Advancement of Science (AAAS), organizations influential in the writing of science textbooks. It is accepted as fact in the education community that evolution is necessary for proper instruction in the natural sciences. The AAAS board of directors published a statement saying that evolution is ". . . a core element in science education," and believes it is necessary for the proper understanding of the natural and physical sciences (AAAS 2006, para. 1).

Evolution is not just another science topic within the science curriculum. It is estimated to be foundational, essential for a complete education in the sciences, especially biology. If evolution is indeed the framework for biology, any student studying this subject could not become proficient in biology unless he or she has had a thorough understanding of this framework. There are many fields of science involved in the study of evolution, but biology is the most pertinent because it addresses the evolution of life on earth. One would think a topic of such significance, should be mastered by well-prepared science teachers who work in secondary schools and colleges. Research done by Nelson (2008) and Smith (2010a, 2010b), however, indicates that evolution is not as well understood by students or teachers, as its importance implies that it should be. So, the perception from the educational community is that public school teachers are not doing an effective job at teaching evolution (Nelson, 2008; Smith, 2010a, 2010b).

Through research, Smith (2010a, 2010b) and others have observed that teachers, as well as students, do not necessarily accept evolution, even after taking college courses. Smith (2010a, 2010b) points out that, even after receiving instruction in this subject, students are not willing to change their minds because the arguments presented contradict their worldview, and often, that of the teacher. I suggest that the teaching of evolution in the public school system is a challenge for two important reasons: a) the religiosity of the teacher and b) the religiosity of the student. Teachers and students both adhere to certain religious beliefs, and unless their presuppositions can be altered, they will not readily accept a philosophy that opposes those beliefs, even if it is accompanied with factual information. Evolutionists partly blame the creation movement, those organizations involved with it and the direct teaching of creationism, for hindering the acceptance of evolution (Berkman, 2008). Because creationists have published thousands of

books, journals, magazines, newsletters, and a variety of literature over the last five decades, evolutionists believe antievolutionism is greatly responsible for teachers not instructing evolution effectively or persuasively (Cleaves & Toplis, 2007; Hitt, 2009; Yalcinoglu, 2009;). Such antievolution groups include the Institute for Creation Research, Answers in Genesis, and the Discovery Institute. The latter organization in this group produces information related to the Intelligent Design (ID) philosophy, which does not always coincide with the young-earth creationist philosophy taught by the former two organizations. These organizations are blamed for creating a problem in the science classroom in spite of the fact that many scientists and science educators agree that evolution is important for teaching biology and other sciences.

Nehm, Kim, and Sheppard (2009) draw the following conclusion concerning the teaching of evolution in the public school: "Thus, despite overwhelming agreement from the scientific and science education communities, evolution remains a problematic subject for many science teachers" (Nehm et al, 2009, p. 1123). The science education communities these researchers are referring to include "The National Academy of Sciences (Short, 2015), 1998; The National Association of Biology Teachers, 2002; National Science Teachers Association, 1997)." The National Science Education Standards and the National Research Council are also included. It is interesting to note that no other science subject is addressed as *problematic* to teach.

Teacher Preparation.

Preparing to teach evolution as a science topic.

Science teachers appear to have difficulties teaching evolution effectively, even after acquiring a college education and state credentials. The fact that biology and non-biology science teachers have similar misconceptions about evolution would indicate a problem in college preparation (Nehm, Kim, & Sheppard, 2009). Research has little to say about the misconceptions

science teachers have about the laws of physics, chemistry, or biology. Some may have been poorly trained, but poor training does not appear to be an issue until we address the ongoing misconceptions science teachers and college biology majors still have about certain basic concepts foundational to the understanding of evolution, like natural selection, for example, and what they call *naïve* misconceptions, (Nehm & Reilly, 2008; Smith, 2010a, 2010b). This has caused educators to look for methods of teaching evolution that go beyond the normal science class teaching methods.

The kind of teaching method they are working with is primarily for conceptual change. This is well defined and explained by Pugh (2010a) in an article on learning by transformative experience. It is a method of teaching for conceptual change which has been used in studies to remove misconceptions and to change the attitudes college students have about evolution (Heddy & Sinatra, 2013). Short and Hawley (2015) have discovered, through their research that a course in evolutionary psychology is more effective in influencing college students to accept evolution than science courses. Science courses do not, as a practice, use transformative methods but are more straight forward and traditional in their teaching. They teach directly out of the text in the classroom and use the laboratory environment to illustrate the principles learned in class. Teaching methods that incorporate transformative experience and the use of evolutionary psychology courses appear to be the most promising methods for helping students to accept evolution. These classes produce students that have fewer misconceptions about the theory of evolution (Pugh, 2010; Short and Hawley, 2015). This type of research could be used in preparing future teachers to teach evolution. Another option perhaps would be to introduce a new type of course in the schools that would focus specifically on conceptual change.

This method of teaching science is normally used in the teaching of values and must attempt to incorporate the principles of science into the daily life of the student. In their research Heddy and Sinatra (2013) call it the Teaching for Transformative Experiences in Science (TTES) model, quoting Pugh (2002). The teacher attempts to make the science relevant to the student on a personal basis. It incorporates group discussions and projects which allows for more interaction between students as well as with the teacher. The teacher tries to involve the students as much as possible into the teaching of the lesson. Evolutionary psychology is at present a key to influencing students to accept evolution. It is also used to explain the origin of morals and other psychological mechanisms normally explained in psychology.

Psychologists do not normally use evolutionary psychology to help understand human psychological mechanisms (Burke, Kaighobadi, & Barrett, 2014). Burke et al (2014) explain that most of the research performed in psychology is done with no regard to the theory of evolution. There are many skeptics in the field who see no purpose in depending on *story-telling* to help understand psychological processes. Some of the skeptics of evolutionary psychology include Buller (2005), Harris (Harris, Chabot, & Mickes, 2013; Harris & Mickes, 2014), and Confer (Confer, Easton, Fleischman, Goetz, Lewis, Perilloux, & Buss, 2010) and Fitzgerald (Fitzgerald, & Whitaker, 2010). There are others also who do not trust the evolutionary basis for attempting to explain the origin of and the mechanism of psychological processes. Harris criticizes evolutionary psychology in the many assumptions that are made about human behavior without ever having tested the hypotheses (Harris et al, 2013). Burke et al (2014) say that explanations of human psychology depend on cross-species comparisons. This means that first evolution is assumed to be true and then animal species' behavioral patterns are observed and finally applied to explain human behavior. He refers to them as phylogenetic comparisons used to test

hypotheses. This is one of the main reasons non-evolutionary psychologists do not depend on evolutionary psychology to explain human behavioral mechanisms. The same is true of evolutionary developmental psychology (Machluf, Liddle, & Bjorklund, 2014). She points out that when the *Origin of Species* was first published the development of the embryo was very important because it was used as evidence for the evolution of life, as it is still today, although to a lesser degree. Darwin stated "Embryology is to me by far the strongest single class of facts in favor of change of forms, and not one, I think, of my reviewers has alluded to this" (Machluf et al, 2014, p. 264). In 2006 Dawkins admitted in his book, *The Selfish Gene,* that the processes of embryology are irrelevant to our understanding the theory of evolution (Machluf et al, 2014). Dawkins and other evolutionists do not see the relevance of embryology to the support of the theory of evolution, probably because cross-species comparisons of embryological development do not demonstrate parallel tissue development from one species to the next. This study will not address the topic of evolutionary developmental psychology or evolutionary psychology except in this chapter. These applications of the theory of evolution are rarely used by evolutionists and do not seem worth investigating at this time.

Science teachers who take courses in evolution usually come out with a greater understanding of evolutionary processes and have fewer misconceptions about evolution. But, these teachers still have difficulty teaching evolution due to their religiosity (Nadelson, L. & Nadelson, S., 2010). In spite of instruction in evolution, secondary science teachers and college biology students still have problems understanding the process of evolution, as it is presented in the science curriculum. Students are more likely than teachers to apply naïve reasoning, believing that animals, such as fish, living in underground streams, lose their eyesight from lack of organ use, or that new traits are acquired because of a need for a new organ or appendage. It

makes one wonder why it is that biology teachers have little trouble teaching photosynthesis or protein synthesis, yet have trouble with teaching how processes like natural selection produce new species?

Nelson (2008) believes that teachers need to teach evolution more effectively by overcoming in the classroom the numerous misconceptions introduced into our society by the Intelligent Design (ID) community. He uses ID and creationism interchangeably, although the two groups do not necessarily want to be lumped into one. Reiss (2008) takes a less direct approach, holding to the belief that evolution should be taught, not as a concept contradictory to creationism, but as another scientific worldview. This renders the creation-evolution controversy less controversial and allows the teacher to deal with evolution in the classroom as a worldview that is different from creationism, and not as a worldview that opposes creationism. Nelson, Reis and Seals represent different ways of dealing with the same problem. Seals' approach is that of introducing creationist arguments to teach students to think critically (Seals, 2010). His thought is that keeping opposing arguments from students does not prepare them to defend and confirm their own convictions, he contends that a better understanding of opposing views has the effect of reinforcing personal convictions, that abstaining from exposure to contradictory views can have the effect of creating instability about one's own beliefs. In classrooms, presenting opposing arguments is characteristic of teaching a controversial subject. Often when teaching evolution opposing arguments are presented as misconceptions and *refutation* texts are used to help the students to make conceptual changes.

Heddy and Sinatra (2013) used refutation texts with the comparison group of their research which proved effective in implementing conceptual change. They state a misconception and present information to refute that misconception. Some of the misconceptions include beliefs

associated with the creation model, such as a worldwide flood. Creationists do this in apologetics classes to attempt to show the weaknesses of the non-creationist theories on the origin of the universe and life on earth. This method of teaching evolution is not permitted in public schools since it would reinforce a religious view, creationism, and refute a scientific view.

Science teachers are trained in today's colleges and universities to teach science, not controversy. When teachers present information to their class that contradicts the students' religious beliefs, they will confront students whose convictions are reinforced by creationist thinking, a situation for which most teachers have not been prepared. Additionally, teachers have their own religiosity to consider, a factor targeted by certain researchers previously mentioned.

Preparing to teach evolution as a controversial topic.

Science teachers are usually not prepared to teach controversial topics. There is nothing controversial about teaching the law of gravity, photosynthesis, or redox reactions. Therefore, on the surface, there appears to be no need to prepare teachers to handle controversy. Yet, science teachers do encounter socio-scientific topics such as stem cell research or cloning, subjects which should not be ignored. Levinson (2006a, 2006b) and Hermann (2008) propose a framework to prepare teachers to address controversial topics, including evolution. Levinson proposes a general framework for teachers to use to address any controversial issue, while Hermann specifically targets evolution. Hermann concludes his study with the recommendation that students should be presented with evolution in a discussion format, as opposed to an attitude of *believe-in-evolution-or-else*.

Regardless of the method of preparation, it is evident that science teachers should be prepared to handle controversial topics, even if the topic is unrelated to evolution. In our context,

a controversial topic is one in which there is disagreement within a population of students, and therefore, is one which should be handled with tact (Hermann, 2008; Levinson, 2006a).

Research indicates that when students, including high school teachers and high school and college students, are presented with knowledge of evolution, they will usually have a greater understanding of evolution, although not necessarily a greater acceptance of it (Nehm & Reilly, 2008; Nehm & Schonfeld, 2007). Knowledge of evolution includes processes and *factual* information. In dealing with teachers' perceptions of evidence, Levinson (2006b) discovered that it is not enough to present facts. The facts must be accepted by the recipient as valid, and not in opposition to his or her values. The recipient of the information will interpret it according to a set of presuppositions and will attempt to assimilate the information. A fact presented in a manner that proves that a discussion participant is wrong shortens the discussion and shuts down some of the participants. This occurs because facts, by definition, are viewed as true and real. However, such facts may not be accepted as *facts* by all parties. Some people believe that an ape-man fossil is a fact that proves humans evolved from the apes, while others look at the words *ape-man fossil*, as an interpretation.

Most people will not forsake their religious beliefs when presented with evidence that contradicts those beliefs, even when the evidence is presented as scientific (Levesque & Guillaume, 2010; Sinatra et al, 2008). A worldview is not easily altered, and some researchers who realize that this is the case, suggest teachers present evolution to students as a scientific concept which does not necessarily oppose their creationist worldview, and that evolution can be incorporated into a creationist worldview (Schilders, 2009). This can only be true if evolution is itself a worldview which attempts to explain the origin of ". . .the descent of man, mind and matter, . . ." (Schilders, 2009, p. 115). Worldviews are based on religious presuppositions and are

not changed until the presuppositions are changed. Science is based on empiricism, but its practitioners adhere to belief systems that range from atheism to theism, all of which are faith-based systems. Research, as previously mentioned, bears out the strong influence of personal religious convictions in light of presented *facts* that oppose those convictions. Neither teachers, nor students, nor scientists detach themselves from their religious convictions, regardless of any evidence that is contrary to those convictions.

Commitment to Religious Beliefs.

Religion and Science: a relationship.

Science and religion were not always at odds with each other. There was a time when evolution was not thought to be so scientific. Paul Davies, a professor of mathematics, explains in his book, *The Mind of God*, that if it were not for Western theology, science would probably not have developed the way it did, and maybe not at all. Davies explains how John Barrow, author of *Theories of Everything* and Joseph Needham, author of *The Grand Titration,* deduce that if it were not for the Christian beliefs of Isaac Newton, Newton probably would not have developed calculus (Davies, 1992). These authors use Japanese mathematician Kowa Seki as a counter example of someone who also developed calculus, but who did not believe in an immutable God who created immutable laws of nature, and, therefore, discarded his material. Barrow (1991) explains how the Chinese believed in a natural world of forces which interacted holistically, influencing each other in such a way that a living organism appears to be greater than the sum of its parts. They believe that any event could be influenced by any other event from anywhere at any time. The western world looked at nature linearly, in that one event caused another which caused another and so on in a local area of nature and was not going to be affected by a remotely located force. It is somewhat like looking at ecological relationships between

organisms. We can work with a food chain from producer to tertiary consumer, but realize that the world really works as a food web rather than a food chain (Barrow, 1992; Needham, 1969). Eastern thinking expected influences from anywhere at any time to affect present events but western thinking expected that a local event was affected by a previous local cause.

Scientific discoveries were made by men and women who dealt with natural events linearly. Past scientists and mathematicians, who believed in an immutable God who developed immutable laws of nature and mathematics, relied on the characteristic of immutability to develop their scientific thought (Davies, 1992). Laws of physics, chemistry, and other fields must be unchangeable, or they cannot be used in formulas, and cannot be called laws. Scientists must believe that processes of nature stay constant, or scientific application of these principles cannot exist. Many formulas have constants which are relied upon for the formulas to work (Barrow, 1991; Needham, 1969).

It took faith to believe that the laws of nature would be just that-laws, which are unchanging and reliable. Many of the scientists who laid down the foundation for the development of science had religious beliefs in God, the Bible, and a young creation (Graves, 1996; Morris, 1982). Instead of causing science to be stunted in its growth, their faith caused it to grow, according to evolutionists like Barrow and Needham who studied the historical development of science. Contrary to popular thought, Christianity, with its belief that man and the universe were created, is not a modern religion, and neither is belief in the evolution of man.

For example, Empedocles, who is sometimes referred to as the *father* of the philosophy of evolution, (Davidheiser, 1969) believed that somehow parts of animals and humans were formed and united through random processes into many different combinations, eventually arriving at the workable combinations of body parts that we recognize today in the various forms

of humans and animals. Although Empedocles, who lived in the fifth century BC, may be called the father of evolutionary thought, another Greek philosopher, Anaximander (610-540 BC), had, a century earlier, also concluded that man had developed in the past from "…animals of a different kind…" (Cooper, 1995, p. 21). His teacher was Thales, referred to by Aristotle as the father of natural philosophy. Natural philosophy led philosophers to develop faith in forever-changing random processes, which could not be relied upon in the development of mathematical and scientific principles (Barrow, 1991). Yet Christianity is now recognized by some historians (also evolutionists) as the probable philosophical reason that the principles of mathematics and science were developed (Barrow, 1991; Needham, 1969). The relationship between religion and science is debated today. Yet it is not actually a debate between religion and science, but is actually a debate between two worldviews, creating the illusion that science is knowledge that opposes religion.

The purpose of this study is not to attempt to prove that evolution is religion rather than science, but to work with the status quo thinking of the public school system and the science organizations that influence and sometimes write the science standards adopted by school systems. They believe that evolution is scientific, and because the subject of evolution is controversial, I'd like to show that we need to study how the two subjects can be dealt with effectively in the science classroom. Several approaches have been used to address the process that we call evolution.

Stephen J. Gould, a paleontologist and evolutionary biologist who taught at Harvard, believed in the principle of *non-overlapping magesteria* (Astley & Francis, 2010). He felt that as long as religion concerns itself only with the spiritual realm, and not with the realm of empiricism, no conflict arises. This implies that religion is for spiritual issues, and science is for

empirical issues. This view assumes that in the science classroom there is no room for creationism, a religious topic, only evolution, a scientific subject. However, conflict arises when evolution dictates religious principles or when religious principles dictate scientific processes, such as the origin of things, because, at this point, an overlap occurs. On the other hand, Dr. Ruse, a philosopher of biology, and many others with similar Christian beliefs, have concluded that science and religion can coexist in the science class by merging the two through a blend known as theistic evolution, or some variance of theology such as the Gap Theory. Most creationists do not blend the two accounts of origins together, so conflict occurs. Some have suggested that perhaps certain religious topics can be taught along with science topics. But that seems to be problematic (Astley & Francis, 2010) since it is illegal at present. Many creationists would not object to this idea and neither would many who are agnostic and atheist (Newport, 2012). This paper is not attempting to resolve the issue of teaching religion and science together, but rather to determine how science teachers in a school district in Florida deal with this situation.

Most research on the teaching of evolution has addressed the effects of the religious training of students on their acceptance of science information (Stolberg, 2009). This specifically refers to the acceptance of evolution, when we consider that most of the research that covers this subject deals primarily with methods of teaching evolution, tools which measure levels of acceptance of evolution, and why teachers are not doing a better job at teaching evolution (Rutledge & Sadler, 2007; Stolberg, 2008). No research, as far as I know, has been conducted to try to explain why students cannot accept the concept of gravity, or magnetism, or the conduction of chemical reactions, or genetic variation. Most of the research conducted addresses the teaching and acceptance of evolution. Research in science education addresses more effective

ways of teaching science, not how to teach the acceptance of the scientific material or belief in the scientific material. Stanisavljevic, Papadopoulou, and Djuric (2013) explain that acceptance means that the teacher or student views evolution as scientifically valid. When these researchers say that among teachers the biology teachers have a higher acceptance of evolution they do not make a distinction between microevolution (a non-controversial topic) or macroevolution (a controversial one). This is typical of the research that is available in the journals. It is important for students to accept evolution because it is related to a worldview, as previously mentioned by Stolberg, Schilders, and others (Schilders, 2009; Stolberg, 2009)

Reiss suggests that creationism be treated, not as a problem, or as an erroneous belief, but as a worldview, different from evolution. This allows students who are creationists to have an opportunity to understand the scientific position. Reiss would like teachers to present creationism as a different view not as a wrong view. Although it strives to be fairer, this approach is problematic since creationism cannot be taught in the science classroom in most states (Reiss, 2008, 2009, 2011). Reiss and other researchers who recommend teaching religious views in the classroom have completed their research in English schools, where religious education is required. This does not apply directly to our present system, but might cause our educational system to consider some options, such as teaching world religions. Reiss (2009) quotes Chinsamy (2007), who has written about research done in South Africa, where it was discovered that a straight-forward approach to teaching facts of evolution does little to change the minds of students and teachers. Reiss believes that the direct approach is controversial and not very effective in changing views. Most research supports this same conclusion, with some exceptions.

When teachers were given a course in evolution, to see if acceptance of evolution improved, the results were statistically significant. However the statistical significance was so

low as to be deemed relatively ineffective (Nehm & Schonfeld, 2007). In England, it is easier to blend science information with religious education, and its system is more conducive to allowing the teaching of evolution as a different view rather than a scientific fact.

Although students take sides when confronted with views opposite to those with which they were raised, they are usually not well informed on either side of the issue (Taber et al, 2011). When the religious and scientific views are presented together by a teacher who understands both sides, a compromise can usually be found, where most can agree. Research results from Taber indicate that some students who enter the science classroom with a confrontational attitude are left realizing that the differences between their religious view and that of the science curriculum were not that different. These are generalizations that will change according to the particular slant of the religious view of the student and the manner in which the science material is presented. In America, religious views are usually not allowed in the school, much less in the science classroom. This attitude toward religion, science, and education, in general, does not lend itself to the discovery of common ground between the worldview of the student and that of the teacher (Taber, Billingsley, Riga, & Newdick, 2011). This American way of approaching religion and science in the classroom has a way of creating sides and promotes controversy, rather than agreement.

The law does not permit religion, in the form of creationism or intelligent design, to be taught in public schools along with science (Ravitch, 2012). So he presents a definition of science, as well as the legal aspect. This position establishes lines of distinction between the two sides, rather than attempting to bring the two together. This does nothing to alleviate tension between the teacher and the student, with the student seeing only that his or her view is not allowed (Ravitch, 2012). When students approach this type of situation, they have a tendency to

entrench themselves in their view, without much hope for change. But when approached from the perspective of having the teacher consider the opposing view, there is less of a tendency to arouse controversy. In most science classrooms, science and religion, more specifically, creationism, are dealt with as opposing worldviews, with no common ground. Can we find an area of no-dispute in the science classroom between creationism and evolution?

Evans mentions in her research on conceptual change, that, almost always, when controversy exists between religion and evolution, it falls into the area of macroevolution, rather than microevolution (Evans, 2008; Nelson, 2008). Baker (2013) says that only fifty percent of Americans accept macroevolution as an acceptable explanation for the evolution of man. Microevolution does not present much of a debate, since it is observable and taught by creationists as a means of creating variation within kinds. On the other hand the subject of evolution is taught as all-or-nothing. To say that there is no common point of agreement between creationism and evolution is not an honest approach, and such an approach has the distinction of promoting controversy in the science classroom.

In the United States.

Moore, et al (2011) found that some teachers will not only avoid teaching evolution, but will introduce one side, creationism, as an alternate theory of origins. In some cases, teachers do so in spite of the state laws, which is irritating to some researchers (Moore, 2007, 2008; Moore & Cotner, 2009; Moore et al, 2011). Moore, Cotner, and Brooks (2011) came to the conclusion that twenty percent of students are taught creationism in high school and that the religious knowledge they possess hinders their ability to acquire and assimilate new knowledge of evolution. The conclusion that a high percentage (16-20%) of public school teachers may be teaching

creationism directly, or that they may be presenting it as an alternative view in the science classroom, is substantiated from other research (Nehm & Schonfeld, 2009).

As mentioned, research reveals that religious beliefs will seldom be changed from instruction presented in a classroom environment (Levesque & Guillaume, 2010; Nehm & Schonfeld, 2007). Nehm and Schonfeld conducted studies to try and find out if increasing the knowledge level of science teachers would influence their desire to have evolution taught in school. These researchers discovered that, after taking a course in evolution, approximately 50% of teachers preferred that students be taught some sort of creationism. Prior to the course, 57% of the teachers preferred that students be taught a form of creationism. In the same study the researchers pointed out that numerous education-oriented intervention studies showed that a change in attitude toward a target concept were not statistically significant from the control groups three to six months after the intervention.

Research (Nehm & Schonfeld, 2007) does not indicate that the level of knowledge of the nature of science and evolution increases the biology teacher's desire to teach evolution in the classroom. About half the teachers involved in recent research prefer that students be exposed to some instruction in creationism. In spite of the biology teacher's level of education, such as a bachelor's degree in biology, the teacher was still thought to have a less-than-desirable level of knowledge of evolution and of the nature of science. From research conducted in the last five years, one must conclude that knowledge of biology does not lead to understanding of, increase in the knowledge of, acceptance of, or belief in, evolution. There appears to be weak positive correlation between knowledge of biology and knowledge of evolution. These results do not support the belief that evolution is the framework of biology.

It appears to be common sense that if one increases his knowledge of a subject he increases his understanding of that subject. Yet, this is not the case with most of the research conducted in the past five years dealing with the subject of evolution. There appears to be a built-in problem with evolution in that teachers can believe or accept that particular subject and in the eyes of the researchers they are perceived as lacking understanding because they don't accept it. Many teachers don't explain evolution to the satisfaction of those who research and those who construct the curriculum. This might be because they don't explain it right because it contradicts their beliefs. Even after a fourteen-week course teachers still had misconceptions about the process of evolution, which usually includes the process of natural selection (Nehm & Shonfeld, 2007).

Nehm mentions that knowledge and belief are usually positively correlated in the context of subjects like *photosynthesis* or *respiration* (Nehm & Schonfeld, 2007). This wording is interesting, as I have never seen the term *belief* employed in the context of natural processes. Such processes are usually observed and studied, never *believed in* or *accepted*. However, this is not the case with evolution. Research affiliated with the study of evolution, in the context of education, is very often referred to as being *accepted* or *believed*, and in many cases, the terms *accepted* and *believed* are used interchangeably. Another term associated with evolution is *worldview*. This is another term not usually associated with a science curriculum.

Evolution is not the only controversial topic that causes students and teachers to feel uncomfortable in the science classroom. Topics, such as genetic engineering, must also be addressed in classes comprised of students representing a variety of worldviews with tenets that may not coincide with the majority of classroom opinions. In spite of the potential for controversy in the science classroom concerning genetic engineering, abortion, and other

controversial topics I have not come across any research where instruments were used to measure a student's acceptability or belief of those topics. The literature review has not revealed any researcher who has created a research instrument to measure the level of acceptance held by a student or a teacher on the topic of abortion, global warming, or cloning. MUM (Measurement of Understanding Macroevolution) (Nadelson & Southerland, 2010), MATE (Measurement of The Acceptance of The Theory of Evolution) (Nehm et al, 2009), and KEE (Knowledge of Evolution Exam) (Moore et al, 2011) are such instruments used in research to test the level of knowledge and acceptance of evolution of students.

Controversial topics are presented in the science classroom, but few cause as much debate as evolution, probably because it attacks the very foundation of religions, including Islam, Christianity, and Orthodox Judaism. The creation-evolution controversy in the science class and the presence of large numbers of public school teachers who prefer not to teach evolution in their classroom are not American problems for the evolutionist, they are global.

In Foreign Countries.

Throughout the world, we find a low acceptance of evolution. It is only since 2008, that South Africa has required the teaching of evolution in its public schools. (Chinsamy & Plaganyi, 2008). Religions, like Islam and Christianity, have held on to the creation doctrine, and many have merged the two into a doctrine of theistic evolution. Yet, the creation-evolution controversy is still a hot issue in the classroom, and science teachers have difficulties dealing with it, to the point that they are ignoring the topic of evolution entirely. This avoidance is especially true of teachers in South Africa. The concern in that country is how to train new and experienced teachers to teach evolution effectively in an environment in which evolution has not been taught. If evolution is necessary for understanding biology, in fact, the framework upon which biological

information is intertwined; it must be taught in the science curriculum (Sanders & Ngxola, 2009). At least three studies which address the teaching of evolution have been conducted in South Africa since 2008. Researchers were concerned about students gaining acceptance of evolution in South Africa because of its lack of acceptance around the world by teachers, students, and the general population.

In the Middle East, where most of the high school teachers and professors are Muslim and a minority are Christian, most entirely reject evolution. However, some have incorporated evolution within Christian doctrine, or Muslim or Jewish, depending on the country. Israel for the most part lets teachers decide how they want to handle the subject of evolution (Hermann, 2013). In one study, conducted in Lebanon, Boujaoude, et al (2011) discovered that there are teachers who had assimilated evolution into their religion, as well as those who rejected evolution, or did not believe that it should be taught. It should be noted that the high school biology teachers and college biology professors there earned their doctoral degrees in biology, and these teachers obtained their training and taught biology courses without accepting the whole evolutionary framework. Another country, Turkey, is more adamant in its adherence to Muslim doctrine, and is not so willing to accept evolution. One study (Köse, 2010) revealed that 80% of the students and 81% of the teachers believed in creationism. Of that group 57% of the students and 61% of the teachers believed that evolution should also be taught in the science classroom. This is probably because microevolution is accepted by religious people who do not accept macroevolution.

In Pakistan, the school system has incorporated the evolution of life with the Quran in biology textbooks. Teachers explain that Allah originally created life forms, and over the years, life forms changed into different types of animals within the boundary of an original kind

(Asghar, Willes, & Alters, 2010). This sounds very much like microevolution, a process taught by creationists throughout the world, not to be confused with macroevolution, the changing of one kind into another, for example a lizard changing into a bird over time.

As a part of their cross-cultural study, Kim and Nehm (2011) give a synopsis of the acceptance of evolution in over twenty different countries throughout the world. The major portion of the study compares the view of Korean and American science teachers with regard to evolution and the nature of science. These researchers discovered that the percentage of acceptance of evolution by Korean teachers was lower than that of the American science teachers. These researchers also found a positive correlation between a teacher's knowledge of the nature of science and his/her acceptance of evolution, a result that we also find in the U.S. The correlation is positive, but weak, and depends on which study the author is referring to, since not all research results agree.

In Greece, about 16% of 111 biology teachers surveyed wanted to remove evolution from the classroom. About 20% of Germans and Austrians, and 22% of the Swiss population, claims to be young-earth creationists (Kim & Nehm, 2011). In 2006 approximately 40% of those surveyed by the BBC in the United Kingdom wanted creationism taught in school, and 48% accepted evolution as the natural mechanism by which life developed on Earth. Out of 923 teachers who participated in the same study in England and Wales, 37% thought creationism should be taught in school, and 30% of the biology teachers in the group agreed (Kim & Nehm, 2011). Papua New Guinea has proclaimed itself to be a Christian nation and teaches creationism. Next door, in Australia, only 12.6% of first year biology teachers believe man to have been created on a young earth (Kim & Nehm, 2011).

Wilson (2010) conducted a study using an internet survey, to which 4300 participants responded. Twenty-two hundred and fifty eight claimed to be Christians. Overall about 59% of Christians claimed belief in creation, 7% in evolution, and approximately 30% in theistic evolution. These percentages were consistent worldwide, with the exception of Europe. Of the European group, 20% believed in evolution, 52% in theistic evolution, and 24% in creation (Wilson, 2010). To the evolutionist, the lack of global acceptance of evolution is a problem that must be confronted.

Alternative Perspectives.

The main reason given for the level of rejection of evolution throughout the world and the embracing of creationism is that the creation movement encourages it. Researchers sometimes will mention an organization, such as Answers in Genesis, (Moore et al, 2011), whom they blame for the misconceptions still used by students and science teachers in the classroom, in spite of student exposure to courses established to correct such misconceptions.

Few researchers make a distinction between biblical creationists and those who believe in Intelligent Design. Most just lump both into one group, whom they call creationists (Nehm et al, 2009). Yet, Biblical creationists and ID people do not usually wish to be combined into one group. The ID community believes in an old earth, where life was designed by an intelligent force or being, whatever or whomever that might be, God, a god, or perhaps a naturalistic *force,* whereas biblical creationists believe in a young earth created by God.

Some researchers advocate confronting the creationist ideas students believe in (Nelson, 2008), while others, usually teachers, avoid the issue because they lack training in dealing with controversial socio-scientific issues. The creationist movement confronts the socio-scientific

issue directly, and has been encouraging billions of people of different religions throughout the world to take their stand on creationism.

Sometimes teachers and students who believe in creationism will also express the belief that evolution should be taught in the science classroom (Kim & Nehm, 2011). Others teach biology and the processes of evolution, while explaining to their class that God is responsible for creating life and its diversity (Boujaoude et al, 2011). This perspective sometimes seems laughable and contradictory, but it is not uncommon to read about these positions toward evolution and creation in the science classroom. The reason for this apparent discrepancy in which God creates via evolution, is that evolution can be divided into two separate processes: microevolution and macroevolution. Processes involved in microevolution include natural selection and mechanisms that produce genetic variation, processes which explain horizontal change, that is, within the classification levels of family or order that should not be associated with the term *evolution*. Macroevolution is the process that attempts to explain vertical change, such as, amphibians from fish, reptiles from amphibians, mammals from reptiles, etc. Most instruction in evolution in the biology classroom deals with microevolution (Nadelson & Southerland, 2010), which is usually not a problem for creationists.

The term *evolution* covers the natural development of life from chemicals to life forms present today on Earth, a process that is believed to have taken billions of years on an Earth with an original atmosphere more reduced than the present atmosphere. Evolution becomes more acceptable when it is divided into these two processes: micro and macro, because microevolution is observable (Nadelson & Southerland, 2010). Microevolution can easily be associated with the nature-of-science material. From the acceptance of microevolution, one can more easily be

persuaded to believe in macroevolution. However, macroevolution is a process that many people on this planet do not accept (Kim & Nehm, 2011).

Research indicates there is a positive correlation between knowledge of the nature of science and the acceptance of evolution (Nehm &Schonfeld, 2007). Nehm and Schonfeld and others have also mentioned that religious people exposed to a course in evolution increase their acceptance of evolution. This acceptance of evolution is probably due to their exposure to the processes of microevolution, not the processes of macroevolution (true evolution), because creationists do not have problems with the processes of microevolution (Evans, 2008).

The science education community believes the teaching of evolution has become problematic. From the research, this is due, in part, to inadequate teacher preparation and the religious convictions of teachers and students. Teachers trained in the teaching of biology should know better than to teach naïve misconceptions and should be able to teach the process of natural selection. Science teachers should not fear teaching controversial socio-scientific topics, and especially not to the point of avoiding the topic altogether. The teaching of evolution is also problematic because it contradicts the creation doctrine of some of the most prevalent religions in our society, in the US, and throughout the world. Presenting information that opposes religious convictions is not very effective in changing those convictions.

Some research indicates a positive correlation between knowledge of the nature of science and the understanding of evolution. This relationship is probably due to a lack of teacher preparation in the area of microevolution, which is the topic usually addressed in science classrooms when evolution is taught. Microevolution is also the part of evolution that is believed by those whose religious convictions cause them to reject evolution as a whole. Researchers do not often make a distinction between microevolution and macroevolution, which can become

confusing when they report a positive correlation between instruction in evolution and understanding, or acceptance, of evolution, with reference to participants holding religious convictions.

Summary

We know that religious beliefs have a greater impact on our acceptance of macroevolution than the science teacher in a science class, where students, young or old, study the accepted processes of evolution and the processes of science (Reiss, 2008). Holding to religious beliefs, for the most part, makes the teaching of evolution controversial. The controversy is not only that students' religious views differ from the classroom instruction but that teachers' religious views may also differ from the material they are required to teach. Teachers who have college-level training in the sciences, including biology and others, who are given extra classroom instruction on evolution, will probably not change their minds about exposing students to some form of creationism or accepting the theory of evolution (Nehm & Schonfeld, 2007; Nehm, Kim, & Sheppard, 2009). Nehm and other researchers have discovered correlations between the various variables they have employed in their research, yet correlation does not prove or explain causation, and we have yet to discover the reasoning behind the positive and negative correlational relationships discovered by researchers. The research does not attempt to find out why teachers with degrees in biology may not be using evolution as a framework for teaching biology, only that they do not do so effectively. Neither does research indicate the value science teachers place on evolution in the science classroom or evolution's relationship with the nature of science. Nehm, Schonfeld (2007), and others have discovered that science teachers do not necessarily accept evolution, even after taking a course in evolution and

the nature of science. Teachers should be asked why this is so and why participants who have a high religiosity index believe that evolution should be taught.

To contribute to the research already started on the subject of evolution as a controversial subject, teachers need to be asked how they manage religion in the science classroom. We have been introduced to the significant effect of religiosity in the steering of classroom instruction. What needs to be explored is how teachers maintain a balance between their religious beliefs, those of the students, and institutional requirements that conflict with them.

By interacting with teachers who are required to teach evolution, we can endeavor to discover how they balance the subject of religion and evolution in a state where science curriculum standards have only included evolution since 2008. It is important to be able to gather information on how teachers manage these subjects. Religion is an area of human existence that is very personal, and, according to research, confronting it directly with an opposing concept, no matter how scientific, will not force students or teachers to change their minds. Research has demonstrated this fact. Approaching teachers and students through qualitative research should provide more insight into the ways that controversy can be approached in the classroom.

The state of Florida voted on The Next Generation Science Standards June of 2013 and principles of evolution have been written into these standards (CPALMS, 2013). This study allowed me to inquire about the acceptance or rejection of the new standards and to ask how the teachers and students are addressing the changes in the classroom. It assisted me in discovering to what extent some biology teachers accept or reject evolution and how they present the concepts of micro and macro evolution. This helped in deepening an understanding of how teachers and students of a Southeastern school district perceive the presentation of evolution in the classroom.

CHAPTER THREE: METHODS

Overview

The purpose of this case study is to inquire about how science teachers manage to teach a controversial subject, like evolution, in the science classroom, when it is very possible that the teacher and some of the students will not accept it (Moore, 2009, 2011). Much quantitative research has been accomplished on the various characteristics that are considered necessary for teachers to instruct students in the subject of evolution. Little has been done to uncover the reasons behind the disappointing results revealed so far. It is the purpose of this study to try and discover how science teachers, in a school district in Florida, teach a controversial subject, such as evolution, in an area like the Southeast, where the science standards had not even mentioned evolution until 2008.

This chapter first establishes the design of the study which is based on a case study style of research. This is followed by a list of the research questions which guided how the research was conducted. The next section describes the setting where the study was conducted, a public school district in Florida. The type of participants I looked for in this study is then addressed, followed by the procedure used to conduct this research. My role is then described which covers my personal background and biases. The section on data collection describes the methods of collection which included interviewing, gathering site documentation, conducting a survey on student volunteers, followed by document analysis, and finally conducting observations of the participants in the classroom. The next section, data analysis, has a list of the procedures I used to analyze the data gathered during the study. Finally the last two sections include trustworthiness and ethical considerations. The section on trustworthiness describes the member-

checking procedure I used in this study as well as certain aspects of that topic. The last section describes the measures I used to protect the identity of the participants.

Design

The case study method is appropriate for this type of research because it seeks to find out how science teachers from a particular school district balance teaching evolution with religious beliefs (Creswell, 1994). The case was within-site from the perspective of location: a school district in Florida, which is referred to as FSD-Florida School District and includes seven high schools and eight middle schools from which the participants were selected. In 2013 the school district adopted the science curriculum, Next Generation Science Standard which included the teaching of evolution. Determination of acceptance is done by voting from the general public at the site given in the reference section under Collaborate, Plan, Align, Learn, Motivate, Share CPALMS (2013). This is an *instrumental* case study because it is addressing a single issue, the teaching of evolution. A description of researcher classroom observations, an analysis of interviews, and classroom documentation were utilized, and during the analysis I attempted to bracket out my personal biases as much as possible. Bracketing is a term coined by Husserl, which means that the researcher interprets the data at the exclusion of his or her own experiences (Creswell, 2007; Denzin & Lincoln, 2000). This term refers to the identification of the personal preferences, beliefs, and presuppositions of the author. Fischer, in his paper on the practical matters of bracketing in qualitative research (Fischer, 2009) emphasizes that bracketing is not an activity that should be addressed only once during the research but that it is an ongoing process throughout the entire period of research. Before addressing each theme in chapter four I present what my personal beliefs are on the topic addressed under the theme.

I conducted an *embedded* analysis, in that the focus was primarily on the teaching method. I did not use focus groups (Creswell, 2007). Farmer and Rojewski point out that focus groups are primarily used with success in marketing, applied evaluation, and in the social sciences.

Research Questions

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?
2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?
3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?
4. How do science teachers in the FSD perceive the relationship between religion and science?

Setting

A public school system, as opposed to private schools, was the site for this study because public schools are required to teach secular science curricula, which do not contain alternative theories of origin, and because none of the research in the literature review includes private schools. The population of the school district where the study was conducted based on 2013 figures is 87% white, 7% black, and 5% Latino (U.S. Census Bureau, 2013). The median household income from figures taken from 2009-2013 was $57,703. This school district ranks second in Florida in academic achievement.

Participants

The participants included two high school biology teachers and one middle school science teacher located at the FSD. There was a total of three teachers interviewed from this FSD, out of a total of 96 science teachers in the district. The sampling was purposive, since I was looking to interview a specific type of teacher. Purposive sampling is used in qualitative research as opposed to random sampling (Miles & Huberman, 1994). The research sampling will be purposive because the study focuses on one specific area of science education and in a specific location.

I looked for a particular group of people who work in a particular area of education, the science classroom. I was primarily interested in the perspective of science teachers, because that is where the controversy between the science lessons on evolution and creation take place (Hitt, 2009). The reason evolution is a controversial socio-scientific topic is because of the belief of most of the population in some sort of creationism and science teachers are in the middle of this controversy. Two of the participants were theistic evolutionists and one was a creationist. All three were Caucasian, one female, Carol, in her twenties and two males, one in his twenties, Doug, and the other, George, in his late sixties, two years from retirement. George taught physical science for ten years and biology for four years. Doug taught science classes in the middle school for two years, and Carol taught biology and other sciences for eight years.

Procedures

The assistant superintendent of the FSD was contacted and gave approval for me to conduct interviews with the teachers. I contacted the school district assistant superintendent who forwarded my email, to the principals who, if they so chose, forwarded the email introducing the study to their teachers. The teachers who volunteered were interviewed; observed in the

classroom, and documentation was collected. Before the interview, each teacher filled out a questionnaire to obtain certain information, such as personal beliefs on the subject of origins, religious preference, and their preference of method for teaching evolution. The intent of the study was to interview teachers who teach evolution to attempt to find out on a more personal level how they felt about working with that subject in their classroom. Classroom observations were conducted according to permission granted by the teacher and principal, and according to the availability of the teachers. The intent was to observe some lessons on evolution, or that mainly included the topic of evolution that were taught by the interviewed teachers. Lesson plans and any other available documentation were requested for inspection, to see if the teacher used them as a guideline, and to see if information was consistent with the way the lesson was taught. If the teacher had deviated from the lesson plan it would have been obvious. After receiving approval from the Institutional Review Board (IRB) data was collected. The IRB is responsible for reviewing research which involves human participants, according to the Liberty University IRB Handbook.

The Researcher's Role

My personal bias in this study is towards creationism rather than evolution. I attended public schools through high school in two different countries, in France and the U.S. In public schools we were taught evolution as a fact. After making a profession of faith while in the Navy, I attended Christian Heritage College where I earned two Bachelor of Science degrees, one in counseling psychology and one in science education with concentration in biology. I also earned a Master of Science degree in science education at the Institute for Creation Research.

In this study my role was that of an observer and interviewer. I interviewed each participant and then I observed them teaching. They each administered the survey to their

students. I did not participate in any of the classroom activities. The teachers introduced me to the class and that was extent of my involvement in the class. I did not know any of the participants until I walked into their classroom for the first time when I introduced myself and the study.

I collected the information, analyzed it, and drew some conclusions.

Data Collection

The preferred procedure for gathering data for qualitative research is triangulation, which involves the use of three methods of gathering data, each substantiating the results of the other (Creswell, 2007; Patton, 1990;). In this study the three methods of data gathering included an interview of the science teachers, observation of the teachers, and examination of site documentation. Observation is used to witness how the teacher manages the balance of religion and evolution in the classroom. Site documentation can be a part of the strategy used by the teacher to teach the lesson, as well as written documents that inform the teacher what is expected of him or her on the part of the Florida Department of Education. The interview is necessary to find out the motives of the teacher in organizing the delivery of the lesson, and especially, the strategy for teaching a controversial subject like evolution. I interviewed first, made classroom observations, collected site documentation, and at the end of a set of lessons the teacher gave an anonymous exploratory survey to the students which became an additional source of information to substantiate the input received from the interviews. This survey cannot be used as a research tool as the Cronbach's Alpha reliability coefficient was 0.05 for all three groups combined, .27 for Carol's group, -.08 for Doug's group, and -.99 for George's group. Cronbach's Alpha was obtained by use of the SPSS (Statistical Package for the Social Sciences) 23 statistics program (Field, 2005).

Interviews.

Interviewing is one of the main methods of acquiring information for qualitative research. This method is taught in a variety of research references from Creswell (2007), Gall et al (2007), and Patton (1990). I used a standardized open-ended interview format where all participants received the same questions in the same order, but open-ended. According to Gall et al (2007) semistructured interviews, used for quantitative research, include a set of structured questions with closed-ended answers followed by open-ended questions. My interview questions were not necessarily semistructured since (Gall et al, 2007) I did not have answers to choose from and I used the same set of open-ended questions for all participants. An advantage to this format is that it makes it easier to compare interviewee responses. Patton (1990) believes that the structured style of interview makes the questions and answers less relevant because the participant is presented with a set of answers. Creswell, Gall et al, and Patton describe in detail the proper ways of conducting interviews for qualitative and quantitative research, describing the differences in interview styles that apply to quantitative and qualitative methods. The interviewee must have an opportunity to explain his or her experience, in this case, a method of managing a controversial socio-scientific topic.

In interviews conducted in quantitative research the participants are asked a few questions to enhance the surveys to which they have previously responded. Gall et al (2007) point out that the interview allows the researcher to do more in depth probing, to find out what the participant is thinking, and allows for the opportunity to establish a trusting relationship between researcher and participant. The success of the interview is very much dependent on the ability of the researcher to conduct the interview. My lack of experience in interviewing people

probably limited the value of the interview method for acquiring information. The interviews lasted 30-75 minutes each.

Standardized Open-Ended Interview Questions

1. Could you tell me how you believe teachers' religious views affect the way in which they teach science topics and evolution?

2. How do you encourage or avoid class discussion of evolution or similarly controversial topics?

3. How do you feel that religious views affect how students and teachers understand the nature of science?

4. How do your students' religious views affect how you teach evolution?

5. How do you handle a situation when a student brings up personal religious beliefs during your science class that oppose what you are teaching?

6. How do you believe that making a distinction between micro and macro evolution might affect the way your students learn evolution?

7. If it were permissible, could you tell me what kinds of antievolution material, if any, from Intelligent Design or creationist organizations you might use during science instruction?

8. How do you believe your personal religious views affect how you teach evolution in the classroom?

9. How do you believe the Next Generation Science Standards, as they address evolution, will affect the preparation of your students for work in a field of science?

10. What else might you like to mention about science instruction, religious beliefs, and controversial topics for instruction that I may not have asked about?

Interview question 1 answers research question 3, which deals with the religiosity of the teacher. (Nehm & Schonfeld, 2007). Interview question 2 answers research question 1, which asks how teachers approach the religion-evolution issue. Interview questions 3-6 attempt to answer research question 2, which asks how teachers reconcile evolution with the religious views

of their students. This takes into consideration that the teacher may not know the religious views of their students, but that if those beliefs become revealed in the course of the lesson, the teacher will act according to the answers given during the interview (Evans, 2008; Nadelson & Southerland, 2007;). Interview questions 7 and 8 answer research question 3, which asks how teachers work out their own religious beliefs with teaching evolution (Moore & Cotner, 2009), (Moore et al, 2011). Interview questions 9 addresses research question 1, which inquires about the beliefs of the teacher with respect to the required curriculum. One teacher was a creationist and the other two were theistic evolutionists. This did not affect the manner in which the study was conducted.

Site Documentation.

Site documentation is the source of written information made available to the researcher, in this case study, at the school where observation took place (Creswell, 2007). After making observations in the classroom, I asked the teacher for a copy of the lesson plans as well as other documentation. The teachers did not produce lesson plans but instead gave me worksheets, personal notes, and one gave me his Microsoft PowerPoint presentations.

The documentation the teachers provided was the same material, worksheets and Microsoft PowerPoint presentations used during the lecture. This was all very consistent with the teachers' interview responses and time of observations.

Surveys/Questionnaires.

I put together a survey for exploratory purposes and included the results on tables in chapter 4. This survey cannot be used as a research tool as the Cronbach's Alpha reliability coefficient was 0.05 for all three groups combined, .27 for Carol's group, -.08 for Doug's group,

and -.99 for George's group. Cronbach's Alpha was obtained by use of the SPSS23 statistics program (Field, 2005).

Document Analysis.

Documentation included notes from the teacher, worksheets, and Microsoft PowerPoint presentations. The worksheets were comprised of fill-in exercises which could be used while the teacher was speaking as well as exercises with new vocabulary for homework. I wrote notes and themes on the worksheets which were almost entirely divided into microevolution and macroevolution categories. The Microsoft Power Points had statements that were often repeated. I took each frame and wrote on a separate sheet of paper statements as they appeared for the first time in the lesson. When the list was complete I wrote notes in the margins and divided the lists into categories, the two prevalent categories being microevolution and macroevolution.

Observations.

Observations were conducted in the classroom, but I was not a participant. Patton (1990) explains the variety of ways a researcher becomes involved in observations he or she conducts so as to obtain information about the topic being studied. I observed classrooms as an outsider, but was in the classroom while science lessons were presented. Denzin and Lincoln (2000) and Patton (1990) point out that during the observation process the mere presence of the observer can change the behavior of the participants he is observing. Observations were made to see how the teachers work with the topic of evolution. I was able to see how the teachers and the students responded to each other, as well as how the topic was presented to the class and whether or not the teacher used activities to explain or reinforce the concepts of the lesson.

After the teachers were interviewed, I requested an opportunity to observe the teacher instruct the class for two class periods. The time of observation involved sitting in a classroom with the students while they were instructed in a chapter or sections of chapters. I watched the teachers present lessons on some aspect of evolution and observed whether or not their approach to the management of evolution and religion in the science classroom agreed with the answers they provided during the interview.

As an observer in the classroom I was able to better answer how teachers reconcile their religious beliefs with those of the students in the process of teaching a subject that may contradict their own religious beliefs and those of the students. It also allowed me to see how they presented a subject with which they may disagree, but are nevertheless required to teach. Classroom observations assisted in substantiating the answers of the teachers from the interview questions and gave me the opportunity to be present when they presented the information to the students. The classroom sessions were not recorded as it was requested of me not to record or take pictures. I produced field notes during the times of observation. I was only a complete observer, (Gall et al, 2007). According to Gall et al (2007) a complete observer has no part in the activities observed but an observer-participant may have indirect and casual contact with the participants, on purpose or by accident. Gall et al divide the observation process into three stages: Descriptive stage, focused stage, and selective stage (2007, p. 278). During the descriptive stage the observer describes the classroom environment, including handouts and activities pertaining to the lesson. During the focused stage the observer notes the methods the teacher uses to manage, in this case, the balance of religion and evolution during the lesson. During the selective stage the researcher defines research questions (Gall et al, 2007, p. 278).

Research questions were formulated during the writing of the proposal and my observations were focused on answering those questions.

During the time of observation I was able to determine how the teacher allowed the students to express their personal beliefs about evolution as well as how the teachers responded to the opinions of the students. It was evident that the teachers remained neutral and did not reveal their personal beliefs to the students. There are many issues to consider in the managing of controversial topics. Students can be unpredictable and reaction of the teacher to the students is a part of how the teacher manages the controversy. These classroom situations helped answer the research questions.

According to Gall et al field notes are descriptive, reflective, detailed, and concrete (2007, p. 281). During the time of observation I included my own personal interpretations of what took place with detail and in specific terms, not oversimplified. There are no set patterns for taking field notes, but according to Patton (1990), they are not optional. Notes should be descriptive and as thorough as possible with quotes. They should contain the feelings, interpretations, and insights of the researcher (Patton, 1990). Appendix G is a template for the field notes and shows the format I used. This template reflects what I believed to be the intent of the information from Patton (1990) and Gall et al (2007). The observation times proved the teachers to be very consistent with the interview question responses. They all took a neutral position, taught the curriculum, and diverted controversial statements from the students in the manner described during the interview.

Data Analysis

I used a coding method described by Saldana (2009), Miles and Huberman (1994), and Wolcott as described by Creswell (2007). It is called descriptive coding and can be used on all

forms of qualitative research according to Saldana (2009). It is also recommended to first-time researchers. The following steps were used in the case study in accordance with the suggested procedure of analysis with some changes made to accommodate the present study. I used the following steps in arriving at the themes discussed in chapter four.

1. I gave an account of my personal experiences in the teaching of evolution in the science classroom in the personal biography in this chapter.
2. I used codes in the form of short phrases and sometimes single words sometimes referred to as open-coding or initial coding (Saldana, 2009)
3. I wrote memos in the field notes and documentation.
4. I identified patterns which allowed me to group the codes into categories or themes, sometimes referred to as selective coding (Saldana, 2009). Saldana points out in his book that in his own research of how coding is conducted, the terms category and theme are often used interchangeably (2009).
5. I compared the themes and attempted to determine how and why certain codes could fit under a certain category and why they could not fit in other categories.
6. I then wrote in the margins the number of specific research questions which can be answered by the various comments from the interviews.

An exploratory survey was used to check student response to the teacher and to his or her approach to the teaching of evolution. I tried to express the views of the teachers at the exclusion of my own opinions, *bracketing*. The purpose of this case study is to find out how the teachers I observe manage the teaching of the socio-scientific controversial topic of evolution, not explain how it should be done. The perceptions of how it is best performed must come from them not me.

Trustworthiness

The following steps were taken to ensure, as much as possible, the highest level of trustworthiness. I used two different methods to establish trustworthiness, triangulation and member-checking. Triangulation is the use of multiple sources and comparing these sources for repeatability, confirming the data is accurate (Creswell, 2007; Denzin & Lincoln, 2000). It also provides validity to the study which translates to trustworthiness in qualitative research to help ensure that the data gathered during the study is reliable and the case study credible (Creswell, 2007).

A second means of validation is member-checking, which involves asking the participants to express their views on the integrity of the conclusions drawn by the researcher. This method is considered, by some researchers, to be the most critical (Creswell, 2007). I provided a list of summary statements from the answers of each teacher from the interview questions. All participants responded positively to the summary statements by email. I also sent out by email a file with chapter four and requested the participants respond but only two responded affirmatively and the other did not respond.

There are certain aspects of this section that must be taken into consideration and explained. Issues related to the principle of trustworthiness included the following: confirmability, transferability, and authenticity. These terms are defined and addressed in the context of the work of Miles and Huberman (1994) on qualitative research. In the area of confirmability, the concern is the bias of the researcher. The conclusions need to be as objective as possible, reflecting the information given by the interviewed participants.

Transferability deals with the extent to which we can apply the information acquired from the research (Miles & Huberman, 1994). This is also referred to as generalizability. The

information I obtained from public schools in the Southeastern U.S. may or may not be applied to the public schools in the Northwestern U.S. The information acquired in this study can only be honestly applied to the school district involved in the study. However, it is evident that public school teachers of the Southeast share some common characteristics with public school teachers in other parts of the country. From the research quoted in chapter two, it is evident that the conclusions of researchers mentioned was extended beyond their immediate location of research, and that the conclusions drawn from within the United States overlapped with the results obtained from teachers of foreign countries (Kim & Nehm, 2011). So generalizability can be made by the various studies already conducted throughout the country and the world, since the topic of evolution is a worldwide issue.

Authenticity deals with whether or not the results of the study truly reflect the attitude of the participant (Miles & Huberman, 1994). In this study I asked teachers questions addressing religion and evolution in their science classes. They expressed their views on the management of evolution and religion in their classroom during the interview. That perception was compared with their teaching of the subject during a time of observation. My responsibility for authenticity is to the participants of the study. What they say, teach, and plan must be accurately recorded. The participants had an opportunity to check the recording of the information before it was checked by my Chair.

Ethical Considerations

All participants had pseudonyms of their choice assigned to them, to maintain their anonymity, and only two computers, whose access is controlled by password, were used to work with the research material. The researcher is the only one who knows the code name for each

participant. There may be a need to temporarily store information in my locked office, occupied by two people. But most of the time, it is kept in a private location under lock and key.

Summary

In this study I interviewed three participants, Carol, George, and Doug, collected documentation from them, and observed two of their classes. Prior to my time of observation the teachers handed out a survey to those students who had had prior approval from their parents. The survey gave some information about the religious beliefs of the students as well as some of their views about evolution and creation. I analyzed the data from which I produced four themes. I did not analyze the survey data, only the data obtained from the teachers themselves. After analyzing the data I implemented member-checking twice, once with summary statements from the interviews and a second time from chapter four information.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to research the manner in which some of the public school teachers of a Florida School District balance the teaching of evolution in their science lessons with their religious beliefs and those of their students in light of the restrictions imposed on them by the curriculum standards and the school district. It is also an attempt to find out how some teachers manage the controversial atmosphere generated by the teaching of evolution in their classrooms. The research questions were written as follows:

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?
2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?
3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?
4. How do science teachers in the FSD perceive the relationship between religion and science?

In this chapter I first introduce the participants, give supporting information for each theme from interviews, observations, and documentation. I introduce the themes that were inferred from the coding and memos applied to the field notes, documentation, and interviews obtained from working with each of the participants. Information from the exploratory survey is presented in tables after the introduction of the participants. Lastly I provide a summary of the findings which are given under each theme.

Participants

There were three participants in this study from a school district in Florida. It took about one year to get three volunteers who were willing to participate in this study. The first two, Carol and George, taught in two different high schools, and Doug taught in a middle school. Carol, George, and Doug are pseudonyms as per IRB requirements. After each participant description is a list of summary statements produced from each of their answers to the interview questions. This should provide a more in-depth perspective on the way each participant thinks. I emailed each participant the list of summary statements for member-checking, to which all three participants responded positively.

In this chapter all of the quotations will be from the interviews unless otherwise cited.

Carol

Carol teaches biology, earth science, zoology, and marine science and has taught high school for eight years. She has a Bachelor of Science in biology and a Master of Science in health education. Carol is a theistic evolutionist. She has 125 students, 19 of which responded to the survey given in class. At the end of the school year during which she was interviewed Carol stopped teaching and gave me her email address.

Summary of Carol's interview questions.

1. Teachers' religious beliefs affect how they teach evolution.
2. You do not invite controversy into the classroom but when a student has a problem with what you teach or directly opposes it you try not to take sides.
3. You don't believe that the religious beliefs of students affect their ability to reason scientifically, that is to practice principles reflecting the nature of science.

4. Your students' religious views do not affect how you teach evolution but when you know them and know that you are teaching something that opposes their beliefs, it makes you feel uneasy.
5. If a student tells you that you are wrong in what you are teaching, you explain that there are other theories on the development of life on earth.
6. You believe that microevolution is a big step towards neutralizing the controversy over evolution that occurs in the classroom between teachers and students.
7. Although you would not bring creationist material into the classroom, you wish you could talk about creationism and other theories on the development of life more openly.
8. You don't let your religious views interfere with your lessons on evolution and actually try to remain religiously neutral in class.
9. You feel that the NGSS is good in that it does not permit teachers to avoid any part of the science curriculum with which they might feel uncomfortable teaching. You wish that you could have open discussions with your students on more than one theory on the origin of life and its development on earth.

George

George teaches physical science and biology at a local high school. George has taught physical science for ten years and biology for four years. He has earned a Bachelor of Arts degree in science education and a Master of Science degree in library media. George is a theistic evolutionist. There are only eight summaries instead of ten because a couple of answers were combined since they overlapped each other.

Summary of George's interview questions.

1. It is not your practice to discuss religious views in class.

2. You don't purposefully get students involved in discussions on controversial issues but you address the students' questions about the issues.
3. Students' religious views don't seem to affect how they deal with the nature of science but it does affect how they handle controversial issues.
4. You don't teach evolution from a religious perspective because you do not feel qualified to do so, but neither are you allowed to do so.
5. Microevolution is the main common ground between the most committed evolutionists and creationists.
6. You would not use creationist material in class if it was available to you and you would not use it now because it is not permitted for you to do so.
7. You do your best not to allow your religious views to interfere with your lesson on evolution.
8. With all of the material you are expected to teach you really do not have much time, if any, for discussions on any controversial topic, including evolution.

Doug

Doug teaches science in a middle school which includes biology. Evolution is one of the subjects he teaches his classes of gifted students. He has a Bachelor of Science degree in science education. Doug is a creationist who admittedly does not know very much about evolution. In his own words "…for example with me with evolution because I'm not a believer in evolution I'm not as informed about evolution, so I can't really answer as many in depth questions about it …"

Summary of Doug's interview questions.

1. Teachers' views are going to bias the way the teacher teaches evolution or any other controversial topic.

2. You like to have discussions in class on controversial issues like evolution because the students are interested and want to be involved in those kinds of lessons.
3. A student's religious views affect his or her interpretation of the topic being discussed.
4. You teach your students that it is the data they should consider, not their preconceived ideas about the issue being discussed.
5. You try to distance yourself from your students' religious beliefs to keep them from influencing how you teach your lesson on evolution or other controversial topics.
6. You try to present the information without bias and they are to come to their own conclusions.
7. You want your students not to be affected by your own beliefs.
8. You primarily teach microevolution because it is observable and you have noticed that students have difficulties dealing with topics on macroevoluiton.
9. You would not use creationist material in your classroom even if permitted to do so.
10. You don't believe that the teaching of evolution affects your students' understanding of the nature of science (scientific method; concepts about scientific research).
11. You want your students to be able to draw their own conclusions and to be able to defend those conclusions

Results

Survey Data.

The survey was given for exploratory reasons and was intended to be used for my own interest to see whether or not the teachers had interpreted the perceptions of the students adequately. It was not meant to be introduced as a tool for future use by researchers. Of the students that participated in the survey, some did not answer all of the survey questions.

Table 1.

Scale statistics from survey

Participant	n	M	SD	α	N
Carol	16	47.61	2.73	.27	19
Doug	16	45.37	4.67	-.08	23
George	16	49.82	3.19	-.99	12
All three	16	47.4	4.75	.05	54

Notes. n = number of items; N = number of students; M = Mean;
SD = Standard Deviation; α = Cronbach's Alpha

Tables 2-4 display the percentages of students according to the answers they provided for the survey. The survey was exploratory and provides some idea as to how the students thought about their teacher and their beliefs as well as the beliefs of the students.

Table 5 describes the type of religious beliefs held by the student populations of the science classes of the participants.

Table 2.

Carol's survey response in percentages	SA	A	U	D	SD
1. God created all things	37	32	11	5	16
2. Everything came into existence naturally without supernatural influence.	11	32	37	16	5
3. God used evolution to make living things	16	32	32	16	5
4. Microevolution is genetic variation that produces different kinds of dogs or roses.	0	47	42	11	0
5. Evolution from lizards to mammals is an example of macroevolution.	0	63	37	0	0
6. Evolution contradicts my religious beliefs.	0	11	21	37	26
7. Learning about evolution has changed my religious beliefs	11	5	16	21	42
8. My teacher does not believe evolution is true.	0	0	63	21	11
9. My teacher does not believe creation is true.	11	0	68	16	5
10. My teacher didn't tell us what he/she believes.	37	42	21	0	0
11. My teacher was interested in what I believe about evolution or creation.	0	32	32	16	21
12. My teacher doesn't care what I believe about evolution or creation.	21	37	16	26	0
13. Understanding evolution will not help me to understand science.	5	11	11	47	26
14. Understanding evolution will not help me to get a better job after I graduate.	11	21	37	26	5
15. Understanding evolution will not help me to make my teacher like me more.	16	32	16	32	5
16. Understanding evolution will not help me to understand biology.	0	2	32	42	21

Notes. SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree.

Table 3.

George's survey response in percentages	SA	A	U	D	SD
1. God created all things	42	17	17	17	8
2. Everything came into existence naturally without supernatural influence.	0	25	67	0	8
3. God used evolution to make living things	17	25	25	17	17
4. Microevolution is genetic variation that produces different kinds of dogs or roses.	0	33	42	8	8
5. Evolution from lizards to mammals is an example of macroevolution.	8	25	42	17	8
6. Evolution contradicts my religious beliefs.	8	17	17	25	33
7. Learning about evolution has changed my religious beliefs	0	8	8	42	42
8. My teacher does not believe evolution is true.	8	8	58	25	0
9. My teacher does not believe creation is true.	8	8	58	25	0
10. My teacher didn't tell us what he/she believes.	33	50	0	8	8
11. My teacher was interested in what I believe about evolution or creation.	17	33	42	0	0
12. My teacher doesn't care what I believe about evolution or creation.	0	0	50	17	33
13. Understanding evolution will not help me to understand science.	0	8	0	58	33
14. Understanding evolution will not help me to get a better job after I graduate.	8	42	17	25	8
15. Understanding evolution will not help me to make my teacher like me more.	17	33	17	17	17
16. Understanding evolution will not help me to understand biology.	0	0	17	50	33

Notes. SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree.

Table 4.

Doug's survey response in percentages	SA	A	U	D	SD
1. God created all things	83	8	4	0	4
2. Everything came into existence naturally without supernatural influence.	8	17	8	13	54
3. God used evolution to make living things	25	21	4	33	13
4. Microevolution is genetic variation that produces different kinds of dogs or roses.	8	33	29	4	13
5. Evolution from lizards to mammals is an example of macroevolution.	8	13	42	8	21
6. Evolution contradicts my religious beliefs.	25	21	21	13	13
7. Learning about evolution has changed my religious beliefs	4	0	17	8	71
8. My teacher does not believe evolution is true.	0	4	83	4	9
9. My teacher does not believe creation is true.	0	5	86	9	0
10. My teacher didn't tell us what he/she believes.	25	21	8	0	0
11. My teacher was interested in what I believe about evolution or creation.	13	29	33	21	4
12. My teacher doesn't care what I believe about evolution or creation.	21	25	25	25	4
13. Understanding evolution will not help me to understand science.	13	29	17	17	21
14. Understanding evolution will not help me to get a better job after I graduate.	21	25	21	17	13
15. Understanding evolution will not help me to make my teacher like me more.	38	17	21	0	17
16. Understanding evolution will not help me to understand biology.	8	29	17	17	25

Notes. SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree.

Table 5.

Religious preference of students who answered survey questions

	Doug	Carol	George
Baptist	47	6	32
Muslim	0	0	0
Catholic	26	12	16
Jehovah's Witness	0	2	0
Mormon	0	0	0
Agnostic	0	5	11
Methodist	16	11	0
Jewish	0	0	0
Unknown	0	26	0
Christian	21	5	5

Notes. The numbers represent percentages

Table 6 represents the coding results from which I established the themes. After initial coding I used general group headings and then subdivided the within the subgroups. One of the general groups was *controversy* and then within that group I subdivided into other categories. Some codes were much more prevalent than others, especially microevolution and macroevolution since these were virtually the only topics covered in the documentation used in the lessons.

Table 6.

Open-Codes	Enumeration of open code appearance across data sets	Themes
Teacher's beliefs	20	Religious Beliefs of the Teacher
Teacher's beliefs not revealed to students	6	
Teacher's beliefs important to students	5	
Teacher's personal experiences	7	
Student's beliefs affect reception of lesson	6	Religious Beliefs of the Student
Student's beliefs affect teacher's approach	10	
Student's beliefs from home	3	
Student's beliefs in confronting the teacher	2	
Controversy in the classroom	20	Evolution as a Controversial Subject
Controversy neutralized or avoided	13	
Controversy as a teaching tool	16	
Teacher preparation	11	Teaching Evolution
Evolution and religion	9	
Microevolution	31	
Macroevolution	18	
Curriculum requirements	9	
State-imposed restrictions	5	
Preparation for work environment	7	

Themes

The following is a list of the themes obtained from the interviews, documentation, and observations from this case study. Each theme has an introduction followed by a short section for bracketing and finally, supporting information. The themes are interrelated yet they can be addressed independently with information that can help to answer the research questions. After the presentation of the supporting information there is a summary section .

Theme 1: Religious beliefs of the teacher.

introduction

The religious beliefs of the teacher can influence how the subject of evolution is presented to the students as well as how the teacher chooses to use the required curriculum. It can also affect how the teacher reacts to students who oppose their views. This theme is addressed directly in research question one but it affects all of the research questions.

bracketing

I do not believe that religious beliefs like creationism interfere with the teaching of science unless the teacher tries to explain the origin of the laws of science he or she is teaching.

supporting information

Carol and Doug explained that teacher bias can play a role in the way a teacher believes and they explain that this can cause the teacher to teach the lesson contrary to what is expected of them from the curriculum. Carol says in answering interview question one

> I think their [the teacher's] religious beliefs play a role in how convicted they are on the topic they teach and the wording that they use, so I think someone who is very strong toward evolution and not religious and not viewing any other options no [pause] I don't

> want to say atheist, but very strong very convicted one way they are going to use words like this is how it happened (Carol, personal interview, April 3, 2014).

Carol often made a distinction between the teacher who teaches that evolution is true and the teacher who presents the evidence for evolution and tells the students that there are other theories out there. The curriculum documentation does not allow for any other option besides evolution. She refers to other theories of origin as ideas, especially when addressing how a teacher should respond to the religious beliefs of the students as expressed in the classroom by the student. She also mentions a more subtle way in which the beliefs of the teacher can affect the presentation of the lesson, even if the teacher does not explain his or her specific beliefs.

> I think someone who is on the complete opposite side is going to use tones that are more [pause] contradict what they're teaching, I think it will be portrayed by the students as not-factual or not real. Something that they can tell the teacher does not believe in it and therefore they probably shouldn't take it seriously either. So I think it has to do with [pause] I think they're going to teach it the same I think they're going to say the same words but I think their tone and their mannerisms will definitely be affected (Carol, personal interview, April 3, 2014).

Carol believes that religious views may hinder the presentation of the lesson but beyond that she also sees religious beliefs as a restrictive element in the ability of the teacher to respond to students. She says "I also believe that religious views can stifle teachers from being open-minded (Carol, personal interview, April 3, 2014). Carol would like to talk about other ideas that are out there (Carol, personal interview, April 3, 2014). Carol presented evolution as a theory and encouraged her students to check out the other theories on Google (Field notes, April 3, 2014).

Doug also points out that teacher bias plays a role in the manner in which the teacher presents the lesson. But being aware of this fact he tries not to reveal what his bias is. “But, but yes, I do think that religious beliefs do play a role in how teachers teach science topics” (Doug, personal communication, January 1, 2015).

George does not reveal his own beliefs to the students but he does know that beliefs are an issue in the teaching of evolution and realizes that students have their own beliefs. So he addresses the issue by saying

> I don’t know cause I, I’m only speaking for myself but I try not to let it influence me other than to let the students know that the science that they’re learning is based on the scientific information and observation that they’re made and ignores anything to do with faith (George, personal communication, April 24, 2014).

He tries to disassociate religious belief from the lesson on evolution. But he does know that some students feel confronted by the teaching of evolution. He addresses that situation when students bring their beliefs to the forefront. The religious views of the teacher are not to be discussed in the classroom as mandated by the state. He recalls having to sign a statement when he says “We actually had to sign a memorandum of understanding. That we are not to express our religious views or bring up religion in the classroom” (George, personal interview, April 24, 2014).

Summary

The religious views of teachers are not ignored by the teacher but must be dealt with discretely since the teacher is not allowed to discuss his or her religious views in the classroom. Other considerations include the preparation of the student for the final state test and the

necessity to be informed on the topic. Just as the religious views of the teacher cannot be ignored neither can the religious views of the student.

Theme 2: Religious beliefs of the students.

introduction

The religious beliefs of the student will affect how the student responds to the teacher and the curriculum. From the theoretical framework obtained from Piaget and others we know that students will assimilate and accommodate new information that differs from previously learned material (Miller, 2011). Students will react differently, in accordance with their beliefs, and this will affect how the student reacts to the teacher or the curriculum or both. This is directly addressed in research question two.

bracketing

I do not believe that religious beliefs like creationism interfere with the learning of science unless the students cannot differentiate between the scientific knowledge being taught and his or her religious beliefs, e.g. believing that Satan created fossils.

participant response

The religious beliefs of students affect how the teacher presents the lesson on evolution. Doug does not want to know what the beliefs of his students are, although he can tell by some of their facial expressions whether or not some agree or disagree with him. He states

> I can probably give you the average view from my students just plain looking at their facial expressions whenever I start bringing up the topic of evolution, but I really don't know and I [pause] I again I try to keep it that way so that it doesn't affect me (Doug, personal communication, January 1, 2015).

Students appear to want to be in agreement with their teacher and sometimes they will ask what the teacher believes. Doug tries to avoid that question by asking in return "Why does it matter? Why does what I believe matter? It shouldn't affect your view" (Doug, personal communication, January 1, 2015). But students will draw their own conclusions about what the teacher believes and probably because they have a desire to be in agreement with their teacher. Doug gives the following example of how students will draw their own conclusion in spite of what the teacher says.

> …I've had a kid mumble "of course he doesn't believe this" you know so it's like little things like that they let their opinions come out so umm, so I really I try to ride that fence as much as possible (Doug, personal communication, January 1, 2015).

Carol sees their religious beliefs as hindrances to their education. This is apparent when she says "I think that sometimes religious views can stifle students' ability to be open-minded" (Carol, personal communication, April 3, 2014). She believes that students should be exposed to other ideas, as expressed in the following quote

> Some will come from all different aspects and I try to let them know that there's all these different ideas out there and that they need to be open-minded because you have to be very careful in a public classroom of [pause] you do not know kids backgrounds (Carol, personal communication, April 3, 2014).

The religious beliefs of students are not disassociated from the beliefs of their families. This puts added stress on the teacher, especially if the teacher knows the families as acquaintances or by church affiliation. In this case the teacher does know the background of her student and it puts added stress on the teacher. This is evident in the following quote from Carol.

> I know her family so it's difficult when I'm looking at her face and I'm saying OK this is this because I know that that's not what's coming at home and I think it makes a little bit of conflict in me because I feel like I'm [pause] I don't know [pause] it's just, it makes me feel weird, I think I actually prefer not to know their religious views because then I can just teach them this is what's out there (Carol, personal communication, April 3, 2014).

The religious beliefs of students affect how they receive the information from the teacher. The way George addresses their beliefs is by disqualifying himself from knowing or understanding religious views on the subject of origins by any means, evolution or creation. He states "Well again, I let them know from the very beginning that I'm not a theologian, I am not an expert on comparative religion" (George, personal communication, April 24, 2014).

There is another aspect to this situation, and that is the response of the teacher to state-imposed restrictions. The teacher is to adhere to the curriculum from which the end-of-the-year test is drawn. George tells his students outright that he is not allowed to address their religious views, that is, their creationist beliefs.

> When they say that [that creation is true] and I say and I respect that but I'm not qualified to teach that and I'm not allowed to, so would you understand that you keep your views I'm not going to criticize you for having those views, but for the test learn this stuff, then do what you want with it (George, personal communication, April 24, 2014).

Summary

Teachers cannot address the religious beliefs of the students but neither do they ignore them. Usually teachers do not know the religious beliefs of their students but sometimes they do

and that produces added stress on the teacher who does not want to alienate his or her students. Teachers must do what they can to avoid controversy in the classroom.

Theme 3: Evolution as a controversial subject

introduction

Controversy in the classroom is never appreciated unless it is well controlled and used skillfully by an experienced teacher to make a point which will hopefully not alienate the students. The fact that evolution is addressed as a socio-controversial topic is plainly stated in much of the literature I've cited in this study (Fowler, 2010; Hermann, 2008; Levinson, 2006a; Reis & Galvao, 2009). From the perspective of the curriculum, the participants create a type of scientific controversy by dividing microevolution from macroevolution, although not evidently in front of the students. This perception is more recognized by the teachers than it is taught as a quality of evolution to the students. However, in the teaching process it becomes evident that one aspect of evolution, microevolution, is more acceptable to the student and that macroevolution is what causes religious controversy in the classroom. In conclusion, evolution is accepted only in part, which creates a type of scientific controversy, and this assists in avoiding religious controversy between teacher and students. If the teaching of evolution was not controversial this study would not be needed. It is a theme that permeates all the research questions.

bracketing

I believe that evolution is controversial because it is a religious view and that it does not have to be taught entirely with the atmosphere of controversy to those who do not agree with it.

participant response

Common sense tells us that all teachers should avoid controversy in the classroom, yet there are times when the potential for controversy is unavoidable. This is especially true when

the topic of discussion contradicts the religious beliefs of many of the students. This is the case when teaching the controversial socio-scientific topic of evolution. Hermann (2008) and Levinson (2006a) use evolution as an example of how to deal with a controversial topic in the classroom. Many of the statements under themes one and two can be used to demonstrate how to avert a potentially controversial situation.

Sometimes teachers can take preventive measures, like George, who disqualified himself as a knowledgeable teacher in the area of religion. Carol and Doug were aware of their religious views but chose not to reveal them to their students. In spite of all that students still confront them with their views by making statements like the following from the interview with Carol.

> I have had students in the past that repeatedly interrupt the discussion to tell me, well that's not what happened because God did this or God did that and, what, is it OK? And what I have to do is continuously say, "that is one of the theories that are out there." "You're not wrong there's lots of theories out there, we're just discussing the ones that the state of Florida has deemed appropriate" (Carol, personal communication, April 3, 2014).

Carol gave that response in class when I was observing her teaching a lesson on evolution (Field notes, April 3, 2014).

Even when Doug refuses to answer direct questions from the students about his beliefs, the students will come to their own conclusions about the beliefs of the teacher as seen above. When George is sometimes asked what he believes he chooses to give them his opinion. He explains to the students that he cannot teach this lesson from a religious point of view. On that situation he says "I don't feel qualified to teach it from that point of view, [Baptist, Catholic, etc.] I have my opinions and should they ask that I try to avoid that, but should they ask it I will

tell them my opinion" (George, personal communication, April 24, 2014). When students express openly how they feel about the topic George responds in the manner previously stated,

> When they say that [e.g. God created the world] and I say and I respect that but I'm not qualified to teach that and I'm not allowed to, so would you understand that you keep your views. I'm not going to criticize you for having those views, but for the test learn this stuff, then do what you want with it (George, personal communication, April 24, 2014).

During the time of observation George responded to a student comment by saying "We are not here to argue" (Field notes April 24, 2014). He refuses to get into an argument or debate in class with a student and stops any potential debate between students. He takes the position that the information is here for the student to use as he or she pleases.

Teachers have various ways of avoiding direct verbal confrontations with students who speak up and contradict the lesson openly. However, controversy in the classroom is not necessarily bad. Some teachers, like Doug, like to use it as a teaching tool to help prepare students to the fact that not everyone in the world will agree with them and not to be shocked by it.

> They have their belief and a lot of them come in and they're dug down because that's how they're raised. And so it's very interesting to have them talk, because they need to learn how to talk about these controversial topics in everyday life because we're gonna interact with people who they don't understand with every day. So just from a non-scientific standpoint controversial topics are really important to teach them that to teach them there are things out there they might not agree with and there are people out who

> don't agree with them but you can still get along (Doug, personal communication, January 1, 2015).

During the time I observed Doug teach his lesson on evolution he told his students "I'm not trying to convince you that what I'm saying is true, I'm just giving you facts so that you can decide" (Field notes, January 1, 2015). He tries to be a facilitator of information not an authoritarian disseminator of information.

Carol has similar ideas on that topic, believing that students should be prepared to handle opinions that differ from their own.

> It is not my role to tell them that they are wrong or right it's my role to tell them about the different things and let them kind of discover on their own. And so when you have a student that has a very strong, you know, opinion on something you don't want to say that they're wrong but you want them to realize that that's not how the world works and that they need to be [pause] little bit more open-minded (Carol, personal communication, April 3, 2014).

Summary

Controversy is not really avoidable but is a situation that teachers must work with and that some teachers actually use as a teaching tool to prepare students for life after graduation. They do not have to wait until after they graduate to realize that not everyone will agree with them, but it does help them to learn how to deal with people of differing beliefs. No matter how different the belief systems, there is always going to be common ground between people on both sides of the controversy.

The common ground can be revealed or hidden by the teacher. It depends entirely on how the teacher presents the subject of evolution to the class.

Theme 4: Teaching evolution

introduction

What is evident in this theme is that microevolution is the common ground that reduces controversy in the classroom when evolution is taught.

The manner in which evolution is taught as a subject can affect how the research questions are answered. Evolution can be divided into two separate divisions: microevolution and macroevolution or it can be taught as one continuous process from microevolution to macroevolution without making a distinction between the two. The participants recognized the distinction between microevolution and macroevolution as being advantageous in presenting the subject of evolution to the students. Their curriculum introduces the students to microevolution but does not make a clear distinction between microevolution and macroevolution. Instead of going from microevolution to macroevolution, the curriculum goes from microevolution to the fossil evidence, macroevolution. Under this theme is the issue of the assumed importance of evolution in preparing students to work in the scientific community.

bracketing

I believe that microevolution is observable and is taught in classrooms by creationists and that macroevolution is inferred by creating the illusion that microevolution leads to and produces macroevolution.

I also believe that macroevolution is not necessary for the understanding of the laws of science.

participant response

Microevolution includes the observed process of genetic variation which produces the varieties of genera and species we observe in nature. Examples of this include the varieties of

dogs within the genus and species *Canis familiaris* and the varieties of species under the Canidae family such as *Canis lupus* (grey wolf), *Canis latrans* (coyote), and others. Macroevolution is the process which produces change from lizards to birds or mammals or from apes to mankind.

In interview question number six I asked the teachers if they believed that making a distinction between microevolution and macroevolution affected the way the students learn evolution. The answers to that question addressed how the students responded to that distinction. All three participants indicated that in their opinion it made a significant difference. One important factor is the effect it had on the level of controversy. This overlaps with the previous theme but I chose to discuss the effects of this aspect of teaching evolution under the present theme because I felt it was more appropriate. Carol believes that teaching microevolution separately makes a big difference.

> I think it's a big deal. And I think in zoology it's particularly when I teach that you need to make a distinction between the little changes that happen over time in fur color, in fur length, and in even people losing you know not having wisdom teeth and stuff, those are microevolution those are natural changes to our environment (Carol, personal communication, April 3, 2014).

I do not necessarily agree with her examples of microevolution but the point is made that making that distinction does affect how students respond to the subject. With regards to macroevolution Carol observes that her students are more responsive to the lesson.

> Macroevolution big, big, big changes and once you explain to kids that evolution does not necessarily mean you came from a chimpanzee, I think it breaks down that barrier and they're a little bit more receptive to learning about nature itself versus the whole controversy around it (Carol, personal communication, April 3, 2014).

Some students do appear to have a problem with accepting large evolutionary changes, a principle of evolution which is taught in the lessons on the evolution of man and animals. This opposes the concept of creation where microevolution does not. She further explains why making that distinction makes a difference in the classroom in the form of stress relief and acceptation of processes like natural selection for students who have religious beliefs. In her statements Carol says that microevolution is observable and is therefore more acceptable to all the students.

> And I think making the distinction between the macro and the micro allows them to feel a little more comfortable with the idea of natural selection and microevolution. Because you're taking away that controversy, you're saying OK we're just going to talk about micro right now we're not going to talk about, you know, people coming from chimpanzees, you know, how I feel about that. But uh, once you take that away it really opens up and I, and I see that in my zoology classes every year. You see kids literally stiffen up and then when you start talking about it [microevolution] like oh yah that makes sense (Carol, personal communication, April 3, 2014).

The documentation I collected was primarily in the form of worksheets and Microsoft Power Points. There were no lesson plans or any other form of documentation available to me from Carol or the others. I divided the documentation into two groups, microevolution and macroevolution, although the worksheets did not always address those two divisions of evolution in such a distinct manner. The term microevolution is listed in the vocabulary section but the term macroevolution is not used. Microevolution is taught first and then the worksheets, with applicable genetics lessons, are followed by lessons on the fossil record and radiometric dating. The fossil record is primarily used for evidence in macroevolution.

Doug also notices a different response from his students when teaching microevolution distinct from macroevolution. After discussing what microevolution was about he stated "Ya so we really just focus on that micro. So that's just really the main thing, we got to leave the macro alone, since this is the introduction [to evolution] in school" (Doug, personal communication, January 15, 2015). When I asked about the student response to macroevolution as opposed to microevolution he responded in the following manner,

> Absolutely my fourth period today, they were asking me about how, or no, it was my third period class, but one of my classes asked if apes were still alive and we came from apes and, how does that work if it's survival of the fittest and how are weaker ones, I did the best that I could with answering that, but how they branch based on this theory where we come from, the same ancestors. We're not related to the modern day apes we're related to who they're related to. So just depends on the environment and the adaptations that had to take place in order to change them. I could definitely see that a lot of the students were very uncomfortable with that answer (Doug, personal communication, January 15, 2015).

George makes it a point to make a distinction between microevolution and macroevolution, whether or not the students say anything. He believes that this is common ground with all the students because it is observable.

> But they can see changes within this species. Then, and I, and I tell them that and I say you know this part of it from my point of view is not very controversial because we have, we scientists have seen this. But it's within the species and I emphasize that. And I say to my knowledge I have never seen any studies that show outside you know of a, using Darwin, a finch becoming a different finch, because of these kinds of things. But we've

> never seen a finch become a cat, which is macroevolution that's kind of the way I explain it to them (George, personal communication, April 24, 2014).

The method with which evolution is taught is addressed in the subjects of microevolution and macroevolution, but one of the reasons for teaching evolution is the preparation of students for working in fields of science, especially biology (Nadelson & Southerland, 2010). Nehm and Schonfeld (2007) concluded that religiosity contributed negatively to knowledge of science and positively to misconceptions of evolution and the nature of science. As a way of review, *nature of science* refers to describing science as a way of gaining knowledge which includes processes of science, analyzing, observing, measuring, etc. Research question one addresses the religion-evolution issue in light of student preparation in science. Interview question three asks how the teacher believes that religious views affect how teachers and students understand the nature of science.

In answering interview question three Carol did not believe that religious beliefs or the study of evolution would affect the understanding of the nature of science which is necessary for preparation in working in a field of science. She mentions the scientific method, which is basic to learning about science, has little to do with teaching about evolution. With reference to teaching the scientific method she says

> The scientific method to me is a daily process, when I pump, put gas in my car and get some on my hand the scientific method is the natural process where we're exploring trying to find a better way. And I don't really think that religious beliefs will stifle that (Carol, personal communication, April 3, 2014).

She does not see a contradictory relationship between religious beliefs and the teaching of scientific principles necessary for student preparation.

During the interview I asked Doug if he thought his students could understand and perform the mechanics of science, understand the nature of science and his reply was,

> Easily, easily, I don't see why somebody would even try to claim that they could still ask a question, they can still come up with a scientific approach to answering that question. There's so much more science out there than just evolution, that I don't see how that would affect how they would answer questions, scientifically (Doug, personal communication, January 15, 2015).

Doug did not associate his religious beliefs with preparing students for science and did not address the issue. George did not associate any effect between his religious beliefs and preparing his students for a field of science. As he states earlier in this study "…the science that they're learning is based on the scientific information and observation that they're made and ignores anything to do with faith" (George, personal communication, April 24, 2014).

There is another aspect to the teaching of evolution which is addressed in the interview, the curriculum requirements. Florida State School Board voted for the required teaching of evolution on February 19, 2008 (Rosenau, 2008). Prior to that time the word evolution was hardly mentioned in Florida schools and in 2008 fifty percent of Florida parents opposed the teaching of evolution as the only explanation for the origin of life on earth (Rosenau, 2008).

Carol felt that the new NGSS curriculum is good because it requires teachers to cover evolution and exposes students to another theory of origins besides what they have learned at home.

> I think it forces teachers to not skip subjects they would normally skip. So evolution would be a subject that in the past we have not tested on. So teachers could literally skip

> it. We could get away without having to teach primate evolution, and believe me it, it's great to skip it (Carol, personal communication, April 3, 2014).
>
> I think it's put the teacher in a very uncomfortable position but I think it's better for the student because they need to see the theories that are out there because when they get to college if they go to a public university they go to anthropology classes or whatever, they don't need to be smacked in the face with a new theory, they need to be aware of what's out there so that it's not brand new and I think it will prepare them (Carol, personal communication, April 3, 2014).

George felt that the curriculum requires a little too much with not enough time to adequately cover the required subjects. He says "I think that the expectations are far too rigorous for the amount of material that they want under whatever standards you're looking at to be covered in any science class" (George, personal communication, April 24, 2014). In his answer to the interview question, George did not associate religious beliefs with the requirements.

Doug felt that the curriculum requirements to teach evolution were needed to prepare the students for a field of science in the area of biology because they need to learn about microevolution.

> Maybe in a biological science field. I don't see the overlap if they're going into a physical science or an earth science, but I think they should have a basic understanding of microevolution if they're going to, if they're going into a biological field, then they need to know that microevolution with the germs and strains adapting to different types of antibodies (Doug, personal communication, January 15, 2015).

Summary

The participants indicate from their testimonies that teaching evolution as two divisions, microevolution and macroevolution, causes less stress in the classroom. The students have less difficulties accepting microevolution, which is observable, than they do accepting macroevolution, which is inferred from microevolution. One of the teachers, George, calls microevolution common ground, since the students accept it without causing a controversial atmosphere in the classroom. They have no problems with learning microevolution as science.

The participants see a direct relationship between microevolution and the nature of science. They stated that microevolution is a part of the study of biology, but not macroevolution. They do not see the relevance of macroevolution in the preparation of students for any field of science, including biology.

CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Overview

In this chapter the research questions are first answered, followed by discussion of the themes. After the discussion section I address implications of the study based on the answers to the research questions. The format is used to present the research question followed by the answer, and finally the implication is discussed. The next section lists the limitations of the study followed by the section on recommendations for future research. The last section of this chapter is the summary.

Summary of Findings

Research Question.

The research question answers are inferred from the above information obtained from the interviews as well as from class observations, and documentation procured from the teachers during the study.

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?

The participants do not believe that religious beliefs interfere with the learning of empirical science, which is observable, including microevolution. None of the participants believe that it is necessary to understand or accept macroevolution to learn the laws of science.

To answer the research question, the participants teach science and prepare their students to work in a field of science without regard to their religious beliefs.

2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?

The participants avoided the subject of religion, taught the lessons as they were presented in the textbook, but did not ignore student questions or statements about their own religious beliefs. Each teacher had his or her preferred way of diverting direct confrontation to avoid controversy.

To answer the research question, the participants avoided the topic of religion and diverted religious questions of the students.

3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?

The teachers tried to remain neutral when teaching the lessons on evolution to avoid controversy. They did not see a need to discuss their religious beliefs while teaching the lessons on evolution. When the participants were asked what they believed each one had his or her preferred answer, but none felt it necessary to divulge his religious beliefs.

To answer the research question, the participants taught the lessons on evolution without regard to their religious beliefs.

4. How do science teachers in the FSD perceive the relationship between religion and science?

Carol looks at the nature of science in its fundamental concepts, the scientific method and processes, as observable and not related to religion. Doug sees that microevolution is necessary for preparation in biology but does not see a connection between religion and science. George does not see a connection between the science of the lessons and the religion of the student. He says “The technique of science doesn’t seem, from my observation to be affected by whether a student has a particular religious point of view or not” (George, personal communication, April 24, 2014).

To answer the research question, the participants deal with religion and science separately, as separate entities.

Discussion

The religious beliefs of the teacher.

In the research literature the religious beliefs of the teacher fall under the heading of religiosity. According to Nehm and Schonfeld (2007) there is a positive correlation between the religiosity of teachers and their desire to teach some amount of creationism in their science classes. Nehm, Kim, and Sheppard (2009) indicate that religiosity causes conflict in some teachers and none in others when it comes to teaching evolution. Their study results showed that the low religiosity teachers had less conflict than the high religiosity teachers. Some researchers have concluded that a substantial percentage of science teachers, 16-20%, in the public schools teach creationism (Moore et al, 2011). The participants in this study do not necessarily fall in with the research results above.

Two of the participants, Carol and George, are theistic evolutionists, and Doug is a creationist. I am going to infer that the creationist, Doug fits well in the high religiosity category since this is the trend in research. Any of the references involving creationists in their research will support this view. Carol and George would then be in the lower religiosity category. All of the participants taught evolution in accordance with the curriculum and used worksheets and other materials produced by the publishing company. These teachers do not fit in the category of those that might teach creationism and teach in a region of the United States that has, relatively speaking, recently been required to teach evolution. Moore (2007, 2008) came to the conclusion that the teaching of creationism was practiced illegally from research conducted in Minnesota.

Religiosity may cause a conflict within the teacher but it does not necessarily mean that

the teacher will not teach evolution. It was evident, however, that the participants did have personal beliefs that probably influenced their teaching, not that they did not teach the subject, but that they might not have taught it as believers of evolution. All three refused to divulge their religious beliefs to the class and each one had his or her way of sidestepping the subject of religion. Carol told the students there are other ideas out there. George disqualified himself as any kind of authority on religion, and Doug told his students it didn't matter what he believed and that they had to make up their own mind about what to believe. Regardless of the religiosity level of each teacher, they each had to get a college education.

Two of the participants have a Master of Science degree and one had a bachelor of science degree which allowed them to teach in a public school system. This does not bypass religiosity and research indicates that level of education does not guarantee acceptance of evolution (Nehm & Schonfeld, 2007; Smith 2010a, 2010b). The interviews let me know how the participants felt about the topic of evolution in light of their religiosity and the observations and documentation demonstrated that they set their beliefs aside and taught the subject they were required to teach in accordance with the district mandate to prepare their students for the state standardized test requirements.

Some researchers partly blame creationist organizations for influencing the population, including teachers, to believe that creationism is true and for causing them to teach evolution ineffectively (Cleaves & Toplis, 2007; Hitt, 2009; Yalcinoglu, 2009). Yet all three of my participants said they would decline using creationist material even if allowed to do so by the school district. This is reflected in the interviews and in the summary statements about their interviews listed in chapter four and approved by each participant. Doug would rather deal with the subject in the classroom by presenting the lesson material and allowing the students to come

to their own conclusions. The teachers made it a point not to let their students know what their beliefs were, although some students chose to guess anyway, either because they knew something about the personal life of the teacher or because they just wanted to guess. This information can be found in chapter four under the theme *The religious beliefs of the teacher*.

In Carol's classes 79% agreed or strongly agreed that their teacher had not revealed to them her religious beliefs. In George's and Doug's classes 83% and 46% respectively agreed or strongly agreed that their teacher had not revealed to them their religious beliefs (Table 1, 2, & 3, p.74-76).

The religious beliefs of the student.

The research indicates that researchers are concerned with students from two different perspectives concerning the teaching of evolution. First the researcher uses the student to find out how effectively teachers are doing their job (Cotner, Brooks, & Moore, 2010; Moore & Cotner, 2009) and second, to find out to what extent the students accept evolution. There are numerous tools used to determine the acceptability of evolution by students: EALS (Evolutionary Attitudes and Literacy Survey) (Short & Hawley, 2015), MATE (Measure of Acceptance of the Theory of Evolution) (Smith, 2010a, 2010b), EES (Evolution Emotions Survey) and ERS (Evolutionary Reasoning Scale) (Heddy & Sinatra, 2013), MUM (Measure of Understanding of Macroevolution) (Nadelson & Southerland, 2009). A factor that is of importance in research which overlaps with the acceptance of evolution by the student is the stress felt by the student when he or she is taught information which contradicts their religious upbringing. Doug mentioned in his interview the expression of stress on the faces of some of his students until microevolution was taught separately from macroevolution (Doug, personal

communication, January 1, 2015). When the student is confronted with information that does not agree with what has been taught at home the student has a dilemma that must be dealt with.

Piaget uses terms like accommodation and assimilation as methods the student uses to deal with this dilemma. The student must manipulate this information in his mind and come to some conclusion to account for the apparent contradiction.

Evolution as a controversial subject.

The United States is only second to Turkey in its aversion to the theory of evolution (Hermann , 2013). There have been many studies conducted on the issue of the teaching of evolution and all those with which I acquainted myself address the controversial atmosphere that surrounds the teaching of evolution. Some of the studies include Levinson (2006a, 2006b), Hermann (2008, 2013), Levesque and Guillaume (2010), Reis and Galvao (2009), Martin - Hansen (2008). Evolution is often referred to as a controversial socio-scientific subject and although researchers are interested in using methods of conceptual change (Evans, 2008, 2001; Hickling & Wellman, 2001; Sinatra et al, 2008), Short and Hawley (2015) go so far as to say that high school teachers usually avoid teaching evolution. This is a rather bold statement since it is a required subject on which students are tested at the end of the year in many states. In Florida the participants all taught evolution and gave the required time because it is required of them and because it is necessary to prepare students for the state test at the end of the year.

All three of the participants in this study dealt with an atmosphere of controversy, each in his or her own way. Carol admitted to her students that there are other ideas to consider that lie beyond their classroom (Carol, personal interview, April 3, 2014). This provides the student with the possibility that their belief is worth considering and is not being thrown out because it does not fit with the theory being taught. Doug presented the evidence and expected his middle school

students to make up their own mind about evolution (Doug, personal communication, January 1, 2015). The research shows that increased knowledge about evolution and the nature of science does not cause teachers or college students to accept evolution (Nehm & Schonfeld, 2007; Short & Hawley, 2015). It probably will not convince high school and middle school students either. George just refused to discuss it in class because he was not supposed to and tried to avoid a confrontation with students by telling them that he was not qualified to talk about religions (George, personal communication, April 24, 2014).

Teaching evolution.

Two issues have been addressed on the teaching of evolution: the division of evolution into microevolution and macroevolution and the necessity of evolution in preparing students for working in a field of science.

Researchers seldom make a distinction between micro and macroevolution. I believe that this creates a misrepresentation of the results acquired by research on the teaching of this subject. I only found one researcher, Evans (2008), who represented the correct creationist view of microevolution and realizes that this is the aspect of the evolution theory that is accepted by creationists as opposed to macroevolution. Some researchers mention that microevolution is usually accepted over macroevolution but refuse to separate the two divisions in the surveys and interpretation of the results unless the surveys have specific questions about adaptations or mutations or other topics that fit under the subdivision of microevolution. I did not run across any research that recognized those two divisions as legitimate separations of the topic of evolution to be addressed separately in the classroom. The importance of microevolutionary processes are always emphasized since they are assumed to lead to macroevolutionary (Depew , 2010) changes, but to suggest that the two divisions might be taught separately is frowned upon.

The research articles I used that dealt with teaching evolution as a controversial socio-scientific subject never use the word microevolution (Hermann, 2008; Levesque & Guillaume, 2010; Levinson, 2006a, 2006b; Reis, 2008; Reis & Galvao, 2009).

All three participants agreed that when they taught microevolutionary processes there was no atmosphere of controversy in the classroom and the students were more relaxed. Teaching the macroevolutionary processes produced a different reaction from the students. Some confronted the teacher directly by stating that it was wrong (Doug, personal communication, January 1, 2015), (Carol, personal interview, April 3, 2014) George referred to microevolution as the common ground between evolutionist and creationist beliefs (George, personal communication, April 24, 2014).

The participants agree with organizations like AAAS, NRC, NCSE, and NSTA, (AAAS, 2006; NCSE, 2013; NRC, 2012;) only with reference to microevolution as directly applicable to the learning of biology but not with reference to macroevolution. These organizations insist on referring to evolution as a single process rather than dividing it into micro and macro and this is one area of disagreement between many teachers and the curriculum developers.

The relationship between science and religion is a point of contention in the research on the teaching of evolution. While some researchers believe that evolution is a scientific fact foundational to the learning of all sciences and should be taught as such, regardless of student feelings and beliefs, others would like to have evolution taught in a way that might merge student beliefs with the science curriculum. The relationship between science and religion does not have to be antagonistic.

Davies (1992) demonstrated through authors like Joseph Needham (1969) and John Barrow (1991), that western religion was instrumental in the development of modern science.

When scientists work with empirical science there is no conflict between the two. A conflict develops when the scientists attempt to develop theories to explain the origin of the laws of nature or the origin of observable processes such as the biochemistry that allows organisms to live. Stolberg (2009), is typical of most researchers in that he believes that the religious beliefs of students affect how they accept or understand science curriculum. He is referring to evolution specifically, not science in general. He then assumes that since they have problems with evolution that students have problems with understanding the nature of science. The beliefs of students may cause them to have a problem with accepting evolution as a whole but I have never found research that shows that the religious beliefs of students prevent them from accepting the laws of physics or chemistry or even biology.

Refusing to accept evolution as a whole is not a rejection of science at all. Donnelly (2009), points out that the topics that trouble students the most involve teachings on the origin of life and the origin of man, both related to macroevolutionary philosophy. To be more specific, the origin of life is a topic addressed in the context of biochemistry whereas the origin of man is more in the context of genetics.

Implications

The implications are referenced to the answers of the research questions since these are what guided the study. The first question asked how science teachers in the FSD approached the religion–evolution issue in preparing students for a career in a field of science. The answer was that the participants teach science and prepare their students to work in a field of science without regard to their religious beliefs. The implication here is that religious beliefs do not have to interfere with the teaching of high school and middle school science. Biology classes can be taught without regard to macroevolution but must include the principles of science which fall

under the heading of microevolution, such as: genetic variation, subspeciation, significance of mutations, relevance of adaptations, significance of the process of natural selection, and other related subjects. Religiosity does not have to be a problem in the public school system (Nehm & Schonfeld, 2007; Nehm et al, 2009; NRC, 2012) even if the teacher is a creationist. The level of interference with the lesson is at the discretion of the teacher and even teachers who are creationists have no problem teaching the empirical portion of evolution.

The second question asked how science teachers in the FSD reconcile the subject of evolution with the religious views of their students. The answer was that the participants avoided the topic of religion and diverted religious questions of the students. The implication is that teachers have developed their own ways of avoiding controversy in the classroom, although not all have the same approach. Some training in teacher-student communication might help. The level of controversy can be controlled and the teacher is the key. The controversial aspect is rarely addressed by researchers but some like Donnelly (2009), Reis and Galvao (2009). The way the participants handled the religious beliefs and sometimes confrontations of the students is in line with Hermann's suggestions on how to deal with controversial situations (2008). Hermann addresses the teaching of evolution specifically because of the level of controversy it produces in the United States.

The third question asked how science teachers in the FSD reconcile their own religious views with the teaching of evolution. The answer here was that the participants taught the lessons on evolution without regard to their religious beliefs. The implication in this case is that teachers can control how they handle their personal beliefs in the classroom regardless of how they believe about the subject. Living without bias is, in my opinion, not possible. However, it can be controlled to a great extent. One of the participants was a creationist who used teaching material

from the textbook publisher as it was made available to him and his class. Each individual is going to do this differently, but if the teacher cannot abide by the rules they should probably consider teaching somewhere where they will not feel they are compromising their beliefs. The literature showed that the higher the religiosity the greater the desire for a teacher to want students to learn creationism (Nehm et al, 2009). However, this did not prove true in this study with Doug who is a creationist. He chose to teach the lessons on evolution as they were presented and stated that he was not interested in using creationist material even if allowed to do so (Doug, personal communication, January 1, 2015).

The last research question asked how science teachers in the FSD perceive the relationship between religion and science. The answer was that the participants deal with religion and science separately, as separate entities. This implies that religious beliefs do not have to interfere with the teaching of empirical science. The conflict arises when science attempts to answer religious questions about processes that are not observable, such as the development of a frog to a reptile, or the development of the conscience. Interpretation is used in the scientific processes when doing research. In that context personal beliefs, whether they be religious or antireligious, will always affect the final conclusions. The history of science, if nothing else, demonstrates that modern science was developed without much hindrance from religious beliefs.

In this study I showed how the participants saw a distinct difference in the response of students when they taught microevolutionary processes and macroevolutionary processes. Researchers do not make a distinction between the two and from this study it seems that their results would come out differently if they did. Religiosity might be less of a problem if teachers and students who are counted high on the religiosity scale were tested on the acceptance of microevolution separately from macroevolution. Basic concepts of biology do not interfere with

the religious tenets of the leading world religions. Science and religion do not have to interfere with each other in the science classroom.

What the research question answers ultimately imply is that there are ways of avoiding controversy in the classroom when teaching controversial subjects, especially evolution. Reduced controversy in the classroom means better relationships between teachers, students, parents, principals, and superintendents. Compartmentalizing microevolution and macroevolution in the science classroom could assist teachers in creating a more relaxed atmosphere.

Limitations

The number of participants was less than I had hoped and the small number reduces the validity and generalizability of the study. The subject was controversial and I suspect contributed to the low number of volunteers as well as the number of principals willing to cooperate and possibly an assistant superintendent with whom I communicated.

Some principals did not acknowledge my emails and phone calls. I assumed that they did not forward my email introducing the project to their teachers. My email was sent to the assistant superintendent who then forwarded it to the principals. One district turned me down for a project that was similar to this one and therefore controversial. I am saying these things to warn future students to be careful about addressing controversial subjects that might scare off volunteers.

The documentation may have been a limitation as well. Originally I had hoped to take photographs and make recordings of the class, but was asked not to do either one of those activities. One teacher gave me only worksheets, another, personal notes, and from another only Microsoft Power Points.

Recommendations for Future Research

A study is needed to find out how science students in schools that teach creationism compare with science students in schools who teach evolution. This could be done by comparing standardized test scores. Public school volunteers would not be necessary. This would be quantitative research, using the results as raw data. This could be conducted with high school or college students.

The science reasoning subtest of the ACT (American College Testing) college entrance test have questions which fit under a heading of science reasoning. Janice Guthrie made this comparison of Christian science textbooks versus secular science textbooks in 2009 for her dissertation requirement (Guthrie, 2009). She conducted her research in the Midwest but this type of research should be repeated on a larger scale throughout the United States. This would indicate that evolution is not necessary to improve science reasoning.

This same type of research should be conducted with reference to topics like understanding the nature of science, understanding important concepts of biology, and other science-related topics for which evolution is thought to be a necessary framework.

I would also like to encourage mixed quantitative-qualitative research which will cause the researcher to go to the teacher in person to acquire information directly and find out what the teacher thinks and believes about a classroom method of teaching as well as the relevance of the certain curriculum requirements for example.

Research on the topic of teaching evolution almost always includes the religiosity factor on the part of the teacher, since this is often considered one of the causes of the lack of effective teaching of evolution. The degree of religiosity usually consists of assessing to what extent the participants take part in religious practices, such as church services, Sunday school, and other

church related traditions. It might be interesting to conduct research that considers the effect of the absence of religiosity or subdued religiosity in the teaching of evolution in the science classroom.

Investigating the effects of avoiding controversy in the classroom might be a consideration. Avoiding controversy may cause the teacher-student interaction to be subdued to the extent that it renders the lesson less effective than if the concerns of students were addressed more directly by perhaps addressing specific evidences. Some researchers see an advantage to discussing evidences in the classroom (Seals, 2010). It might relieve certain tensions on the part of the students who are attempting to accommodate what they've learned at home and the information they are receiving in the classroom.

Further research could be done on the value of microevolution versus macroevolution in the context of student success in the sciences, especially biology, since evolution is touted as essential in establishing a framework for biology. Microevolution is not actually a debated issue overall between evolutionists and creationists and it is expected that microevolution as opposed to macroevolution will found to be valuable in preparing students for science studies in biology.

Research on the impact of a creationist background or an evolutionist one on the ability to work in a field of science would reveal to some extent whether or not it is necessary to accept evolution to be competent in the sciences.

Summary

Virtually all of the research conducted on the teaching of evolution in the public school systems of various states is quantitative. Certain assumptions are made about the teaching of evolution in the research process. First it is usually assumed that evolution must be taught as a whole rather than divided into microevolution and macroevolution and teachers are evaluated on

that premise. Second it is supposed that if teachers have a high religiosity factor they will have less knowledge of science and evolution, and will be more likely to want to teach a version of the creation account. Third, evolution is known to be a controversial socio-scientific topic and therefore a challenging topic to teach. Finally, it is assumed that if evolution is not taught properly it will cause students to be improperly prepared for work in fields of science.

In this study I asked teachers how they reconciled their religious views and those of their students and how they viewed the teaching of evolution with respect to the preparation of their students for the workforce in a field of science. They were also asked about their ability to stick to the curriculum since it is written to help prepare students to join the workforce, including fields of science.

We found out that our participants were able to set aside religious preferences and teach with little controversy in the classroom when teaching microevolution separately from macroevolution. They emphasized the importance of teaching microevolution in preparing students for the future and had no problems teaching the curriculum in spite of religious preferences. The teachers believe there are alternative explanations to macroevolution or *evolution,* but none of them were willing to use creationist material even if allowed to. I believe this study provides some clues to a possible alternative to the present method of teaching evolution in the public school system.

Most of the answers to the research questions in this study did not necessarily contradict research and some supported the research. But by conducting qualitative research we can understand some of the reasoning some teachers go through in trying to avoid controversy in their classroom by balancing religious beliefs with curriculum topics that may contradict those beliefs.

APPENDICES

Appendix A: School District Letter of Approval

Blank County School Board

Regular Meeting
Second and/or Fourth
Thursday of each month

William S. Emerson
Assistant Superintendent
Curriculum, Instruction, and Assessment
5086 Canal Street
Milton, FL 32570
Phone: (850) 983-5040
Fax: (850) 983-5067
E-mail: emersonw@mail.blank.k12.fl.us

Tim S. Wyrosdick
Superintendent

BOARD
Diane L. Scott
District 1

Hugh Winkles

District 2
Diane Coleman
District 3
Jennifer Granse
District 4
Scott Peden
District 5

Mr. Pierre D. Willems
716 Valley Grande Rd
Pensacola, FL 32514

January 23, 2014

To Whom It May Concern:

Mr. Willems has been granted approval to conduct his research in Blank District Schools under the guidelines he has submitted to this office.

Please contact this office if you have any questions.

Appendix B: IRB Letter of Approval

March 7, 2014

Pierre D. Willems
IRB Approval 1791.030714: The Balance Between Religion and Evolution in the Science Classroom: A Case Study of High School Science Classes in a Florida Public School District

Dear Pierre,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master's thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

Fernando Garzon, Psy.D.
Professor, IRB Chair
Counseling

(434) 592-4054

Appendix C: Educator Participant Informed Consent

THE BALANCE BETWEEN RELIGION AND EVOLUTION IN THE SCIENCE CLASSROOM: A CASE STUDY OF IN A FLORIDA PUBLIC SCHOOL DISTRICT

Pierre D. Willems, Doctoral Candidate

Liberty University

Department of Education

You are invited to be in a research study of the management of science and religion in the science classroom. You were selected as a possible participant because you teach one of the following sciences: Natural science, physical science, or social science. I ask that you read this form and ask any question you may have before agreeing to be in the study.

This study is being conducted by Pierre Willems, a doctoral student in the Education Department at Liberty University.

Background Information:

The purpose of this study is to inquire about how science teachers in a school district in Florida reconcile religion and the socio-scientific topic of evolution in their classroom. Research indicates that about half of public school science teachers would prefer teaching both creation and evolution when teaching the subject of evolution. Research also indicates that science teachers have difficulties teaching a controversial subject like evolution for a variety of reasons, and that their personal religious beliefs have an influence on how the teachers deal with the subject of evolution. This sometimes creates a stressful situation for teachers and students. The more we know about how this situation can be managed the less stress their will exist between the teacher, students, parents, and administration, depending on the particular situation. This is the reason why the following research questions are guiding this research.

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?
2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?
3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?
4. How do science teachers in the FSD perceive the relationship between religion and science?

Procedures:

If you agree to be in this study, I would ask you to do the following things:

a) Fill out a short questionnaire which should take no more than five minutes to complete. (This will depend on the number of available teachers.)
b) Participate in a 45 minute recorded interview.
c) Allow me to observe one or two class periods covering one or more topics on evolution which will last the length of your class periods.
d) Provide me with a copy of your lesson plans for that lesson and other available documents used in teaching science lessons that include evolution.
e) Give a short, ten-question survey to your students.

Risks and Benefits of being in the Study:

The minimal risks involved are those associated with being interviewed and observed by a researcher. Observations and interview will be recorded and notes will be taken. Pseudonyms will be used to maintain the anonymity of the participants. The name of the school district will not be used throughout the study and will only be referred to as Florida School District in the final product. You will receive a copy of my observations before submission and will be able to submit comments if you believe that the notes and conclusions are inaccurate. It should take about four months for me to complete my research. It will probably take a total of about two hours of your time.

The study will provide information about classroom management used when teaching a controversial socio-scientific subject. This will be done on a personal level, by way of interviews and observations rather than by surveys or other remote methods of acquiring information. This study should be of help to teachers who teach controversial subjects such as: evolution, stem cell research, genetic engineering, and others.

When it is established that you are a participant in this study you will be provided a set of interview questions to help in preparing for the interview.

Compensation:

Compensation for participants will in the form of a $25 gift certificate to a local restaurant and a $30 gift certificate to a local coffee shop.

Confidentiality:

The records of this study will be kept private in a safe or locked file cabinet and/or on a computer with password access. In any sort of report I might publish, I will not include any information that will make it possible to identify any participant. Research records will be stored securely and only the researcher will have access to the records. The raw data, such as the interview recording and notes, other than the actual dissertation, will be destroyed after three years.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University, the school through which the doctoral degree is earned or Pensacola Christian College, which is my place of work. Neither will your relationship with your school district be affected as the information you provide will be kept private and only be available to the principle investigator. If you decide to participate, you are free not to answer any question or withdraw at any time without affecting those relationships.

How to Withdraw from the Study

1. Tell the primary investigator you wish to withdraw from the study.

2. The recording files will be deleted.

3. Any hardcopies involving your part in the research will be shredded.

Contacts and Questions:

The researcher conducting this study is *Pierre Willems*. You may ask any question you may have at this time. You are encouraged to contact *Mr. Willems* at (850) 619-1181; email *pdwillems@liberty.edu*. My advisor's name is Dr. Russell G. Yocum and can be contacted in the following methods: email ryocum@liberty.edu; phone-434-492-5462.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, you are encouraged to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24502 or email at *irb@liberty.edu*.

You will be given a copy of this information to keep for your records.

Statement of Consent:

Please insert your initials at the beginning of each statement:

_____I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

_____ I agree to be audio recorded during the interview, understanding that my name will not be used, to maintain confidentiality.

Signature: _____ Date: _____

Signature of Investigator:_____ Date: _____

IRB Code Numbers1791.030714:

IRB Expiration DateMarch 7, 2015: March 7, 2015

Appendix D: Parental Informed Consent Form

Parental Informed Consent Form

THE BALANCE BETWEEN RELIGION AND EVOLUTION IN THE SCIENCE CLASSROOM: A CASE STUDY OF SCIENCE CLASSES IN A FLORIDA PUBLIC SCHOOL DISTRICT

Pierre D. Willems, Doctoral Candidate

Liberty University

Department of Education

Your child is invited to be in a research study of the management of science and religion in the science classroom. Your child was selected as a possible participant because he or she is enrolled in one of the school's science classes. I ask that you read this form and ask any question you may have before agreeing to allow your child to participate in the study.

Background Information:

The purpose of this study is to inquire about how science teachers in a school district in Florida reconcile religion and the socio-scientific topic of evolution in their classroom. Research indicates that about half of public school science teachers would prefer teaching both creation and evolution when teaching the subject of evolution. Research also indicates that science teachers have difficulties teaching a controversial subject like evolution for a variety of reasons, and that their personal religious beliefs have an influence on how the teachers deal with the subject of evolution. This sometimes creates a stressful situation for teachers and students. The more we know about how this situation can be managed the less stress their will exist between the teacher, students, parents, and administration, depending on the particular situation.

Procedures:

If you agree to be in this study, I will ask your child to fill out the anonymous survey in class under the supervision of his or her teacher. The survey is to find out how your child feels about the teaching of evolution in his/her class. The survey will take approximately ten to fifteen minutes.

Risks and Benefits of being in the Study:

The risks are no more than your child would encounter in everyday life. The survey is anonymous and written answers are not required.

The study will provide information about classroom management used when teaching a controversial socio-scientific subject. This will be done on a personal level, by way of interviews of teachers and observations rather than by teacher surveys or other remote methods of acquiring information. This study should be of help to teachers who teach controversial subjects such as: evolution, stem cell research, genetic engineering, and others.

Compensation:

Your child will *not* be compensated for participation in this research.

Confidentiality:

The records of this study will be kept private in a safe or locked file cabinet and/or on a computer with password access. In any sort of report I might publish, I will not include any information that will make it possible to identify any participant. Research records will be stored securely and only the researcher will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect his/her current or future relations with Liberty University, the school through which the doctoral degree is earned or Pensacola Christian College, which is my place of work, as well as your child's school district. If you decide to allow your child to participate, he/she is free not to answer any question or withdraw at any time without affecting those relationships. To withdraw, your child only needs to turn in the survey with no answers on it or tell the teacher he/she does not want to take it.

Contacts and Questions:

The researcher conducting this study is *Pierre Willems*. You may ask any question you may have at this time. You are encouraged to contact *Mr. Willems* at (cell phone) (850) 512-9516; email *pdwillems@liberty.edu*. My advisor's name is Dr. Russell G. Yocum and can be contacted in the following methods: email ryocum@liberty.edu; phone-434-492-5462.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher*(s)*, you are encouraged to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24515 or email at *irb@liberty.edu*.

Statement of Consent:

I understand that all data will be secured at all times by the researcher, and consent to allowing

my student to participate in this study by answering the questions of the survey. I understand that

I may withdraw my consent and discontinue my child's participation at any time prior to the

administration of the survey, since there will be no way to identify your student's survey after the administration of the survey.

Signature of parent or guardian: _____ Date: _____
(If minors are involved)

Signature of Investigator:_____ Date: _____

IRB no. 1791.030714

Appendix E: Principal/Superintendent Participation Letter

Date: November 1, 2013

Mr. William Emerson
Assistant Superintendent
Santa Rosa County School District
5086 Canal Street Milton, FL 32570

Pierre D. Willems
716 Valley Grande Rd
Pensacola, FL 32514

Dear Mr. Emerson:

As a graduate student in the Education Department at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The title of my research project is The Balance between Religion and Evolution in the Science Classroom: A Case Study of High School Science Classes in a Florida Public School District.

The purpose of this study is to inquire about how science teachers in a school district in Florida reconcile religion and the socio-scientific topic of evolution in their classroom. Research indicates that about half of public school science teachers would prefer teaching creation as an alternative to evolution when teaching the subject of evolution. Research also indicates that science teachers have difficulties teaching a controversial subject like evolution for a variety of reasons, and that their personal religious beliefs have an influence on how the teachers deal with the subject of evolution. This sometimes creates a stressful situation for teachers and students. The more we know about how this situation can be managed the less stress their will exist between the teacher, students, parents, and administration, depending on the particular situation. This is the reason why the following research questions are guiding this research.

1. How do science teachers in the FSD approach the religion–evolution issue in preparing students for a career in a field of science?
2. How do science teachers in the FSD reconcile the subject of evolution with the religious views of their students?
3. How do science teachers in the FSD reconcile their own religious views with the teaching of evolution?
4. How do science teachers in the FSD perceive the relationship between religion and science?

I am writing to request your permission to conduct my research in the Santa Rosa School District. Participants will be asked to contact me to schedule an interview. The research includes a 45 minute interview, time for classroom observation of one or two class periods, and a copy of

the lesson plan for the periods observed. Participants will be presented with informed consent information prior to participating. Taking part in this study is completely voluntary, and participants are welcome to discontinue participation at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on *approved letterhead*.

Sincerely,

Pierre D. Willems

Appendix F: Teacher Questionnaire

Name _____

Name of the school where you teach _____

What subject(s) do you teach?_____

How many years have you taught this or these subjects? _____

Please indicate the hour(s) you teach_____

What college degrees have you earned?_____

Which of the following do you believe: (choose one)

a. Evolution b. Creation c. Theistic evolution

d. other _____

Please indicate your class size:_____

What is the best time for you to schedule an interview? (You should allow about 1 hour.)

What week(s) of the semester(s) do you teach the subject of evolution?

Appendix G: Field Notes Form

School name:

Teacher's pseudonym:

Topic of lesson:

How was the lesson introduced and presented?

What kind of formal (part of the lesson) interactions were there between the teacher and the students?

What kind of informal (not part of the lesson) interactions were there between the teacher and the students?

Were there any expected interactions that did not occur?

Was there any evident nonverbal communication?

Lesson activities:

Handouts:

Any other comments about the classroom environment and lesson?

Appendix H: Assent of Minor

Assent of Minor to Participate in a Research Study

The title of this study is:
The Balance between Religion and Evolution in the Science Classroom: A Case Study of Science Classes in a Florida Public School District

Why are we doing this study?
We are interested in studying how science teachers combine religion and science in the lessons used to teach evolution.

Why are we asking you to be in this study?
You are being asked to be in this research study because I would like to know what you think of the way evolution is taught in your class.

If you agree, what will happen?
If you are in this study you will be asked to answer some questions in a short survey without giving your name.

Do you have to be in this study?
No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Do you have any questions?
You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.

Signing your name below means that you want to be in the study.

_____ _____

Signature of Minor Date

Researcher contact information:
Pierre Willems email: pdwillems@liberty.edu
Local phone: 619-1181
Faculty Advisor:
Dr. Russell Yocum email: ryocum@liberty.edu

Liberty University Institutional Review Board,
1971 University Blvd, Suite 1837, Lynchburg, VA 24515
or email at irb@liberty.edu.

Appendix I: Student/Parent Consent Form

THE BALANCE BETWEEN RELIGION AND EVOLUTION IN THE SCIENCE CLASSROOM: A CASE STUDY OF HIGH SCHOOL SCIENCE CLASSES IN A FLORIDA PUBLIC SCHOOL DISTRICT

Pierre D. Willems, Doctoral Candidate

Liberty University

Department of Education

You are invited to be in a research study of the management of science and religion in the science classroom. You were selected as a possible participant because you are enrolled in one of the following sciences at the high school level: biology, physics, chemistry, or general science. I ask that you read this form and ask any question you may have before agreeing to be in the study.

Background Information:

The purpose of this study is to inquire about how science teachers in a school district in Florida reconcile religion and the socio-scientific topic of evolution in their classroom. Research indicates that about half of public school science teachers would prefer teaching both creation and evolution when teaching the subject of evolution. Research also indicates that science teachers have difficulties teaching a controversial subject like evolution for a variety of reasons, and that their personal religious beliefs have an influence on how the teachers deal with the subject of evolution. This sometimes creates a stressful situation for teachers and students. The more we know about how this situation can be managed the less stress their will exist between the teacher, students, parents, and administration, depending on the particular situation.

Procedures:

If you agree to be in this study, I would ask you to allow your child to fill out the following

anonymous survey:

Risks and Benefits of being in the Study:

The risks are no more than the participant would encounter in everyday life. Remember,the survey is anonymous and written answers are not required.

The study will provide information about classroom management used when teaching a controversial socio-scientific subject. This will be done on a personal level, by way of interviews

of teachers and observations rather than by teacher surveys or other remote methods of acquiring information. This study should be of help to teachers who teach controversial subjects such as: evolution, stem cell research, genetic engineering, and others.

Compensation:

Participants will *not* be compensated for participation in this research.

Confidentiality:

The records of this study will be kept private in a safe or locked file cabinet and/or on a computer with password access. In any sort of report I might publish, I will not include any information that will make it possible to identify any participant. Research records will be stored securely and only the researcher will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University, the school through which the doctoral degree is earned or Pensacola Christian College, which is my place of work. If you decide to participate, you are free not to answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is *Pierre Willems*. You may ask any question you may have at this time. You are encouraged to contact *Mr. Willems* at (850) 477-0159 or (cell phone) (850) 512-9516; email *pdwillems@liberty.edu*. My advisor's name is Dr. Russell G. Yocum and can be contacted in the following methods: email ryocum@liberty.edu; phone-434-492-5462.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher*(s)*, you are encouraged to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24515 or email at *irb@liberty.edu*.

Statement of Consent:

I understand that all data will be secured at all times by the researcher, and consent to allowing my student to participate in this study by answering the questions of the above survey anonymously. I understand that I may withdraw my consent and discontinue my child's participation at any time prior to the administration of the survey since there will be no way to identify your student's survey after the administration of the survey.

Signature of parent or guardian: _____ Date: _____
(If minors are involved)

Signature of Investigator:_____ Date: _____

Student Assent Form

I, _____, understand that my parents/guardians have given my permission to participate in a study regarding the balance of religion and evolution in the science classroom. I am participating because I want to. I have been told that I can stop at any time. If I so desire. The researcher is Pierre D. Willems who is currently a doctoral candidate with Liberty University.

Appendix J: Student Survey

DO NOT PUT YOUR NAME ON THIS PAPER.

Select the answer that expresses your opinion. There are no wrong answers.

	Strongly agree	agree	undecided	disagree	strongly disagree
1. God created all things	____	____	____	____	____
2. Everything came into existence naturally, without supernatural influence.	____	____	____	____	____
3. God used evolution to make living things	____	____	____	____	____
4. Microevolution is genetic variation that produces different kinds of dogs or roses.	____	____	____	____	____
5. Evolution from lizards to mammals is an example of macroevolution.	____	____	____	____	____
6. Evolution contradicts my religious beliefs.	____	____	____	____	____
7. Learning about evolution has changed my religious beliefs	____	____	____	____	____
8. My teacher does not believe evolution is true.	____	____	____	____	____
9. My teacher does not believe creation is true.	____	____	____	____	____
10. My teacher didn't tell us what he/she believes.	____	____	____	____	____
11. My teacher was interested in what I believe about evolution or creation.	____	____	____	____	____
12. My teacher doesn't care what I believe about evolution or creation.	____	____	____	____	____
13. Understanding evolution will not help me to understand science.	____	____	____	____	____
14. Understanding evolution will not help me to get a better job after I graduate.	____	____	____	____	____
15. Understanding evolution will not help me to make my teacher like me more.	____	____	____	____	____
16. Understanding evolution will not help me to understand biology.	____	____	____	____	____

Circle the answer that applies to you:

17. My religion is

Baptist Islam Catholic Jehovah's Witness Mormon Jewish Other _____

18. Every week I attend worship meetings- 3 times 2 times once more never

Appendix K: Interview Questions

Standardized Open-Ended Interview Questions

1. Could you tell me how you believe teachers' religious views affect the way in which they teach science topics and evolution?

2. How do you encourage or avoid class discussion of evolution or similarly controversial topics?

3. How do you feel that religious views affect how students and teachers understand the nature of science?

4. How do your students' religious views affect how you teach evolution?

5. How do you handle a situation when a student brings up personal religious beliefs during your science class that oppose what you are teaching?

6. How do you believe that making a distinction between micro and macro evolution might affect the way your students learn evolution?

7. If it were permissible, could you tell me what kinds of antievolution material, if any, from Intelligent Design or creationist organizations you might use during science instruction?

8. How do you believe your personal religious views affect how you teach evolution in the classroom?

9. How do you believe the Next Generation Science Standards, as they address evolution, will affect the preparation of your students for work in a field of science?

10. What else might you like to mention about science instruction, religious beliefs, and controversial topics for instruction that I may not have asked about?

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