EXPLORING FRESHMEN UNDERGRADUATES' ACCEPTANCE OF THE THEORY OF EVOLUTION AND VIEWS OF NATURE OF SCIENCE

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Abstract:

Understanding the mechanisms of evolution can help lead to advancements in science, technology, medicine, and agriculture. To enhance student understanding of the Theory of Evolution, science education organizations encourage the teaching of evolution in the K-12 science curriculum. Additionally, holding informed views of nature of science (NOS) has also been suggested to enhance student acceptance of the Theory of Evolution. The purpose of this survey-based research study was to explore the acceptance levels of the Theory of Evolution and views of NOS held by freshmen undergraduates attending a research university in Oklahoma.

An online Qualtrics survey was used to assess the levels of acceptance of the Theory of Evolution and views of NOS held by 377 freshmen undergraduate students. The instruments used in this study included the Measurement of the Acceptance of the Theory of Evolution (MATE; Rutledge & Warden, 1999) and the Student Understanding of Science and Scientific Inquiry (SUSSI; Liang et al., 2006). Further, the influence of participants' demographics on their acceptance levels of the Theory of Evolution and views of NOS were also explored. The following demographic variables were included in this study: gender, STEM major, high school community, religious views, religiosity, political views, science classes taken in high school, exposure to the teaching of evolution and creationism in high school, and in-state/out-of-state tuition.

The results of this study revealed: 1) the majority of participants held moderate or high levels of acceptance of the Theory of Evolution; 2) religious views, religiosity, and political views were found to significantly influence participants' acceptance of the Theory of Evolution; 3) the majority of participants held transitional views of NOS, except for *Scientific Laws and Theories* and *Methodology in Scientific Investigations*, in which the majority of participants held naïve views; 4) none of the demographic variables were found to significantly influence views of NOS; and 5) a relationship between participants' acceptance of the Theory of Evolution and their views of NOS was not identified.

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CHAPTER I

INTRODUCTION

Chapter 1 provides an introduction to the topics explored in this study, the problem statement, purpose of the study, research questions, significance of the study, definition of important terms, methods, and limitations of the study. The chapter concludes by providing a summary of each of the following four chapters included in this study.

Background

In 1859, Charles Darwin presented a scientific explanation for the creation of species in his book, *The Origin of Species.* Darwin's theory, known as "The Theory of Evolution by Natural Selection," suggests modern organisms are the result of a completely naturalistic process in which all species originate from a common ancestor and, due to mechanisms such as natural selection, diverge across lineages (Darwin, 1859). Over the past 60 years, a large amount of genetic evidence has strengthened the Theory of Evolution by allowing further analysis and interpretation of the prior evidence (e.g., fossils, similarities across species in anatomy and physiology) (Zimmer & Emlen, 2013). This overwhelming amount of evidence has led most scientists to no longer question the occurrence of evolution, but rather focus on better understanding the

the mechanisms and processes that lead to the divergence of species (American Association for the Advancement of Science [AAAS], 2006; National Association of Biology Teachers [NABT], 2011; National Academy of Sciences [NAS], 1998; National Research Council [NRC], 1996, 2012; National Science Teachers Association [NSTA], 2013). Scientists' understanding of evolutionary mechanisms have led to explanations of many aspects of biology, such as the diversity of life, resulting in the Theory being identified as a unifying concept of biology (AAAS, 2006; NAS, 1998; Rutledge & Warden, 1999; Zimmer & Emlen, 2013).

Despite strong support of the Theory of Evolution from the scientific community, surveys exploring the American public's acceptance of the Theory of Evolution suggest that a majority of Americans view the Theory with much resistance (Armenta & Lane, 2010; Heddy & Nadelson, 2012; Miller, Scott, & Okamoto, 2006). Miller et al. (2006) compared the results of national surveys from 1985 to 2005 and found the level of acceptance for the Theory of Evolution expressed by the American public has declined since the 1980s. In the same time frame, Miller et al. (2006) also found the percentage of adults who do not accept, and also do not reject, the Theory of Evolution has increased from 7% to 21%. Smith (2010) conducted a review of the growing literature in teaching and learning of the Theory of Evolution and suggested that a majority of the American population surveyed had minimal to no understanding of the Theory of Evolution. Globally, Miller et al. (2005) identified the United States to rank 33rd out of 34 countries in public acceptance of the Theory of Evolution, with Turkey holding the lowest acceptance.

The American public's low acceptance of the Theory of Evolution is met with much concern from the scientific community (Lombrozo, Thanukos & Weisberg, 2008). The

Theory of Evolution not only explains how life has evolved from the appearance of the first self-replicating organism to present day, but it also helps explain the role that biology plays in everyday life (Lombrozo et al., 2008; Nehm & Schonfeld, 2007; Smith, 2010). For example, the biodiversity of species, medical treatments of illnesses, and the change in many species from generation to generation are all direct results of the evolutionary process (Glaze & Goldston, 2015). Understanding biological evolution can help farmers identify how disease-causing bacteria and viruses evolve, which can influence the growth and stability of crops (Heddy & Nadelson, 2013). Understanding biological evolution can help explain the process of artificial selection, which can be used to grow more abundant crops and thereby ultimately feed a larger number of people (Lombrozo et al., 2008). Since current understandings of the mechanisms of the Theory of Evolution explain much of the living world, it is important for future generations to understand and accept the Theory so that advancements in science, technology, medicine, and agriculture can be achieved (Heddy & Nadelson, 2012; Gould, 2002; Nadelson & Southerland, 2010).

To address the low acceptance of the Theory of Evolution held by a majority of the American public, the science education community has placed an emphasis on improving the effectiveness of teaching the Theory of Evolution (Allmon, 2011; Rutledge & Sadler, 2007). Many science education organizations have released position statements supporting the teaching of the Theory of Evolution in public schools (e.g., AAAS, 2006; NABT, 2011; NSTA, 2013), and the Theory of Evolution has been emphasized as an important concept that should be included in state science standards (NGSS Lead States, 2013). This emphasis on the teaching of the Theory of Evolution has resulted in the identification of variables that influence the acceptance of the Theory of Evolution. These variables include: 1) knowledge of the Theory of Evolution (Barone, Petto & Campbell, 2014; Cotner, Brooks & Moore, 2010; Heddy & Nadelson, 2012; Lombrozo et al., 2008; Moore & Cotner, 2009; Nadelson & Southerland, 2010); 2) political views (Barone et al., 2014; Cotner et al., 2010; Lombrozo et al., 2008; Mazur, 2004; Nadelson & Hardy, 2015); 3) economic development (Barone et al., 2014; Heddy & Nadelson, 2012); 4) religious beliefs (Baker, 2013; Barone et al., 2014; Cotner et al., 2010; Coyne, 2012; Heddy & Nadelson, 2012); 5) college major (Moore & Cotner, 2009; Peker, Comert, & Kence, 2010); 6) exposure to creationism (Moore & Cotner, 2009); 7) gender (Peker et al., 2010); and 8) understandings of nature of science (NOS) (Allmon, 2011; Lombrozo et al., 2008; Scharmann & Harris, 1992; Verhey, 2005). Although studies have shown these specific variables to influence the acceptance of the Theory of Evolution, not all of the variables can be addressed in the science classroom. Religious beliefs and political views have been identified as the most influential variables on acceptance of the Theory of Evolution, but they are not easily explored in the science classroom due to prevention by administration/government (separation of church and state) (Lombrozo et al., 2008). Other variables, such as gender and economic development, cannot be changed by instruction in the science classroom (Lombrozo et al., 2008). While teaching about the Theory of Evolution in the science curriculum may appear as the best method for enhancing student acceptance of the Theory, studies suggest that teaching the Theory of Evolution does not always correlate with acceptance of the Theory (Barone et al., 2014; Lombrozo et al., 2008; Sinatra, Southerland, McConaughy & Demastes, 2003; Nadelson & Hardy, 2015).

One variable that has been suggested to enhance acceptance of the Theory of Evolution, and one that can also be influenced in the classroom, is the teaching of nature of science (NOS) (Lombrozo et al., 2008). Research suggests that holding informed understandings of science and how science knowledge is generated will increase acceptance of the Theory of Evolution (Lombrozo et al., 2008). To reach this level of understanding, studies suggest educators should also incorporate the teaching of NOS along with teachings of the Theory of Evolution (Cavallo & McCall, 2008; Glaze & Goldston, 2015; Lombrozo et al., 2008; Rutledge & Warden, 1999; Sinatra et al., 2003). Nature of science (NOS) typically refers to the "epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, 2007, p. 833). NOS is not defined by one set definition, but is rather described through a set of characteristics, generally termed, "aspects" (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002, p.499). A list of aspects was identified in science reform documents such as *Science for All Americans* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996). While the aspects addressed in the research literature may vary based on the study, there are ten aspects typically included when exploring NOS: 1) the empirical nature of science; 2) the tentative nature of science; 3) the inferential nature of science; 4) the nature of scientific theories; 5) the nature of scientific laws; 6) the creative and imaginative nature of science; 7) the theory-laden nature of science; 8) the social and cultural embeddedness of science; 9) the role of scientific models; and 10) the differences and relationships between theories and laws (Lederman et al., 2002). These aspects, which are each individually addressed and described in Chapter II, lay out the characteristics of how scientific knowledge is generated; they are concepts that the science education community suggest that students should know (Lederman, 2007).

For over a century, many scientists, science educators, and science education organizations have advocated that strengthening students' understanding of NOS should be an important goal for science education (Abd-El-Khalick, Bell & Lederman, 1998; Lederman, 2007; Lederman et al., 2002; Duschl, 1990; Meichtry, 1993). Holding an informed view of NOS has shown to enhance understandings of the processes and practices of science, thus enhancing science literacy (Cavallo & McCall, 2008; Lederman, 2007). Educational studies have also indicated that students who hold informed views of NOS are more likely to accept the Theory of Evolution (Allmon, 2011; Scharmann & Harris, 1992; Lombrozo et al., 2008; Verhey, 2005). Although the scientific community has encouraged the teaching of NOS in the science curriculum for over 100 years (Central Association of Science and Mathematics Teachers, 1907), research consistently reveals students and science educators still hold naïve understandings of NOS (Abd-El-Khalick, 2005; Abd-El-Khalick & Akerson, 2004; Bianchini & Colburn, 2000; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Lederman, 2007; Urhahne, Kremer & Mayer, 2011). This lack of understanding by science educators and student alike suggests there is still a need to focus on enhancing views of NOS in teacher preparation programs and in teacher professional development events.

Statement of the Problem

The Theory of Evolution has been identified as a central and unifying theme in the biology discipline (AAAS, 2006; NRC, 2006; NSTA, 2013). Despite the strong support of the Theory of Evolution from science and science education communities, the Theory has often been met with much resistance from the general public (Armenta & Lane, 2010). In fact, the Theory of Evolution is considered by many to be one of the most controversial and misunderstood scientific theories in the United States (Armenta & Lane, 2010; Barone et al., 2014; Nadelson & Hardy, 2015; Rutledge & Warden, 1999). In the state of Oklahoma, specifically, the Theory of Evolution is such a controversial topic that the state legislature has heavily influenced the prevention of the term "evolution" in the Oklahoma science education standards (American Institute of Biological Sciences [AIBS], 2016). Further, while research suggests views of NOS can influence acceptance of the Theory of Evolution (Allmon, 2011; Lombrozo et al., 2008; Scharmann & Harris, 1992; Verhey, 2005), the aspects of NOS are not included in the current Oklahoma Academic Standards for Science (OAS-S; Oklahoma State Department of Education [OSDE], 2014). Since the Theory of Evolution and NOS are not explicitly addressed in the OAS-S, there is a need in the research literature to explore the acceptance of the Theory of Evolution and views of NOS held by undergraduate students attending a university in Oklahoma.

Purpose of the Study

The purpose of this study was to contribute to the science education literature by: 1) identifying the level of acceptance of the Theory of Evolution and understandings of NOS held by freshmen undergraduates attending a research university in Oklahoma; 2) identifying demographic variables that may influence these freshmen undergraduates' acceptance of the Theory of Evolution, as well as their views of NOS; and 3) identifying if a relationship exists between participants' acceptance of the Theory of Evolution and their views of NOS.

Research Questions

Research Question #1: *What is the current level of acceptance of the Theory of Evolution held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #2: *Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?*

Research Question #3: *What are the current views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #4: *Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?*

Research Question #5: *Does a relationship exist between acceptance of the Theory of Evolution and views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #6: *If a relationship is found to exist, how do specific demographic variables moderate the relationship between participants' acceptance of the Theory of Evolution and their views of NOS?*

Significance of the Study

This study is significant for many reasons. First, the results of this study will contribute to the gap in research literature concerning undergraduates' acceptance of the Theory of Evolution and their views of NOS. Second, the results of this study will provide college-level science educators insight regarding the acceptance of the Theory of Evolution and views of NOS held by freshmen students as they begin their entry-level science courses. Third, the results of this study will provide high school science educators with insight regarding the acceptance of the Theory of Evolution and views of NOS held by students as they exit the high school science classrooms. Lastly, it is the hope of the researcher that by educating readers on the importance of student acceptance of the Theory of Evolution and informed views of NOS, that high school and college science educators will be encouraged to include the Theory of Evolution and/or views of NOS in their classroom curriculum.

Definition of Terms

Theory of Evolution. The Theory of Evolution accounts for the similarities among organisms (plants, animals, microorganisms, etc.) by explaining the idea of descent from a common ancestor (Zimmer & Emlen, 2013). A range of mechanisms, such as natural selection and genetic drift, cause populations to change and diverge over time, resulting in the development of new species (Zimmer & Emlen, 2013). Many disciplines of science, such as physics, biochemistry, geology, biology, and astronomy have found overwhelming evidence for evolution, which has led the Theory of Evolution to be recognized as a unifying concept for biology (NSTA, 2013). While the details of how evolution occurs are still being investigated, the scientific community strongly supports the Theory of Evolution as fact, as there is no scientific evidence that evolution has not occurred (NAS, 1998).

Acceptance, Understanding, and Belief of the Theory of Evolution. Research literature identifies three terms commonly used when discussing the Theory of Evolution: "understanding", "belief", and "acceptance." Interestingly, how these terms are referenced within the research literature appears to be based on the conceptual framework of the researcher(s). For instance, Cobern (2004) and Smith and Siegel (2004) argue the three terms can be used in the same context, because in order for one to "accept" the Theory of Evolution, one must "understand" and also "believe" in the Theory. Nadelson and Southerland (2010) argue that "understanding" refers to knowledge of content and can be independent of belief and acceptance. However, "belief" and "acceptance" should be used in the same context, as a person cannot accept without believing. Sinatra et al. (2003) argue that each term is a distinct concept and should have its own identity and not be interchanged.

Since there is such variation of the definition of these terms, it is important to establish how the terms were used in this study.

The differentiation of the three terms as argued by Sinatra et al. (2003), was utilized for this study. The terms acceptance, understanding, and belief are not used synonymously when discussing the Theory of Evolution; each term holds its own identity. The term "acceptance" refers to an individual's scientific evaluation of the knowledge of the Theory of Evolution, which allows the individual to agree or disagree that evolution occurs (Sinatra et al., 2003). The term "understanding" refers to the level of knowledge participants have regarding the content matter associated with the Theory of Evolution (Sinatra et al., 2003). The term "belief" refers to an individual's judgment of the Theory of Evolution (Sinatra et al., 2003). This judgment is derived not from scientific research but from "personal convictions, opinions, and degree of congruence with other belief systems" (Sinatra et al., 2003, p. 512). Thus, an individual may understand and accept the Theory of Evolution, but not incorporate the idea into his/her beliefs (Blackwell, Powell, & Dukes, 2003). This study only addressed acceptance of the Theory of Evolution by exploring participants' perceptions of: a) the scientific validity of the Theory of Evolution; b) the Theory's ability to explain phenomena; and c) the acceptance of the Theory of Evolution within the scientific community. Participants' content knowledge (understanding) or personal judgments (beliefs) of the Theory of Evolution were not explored.

Nature of Science (NOS). NOS commonly refers to "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, 1992, p. 331). NOS is typically addressed through the acknowledgement of specific aspects, which were developed to help science educators identify what students should know about science and scientific knowledge (Lederman et al., 2002). These aspects can include the: empirical nature of science, tentative nature of science, inferential nature of science, nature of scientific theories, nature of scientific laws, creative and imaginative nature of science, theory-laden nature of science, social and cultural embeddedness of science, role of scientific models, and differences and relationships between scientific theories and laws. A complete description of each aspect of NOS, along with a more thorough description of NOS, is provided in Chapter II.

Procedures

This quantitative study used a descriptive, survey-based methodology to explore freshmen undergraduates' acceptance of the Theory of Evolution, their views of NOS, and the relationship between their acceptance of the Theory of Evolution and their views of NOS. An online survey was used to collect data from freshmen students attending a research university in Oklahoma. Along with demographic questions developed by the researcher, the survey utilized the Measurement of the Acceptance of the Theory of Evolution (MATE) instrument (Rutledge & Warden, 1999) to explore participants' acceptance of the Theory of Evolution, and the Student Understanding of Science and Scientific Inquiry (SUSSI) instrument (Liang et al., 2006) to explore participants' views of NOS. Data were analyzed primarily through the use of quantitative analysis, using t-tests, ANOVA, and Pearson/Spearman's correlations. However, qualitative measures were also used to score and categorize participants' open-ended responses to the SUSSI.

Limitations of the Study

There are several limitations that should be taken into account when analyzing the results of this study. First, the population sample for the study was drawn from a single institution, which may have led to biased perspectives. While the sample reflected diverse backgrounds and views, it cannot be assumed that the findings represent the general freshmen undergraduate student population across the state or country. Participants' acceptance of the Theory of Evolution and views of NOS may differ when compared to samples from other institutions. Additional research, sampling a wide range of institutions, would allow better determination of the generalizability of the findings.

Second, the Student Understanding of Science and Scientific Inquiry (SUSSI) (Liang et al., 2006) instrument was utilized to assess participants' views of NOS. The instrument is composed of six NOS themes, each containing four Likert items and one constructed-response item. The low reliability of the instrument required the Likert data and the constructed-response data to be analyzed independently from one another, resulting in a Likert-score and a constructed-response score for each of the six NOS themes. The independent data analysis led to many statistical tests being conducted on the same data, which increased the potential for a type 1 error (false positive error). For this study, potential for a type 1 error was not accounted for during statistical analysis, meaning one or more of the significant findings could have been different than what is reported. This limitation should be taken into consideration when exploring the influence of the demographic variables on participants' views of NOS.

Third, when scoring the constructed-response answers of the SUSSI, only one researcher performed the scoring process. The researcher did attempt to maintain consistency in the scoring process by utilizing a scoring rubric provided by the developers of the SUSSI instrument (Liang et al., 2006), as well as completing the scoring process twice.

However, when considering the results of the study, the lack of other perceptions should be taken into consideration.

Summary

Student acceptance of the Theory of Evolution is important to achieve, as understanding the mechanisms of the Theory of Evolution help explain and inform progress of much of the living world (Lombrozo et al., 2008). It has been suggested that individuals who hold informed views of NOS have an increased acceptance of the Theory of Evolution (Allmon, 2011; Cavallo & McCall, 2008; Lombrozo et al., 2008; Nehm & Schonfeld, 2007). However, research exploring this relationship among undergraduate students is limited, especially in the state of Oklahoma, where the anti-evolution legislation has prevented the term ‘evolution’ from being incorporated in their state science standards (AIBS, 2016). This study was developed to explore the acceptance of the Theory of Evolution and the views of NOS held by freshmen undergraduate students attending a research university in Oklahoma.

Chapter I provided an introduction to the study, statement of the problem, purpose of the study, research questions, definitions of key terms, a summary of the procedures, and limitations of the study.

Chapter II provides a review of the research that is relevant to undergraduates’ acceptance of the Theory of Evolution and their views of nature of science (NOS). The first section of this chapter provides a review of the Theory of Evolution literature. The second section of this chapter provides a review of the nature of science (NOS) literature. The chapter concludes by discussing the theoretical framework utilized for the study.

Chapter III provides a rich description of the research methods and procedures used for this study. This chapter addresses the survey and survey distribution used to collect data, as well as in-depth descriptions of the use and scoring of the MATE (Rutledge & Warden, 1999) and the SUSSI (Liang, Chen, Chen, Kaya, Adams, Macklin & Ebenezer, 2006) instruments.

Chapter IV provides the results of the study. The chapter is organized into four sections: the first section provides the descriptive statistics of the study; the second section addresses participants' acceptance of the Theory of Evolution; the third section addresses participants' views of NOS; and the fourth section addresses the relationship between participants' acceptance of the Theory of Evolution and their views of NOS.

Chapter V provides a discussion of the findings of this study. This chapter explores how the results of the study may contribute to science education and is organized into four sections: The first section discusses participants' acceptance of the Theory of Evolution; the second section discusses participants' understandings of NOS; the third section discusses the relationship between participants' acceptance of the Theory of Evolution and their views of NOS; and the fourth section discusses implications for future research.

It is the goal of the researcher that many science educators, particularly those at the college level, will find the results of this study to be beneficial for their own instruction of the Theory of Evolution and nature of science.

CHAPTER II

REVIEW OF LITERATURE

Chapter II provides a review of the research that is relevant to undergraduates' acceptance of the Theory of Evolution and their views of nature of science (NOS). The first section of this chapter explores the Theory of Evolution. This section includes a detailed definition of the term, a historical look at the role the Theory of Evolution has played in the American school systems, the incorporation of the Theory of Evolution in state standards, the teaching of the Theory of Evolution in Oklahoma, undergraduates' acceptance of the Theory of Evolution, and predictors of the acceptance Theory of Evolution. The second section of this chapter explores nature of science (NOS). This section includes a detailed definition of the term, assessments of NOS, views held about the aspects of NOS, incorporation of NOS in state standards, and undergraduates' views of NOS. The goal of this chapter is to solidify the argument for this study by providing a deeper understanding of the acceptance of the Theory of Evolution and the views of NOS held by undergraduate freshmen.

The Theory of Evolution

The Theory of Evolution is a scientific theory that accounts for the relatedness among organisms (plants, animals, microorganisms, etc.) by explaining the idea of descent from common ancestors through natural selection (NAS, 1998). The Theory of

Evolution helps explain how different species originate through evolutionary mechanisms such as natural selection, mutation, gene flow, and genetic drift (Mayr, 2001). Natural selection, which is a main mechanism of the Theory of Evolution, is a process that explains how an organism's ability to adapt to their environment will give them a better chance at survival, and thus allow a relative increase in reproduction to occur for those organisms. In other words, organisms that are able to adapt to their environment may survive longer, leading to reproductive advantage (Zimmer & Emlen, 2013; Shtulman, 2006).

The science community considers the overall Theory of Evolution to be non-controversial because of the overwhelming amount of supporting scientific evidence (AAAS, 2006; NABT, 2011; NAS, 1998; NSTA, 2013). In fact, the science community considers the Theory of Evolution to be the foundation for understanding biological concepts and the creation of all living organisms because the Theory helps explain the diversity and the similarities that exist among living organisms (AAAS, 2006; NABT, 2011; NAS, 1998; NSTA, 2013).

Despite strong acceptance of the Theory of Evolution among the science and science education communities, the general American public holds a lower acceptance (Miller et al., 2006). According to the Religious Landscape Study (Pew Research Center, 2014), which explored the American public's view of evolution, 34% of Americans reject evolution and say that all living things have existed in their present form since the beginning. While 62% say humans have evolved over time, only 33% of them say that evolution is a natural process that is not guided by a higher power (Pew Research Center, 2014). It has been suggested that this lack of acceptance of the Theory of Evolution is directly related to the Theory contradicting religious beliefs of the supernatural creation of life, such as the story of creation as told in the Bible (Coyne, 2012; Heddy & Nadelson, 2012; Miller et al., 2006). While the Theory of Evolution explains the origin of species through natural processes, religious beliefs attribute the origin of life to the creation of a God or a higher power (Coyne, 2012). These beliefs are often termed creationism (Coyne, 2012).

Definition of Creationism

While the stereotypical definition of creationism refers to those who believe in the six-day creation of life by God, as told in the Bible, there are technically ten groups who classify themselves as creationists (Isaak, 2002). These groups are identified as the flat earthers, geocentrists, young earth creationists, old earth creationists, gap creationists, day-age creationists, progressive creationists, intelligent design creationists, evolutionary creationists, and theistic evolutionists (Isaak, 2002; Scott, 1999; Williams, 2015). The flat earthers, geocentrists, old earth creationists, and day-age creationists view the biblical story of creation literally and believe it to be the truth on how the world was created (Scott, 1999). Though each of these groups may vary in the specifics of their beliefs, they all rely heavily on the literal interpretation of the biblical explanation of how the world was created (Williams, 2015). The progressive creationists, intelligent design creationists, evolutionary creationists, and theistic evolutionists are more inclined to accept the Theory of Evolution because they do not refer to the Bible as a literal representation of creation (Scott, 1999). However, they do believe the world was created from a planned design by a supernatural power (Scott, 1999; Williams, 2015). Taking these different beliefs into consideration, the term creationism can be summarized as any belief that attributes the development of life, and mankind, to the planning of a supernatural being (Isaak, 2002; Scott, 1999).

Theory of Evolution vs. Creationism in Public Schools

Organizations supporting science education, such as the National Association of Biology Teachers (NABT, 2011), the American Association for the Advancement of Science (AAAS, 2006) and the National Science Teachers Association (NSTA, 2013) strongly support the teaching of the Theory of Evolution in school. However, many U.S. citizens continue to reject or question the teaching of the Theory of Evolution in public schools and challenge that creationism should also be taught in the classroom (Moore, 2007; Moore & Cotner, 2009; Moore, Jensen & Hatch, 2003).

In a review of court cases concerning the teaching of the Theory of Evolution in the American public schools, Armenta and Lane (2010) found that for over eighty years, the teaching of the Theory of Evolution has been met with much resistance from the general public. This resistance has resulted in many controversial debates over what science content should be included in the science curriculum. Supporters of both the Theory of Evolution and supporters of creationism have challenged public schools in America with concerns about which topics should be covered in the science classrooms (Armenta & Lane, 2010).

Berkman and Plutzer (2011), Moore and Kramer (2005), Moore (2007), and Moore and Cotner (2009) found those who support the teaching of creationism in public-schools view creationism as a valid alternative to the Theory of Evolution when addressing the origin of species. Supporters of creationism do not agree that the Theory of Evolution is based entirely on scientific evidence and claim that if the Theory of

Evolution is included in the science curriculum, then creationism should also be included (Berkman, Pacheco & Plutzer, 2008; Moore, 2007). On the other hand, supporters of the teaching of the Theory of Evolution argue that religious explanations of natural phenomena, such as the Biblical account of creation, are not supported with any scientific evidence and therefore should not be taught in a science classroom (Berkman et al., 2008; Moore & Cotner, 2009). Supporters of teaching the Theory of Evolution also claim that teaching creationism along with the Theory of Evolution is detrimental to students' understanding of science because students often develop misconceptions that scientific theories are mere speculations that are not based on rigorous scientific evaluations (Moore, 2007).

Disagreement over the teaching of the Theory of Evolution and the teaching of creationism in the American public schools has led to many disputes that have resulted in court rulings in order to be resolved (Armenta & Lane, 2010). The following section of this chapter provides an in-depth background of the most well-known court cases concerning the teaching of the Theory of Evolution and the teaching of creationism in the American public schools.

Influential Court Trials of Evolution vs. Creationism

The Scopes Trial - Tennessee v. Scopes (1925)

The first major controversial court case dealing with the teaching of the Theory of Evolution and the teaching of creationism in American public schools was the *Scopes Trial* (1925) (Armenta & Lane, 2010). In 1925, John Scopes was hired as a substitute teacher to teach Biology at Rhea County High School in Tennessee. Mr. Scopes, a supporter of the Theory of Evolution, used a textbook that included a review of biological evolution (Weiss, 2007). Shortly before Mr. Scopes was hired, Tennessee had passed a law that prevented all state-supported educators from teaching any curriculum that denied the creation of man as it is described in the Bible (Weiss, 2007). This law was known as the Butler Act. When businessmen in the town caught word of the textbook Mr. Scopes was utilizing in his Biology class, Mr. Scopes was accused of violating the Tennessee law and taken to trial (Weiss, 2007). Scopes was eventually convicted of violating the Tennessee law and fined one hundred dollars (Armenta & Lane, 2010). However, it was not the ruling that made the trial famous, but rather the debate that occurred during the trial over the origin of mankind (Armenta & Lane, 2010). Although the immediate effects of the trial resulted in a lack of inclusion of the Theory of Evolution in high school science textbooks until the 1950s, the trial is considered the spark that inspired evolutionists to fight for a change in the anti-evolution laws in America, which has remained a debated topic for decades (Moore, 1998).

Epperson et al. v. Arkansas (1968)

While the *Scopes Trial* took place in Tennessee, it was the *Epperson et al. v. Arkansas* (1968) court case, in the State of Arkansas, that eventually resulted in overturning the ban on teaching the Theory of Evolution in American public schools (Moore, 1998). Leveraging the results of the *Scopes Trial*, Arkansas continued the fight to prohibit the teaching of the Theory of Evolution in Arkansas public schools (Moore, 1998). Anti-evolutionists introduced a bill in 1928 that made it unlawful for any state-supported teacher to teach the idea that mankind descended from a lower order of animals (Armenta & Lane, 2010). The bill passed with 63% of the vote, and for the next forty years, the teaching of human evolution in the Arkansas public schools was considered to be a crime. In 1968, Susan Epperson, a biology teacher in Little Rock, Arkansas, filed a lawsuit with the Arkansas Education Association (AEA) against the state of Arkansas, on the grounds that the law violated the First Amendment (*Epperson et al. v. Arkansas*, 1968). The Supreme Court found the state of Arkansas guilty of violating the Establishment Clause of the First Amendment, which stated that no public entity could support a particular religious view (*Epperson et al. v. Arkansas*, 1968). This was the first court-documented case where the anti-evolution laws were overturned (Armenta & Lane, 2010).

McLean v. Arkansas Board of Education (1982)

In response to the overturning of the anti-evolution law in the *Epperson et al v. Arkansas* (1968) trial, the state of Arkansas continued to re-enforce the teaching of creationism and signed a law that stated if the Theory of Evolution was taught in the science classroom, creationism must also be taught (Moore, 2007). This law was known as the Balanced Treatment Statute (*McLean v. Board of Education*, 1982). The implementation of this law in the Arkansas public schools led to the *McLean v. Arkansas Board of Education* (1982) trial. In the trial, the federal court ruled that introducing creationism into the public-school curriculum was introducing religion, which was a violation of the First Amendment (Morowitz, Hazen & Trefil, 2005). This trial made the teaching of creationism unconstitutional in the state of Arkansas, even if it was accompanied by the teaching of the Theory of Evolution (Moore, 2007).

Edwards v. Aguillard (1987)

The state of Louisiana also encouraged the teaching of creationism in the public-school curriculum (Moore, 2007). In 1981, Louisiana enacted the Balanced Treatment for Creation-Science and Evolution-Science in Public School Instruction Act. Commonly known as the Creation Act, the act stated that the Theory of Evolution could only be taught if accompanied by the teaching of creationism (*Edwards v. Aguillard*, 1987). In 1987, Don Aguillard, a high school science teacher, filed suit claiming the law was in violation of the Establishment Clause of the First Amendment. The Supreme Court ruled that the Creation Act attempted to advance the religious belief that a supernatural being created mankind, thus violating the Establishment Clause of the First Amendment (*Edwards v. Aguillard*, 1987).

Freiler v. Tangipahoa Parish School Board of Education (1999)

In 1999, the Tangipahoa Parish School Board in Louisiana required teachers to read a disclaimer prior to teaching the Theory of Evolution (Moore et al., 2003). The disclaimer explained that teaching the Theory of Evolution was not intended to influence or discourage the biblical version of creationism or any other concept. Furthermore, the disclaimer stated that beliefs on the origin of life were to be left up to the students and their parents. In an effort to prohibit this disclaimer from being used, the American Civil Liberal Union (ACLU) filed a lawsuit in the U.S. District Court against the Tangipahoa Parish School Board. Similar to the rulings against the teaching of creationism in the *Epperson v. Arkansas* (1968), *McLean v. Arkansas Board of Education* (1982), and the *Edwards v. Aguillard* (1987) trials, the U.S. District Court ruled the Louisiana disclaimer to be unconstitutional and in violation of the First Amendment (*Freiler v. Tangipahoa Parish Board of Education*, 1999).

Kitzmiller et al. v. Dover Area School District (2005)

The science community does not accept the creationist view of human creation by a supernatural being because science only seeks to explain the natural world, not the supernatural world (Branch & Scott, 2009). In an attempt to gain scientific acceptance, creationists started a movement known as the Intelligent Design (ID) Movement (Branch & Scott, 2009; Dembski, 1998; Hafer, 2015). ID attributes the creation of humans to the planning of a designer but avoids specifically identifying what/who the designer is (Lee, 2006). However, the science community consistently rejects ID because it relies on supernatural explanations, lack of predictability, and argumentation rather than experimentation (Hafer, 2015). This ID movement led to the court case of *Kitzmiller et al. v. Dover Area School District* (2005).

To encourage the anti-evolution agenda in the public schools, the Dover Area School District in Pennsylvania was the first American public school system to pass a resolution stating that students will not just learn about the Theory of Evolution, but they will also learn about alternative explanations regarding the development of biological species, such as Intelligent Design (Armenta & Lane, 2010; Hafer, 2015). This resolution required teachers in the Dover School District to read a disclaimer that expressed how Darwin's Theory of Evolution by Natural selection was one explanation for the development of humans. The disclaimer also stated that the ID theory was another scientific explanation. In 2004, the American Civil Liberties Union filed suit against the Dover school board on behalf of eleven parents from the Dover school district. The plaintiffs argued that ID is a form of creationism and thus, the Dover school board was in violation of the First Amendment (Lee, 2006). The judge of the *Kitzmiller* *v. Dover Area School District* (2005) case found the school board to be guilty of violating the First Amendment as the disclaimer encouraged students to seek out religious beliefs (*Kitzmiller v. Dover Area School District,* 2005).

Since the Scopes trial in 1925, the teaching of the Theory of Evolution versus the teaching of creationism is still debated in the American public schools today (Armenta & Lane, 2010; Hafer, 2015). When reviewing court rulings over the past 40 years, creationists promoting religion have lost every court case to the teaching of accurate science (Armenta & Lane, 2010; Branch and Scott, 2009; Randy, 2004). However, contrary to the court rulings against teaching creationism, science education research suggests that in many classrooms, the Theory of Evolution is still not being taught (Berkman & Plutzer, 2011; Moore, 2002; Rutledge & Mitchell, 2002). The following sections of this chapter will explore the inclusion of the Theory of Evolution in American science classrooms.

Incorporation of the Theory of Evolution in State Standards

In 1983, the National Commission on Excellence in Education released a review of the American education system titled, *A Nation at Risk: The Imperative Education Reform*. The report indicated the United States was falling behind globally in education, particularly in the area of science. It was this publication that led to the development of educational state standards (Mead & Mates, 2009). The goal of education standards is to help teachers improve the quality of science teaching and student learning in the classroom (Moore, 2002; NRC, 1996). State standards not only provide recommendations for the science content students should know, but they also provide examples of what students should be able to do in order to demonstrate they have achieved full understanding of the concept (Moore, 2002). For example, the Oklahoma Academic Standards for Science (OAS-S; Oklahoma Department of Education, 2014) provides the following for each standard: 1) the science and engineering practices that will be addressed when teaching the standard; 2) the disciplinary core ideas (science content) that needs to be addressed for that standard; and 3) the performance expectations - what students should, "know, understand, and be able to do to be proficient in science" (Oklahoma Department of Education, 2014, p. 7). State standards help science educators determine what to teach, how to teach, and also how to assess student learning.

The development of state standards is left entirely up to each state, resulting in science standards that can vary widely from state to state. National science organizations such as the AAAS and the NRC have developed documents that help states determine subject learning outcomes for grades kindergarten through twelfth (AAAS, 1993; NRC, 1996, 2012). Science education documents, such as *Benchmarks for Science Literacy* (AAAS, 1993), *National Science Education Standards* (*NSES*; NRC, 1996) and the *Next Generation Science Standards* (*NGSS*; *NGSS* Lead States, 2013) provide guidelines to help K-12 science educators know what science concepts should be taught and also provide recommendations on the science practices that could be used to teach these concepts. One topic that both the AAAS and the NRC highlight is the importance of teaching the Theory of Evolution in the classroom. In a 2006 statement concerning the teaching of the Theory of Evolution in the classroom, the AAAS stated:

> But there is no significant controversy within the scientific community about the validity of the Theory of Evolution… The Theory of Evolution, supported by extensive scientific findings ranging from the fossil record to the molecular

genetic relationships among species, is a unifying concept of modern science. Of course, our understanding of how evolution works continues to be refined by new discoveries. (p. 1)

Despite the strong recommendations from national science organizations to teach the Theory of Evolution, many states still do not include the Theory of Evolution in their state standards (Mead & Mates, 2009). In 2000, the Thomas B. Fordham Foundation published *Good Science, Bad Science: Teaching Evolution in the States* (Lerner, 2000). The publication reviewed and evaluated state science standards and gave each state a grade based on the inclusion of the Theory of Evolution. The researchers used a rubric to explore the amount of evolutionary terms included in the standards. Lerner identified that 10 states received an excellent rating for including the Theory of Evolution in their state standards (CA, CT, DE, HI, IN, NJ, NC, PA, RI, SC), 14 states received a good rating (AZ, CO, DC, ID, MA, MI, MN, MO, MT, OR, SD, UT, VT, WA), seven states received a satisfactory rating (LA, MD, NE, NV, NM, NY, TX), and six states received an unsatisfactory rating (AK, AR, IL, KY, VA, WI). Additionally, Lerner identified 12 states as poorly including the Theory of Evolution in their standards (AL, FL, GA, ME, MS, NH, ND, OH, OK, TN, WV, WY), and one state (KS) as not addressing the Theory at all. On average, Lerner (2000) found the United States to hold satisfactory inclusion of the Theory of Evolution in the standards.

Mead and Mates (2009) conducted a similar study to determine if any changes had occurred over a nine-year span. Mead and Mates (2009) concluded that 14 states had improved in their inclusion of the Theory of Evolution in their state standards (AR, DC, FL, GA, IL, KS, ME, MS, NH, NM, ND, OH, TN, and WY), while 10 states showed a decrease (CT, DE, HI, LA, MO, MT, NC, RI, SD, TX, and VA). The remaining states showed no change. The results revealed that since the Lerner (2000) study, several states were still poorly including the Theory of Evolution in the standards.

Theory of Evolution in the *Next Generation Science Standards* (*NGSS*)

In 2009, the Carnegie Corporation of New York released *The Opportunity Equation* report, which called for the need to develop a new set of national science standards (Carnegie Corporation of New York, 2009). To meet this need, Achieve Inc., the NAS, the AAAS, and the NSTA began a two-step process to develop what would be known as the *Next Generation Science Standards* (*NGSS*; *NGSS* Lead States, 2013).

The first step of the process entailed the development of *A Framework for K-12 Science Education* (NRC, 2012), which will be referred to in this chapter as the *Framework*. The *Framework* was guided by many science education documents that identified what all K-12 students should know and be able to do in science. Some examples of these guiding documents included *Science for All Americans* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards (NSES;* NRC, 1996). To build student proficiency in science education, the *Framework* recognizes the importance of integrating the development of science content knowledge with engaging students in the science and engineering practices (NRC, 2012). The *Framework* was released to the public in 2012.

The second part of the two-step process was the development of the national standards document, the *NGSS* (*NGSS* Lead States, 2013). Based on the *Framework*, the *NGSS* document was developed by multiple states' science and policy staffs, higher education faculty members, scientists, engineers, and business leaders (*NGSS* Lead

States, 2013). The *NGSS* can be described by the following characteristics (*NGSS* Lead States, 2013):

- While past traditional science standards kept practices and core content independent from one another, the *NGSS* couple science core content with science and engineering practices. This integration of content and practice allows students to make sense of and apply the material rather than simply memorizing the content and then performing science activities.
- The *NGSS* are written as student performance expectations, which identify what students should know and be able to do in order to show proficiency in science.
- The *NGSS* do not dictate the methods in which the standards should be taught, but through performance expectations, they identify what students should know once instruction is complete.

Each performance expectation has three dimensions (NRC, 2012): Dimension One identifies the science and engineering practices that scientists do to investigate the natural world and also what engineers do to design and build systems; Dimension Two identifies the disciplinary core ideas, or science content; and Dimension Three identifies the crosscutting concepts that help students make connections across the four domains of the *NGSS* (physical science, life science, earth and space science, and engineering, technology, and applications of science). The crosscutting concepts can help students recognize many of the unifying concepts and processes across the domains of science (*NGSS* Lead States, 2013). Each performance expectation also contains connection boxes, which identify other standards that have connecting ideas. These connections between standards are identified within the science standards across all grade levels, and also within the Common Core Mathematic and English standards. The performance expectations of the *NGSS* provide the foundation for educators to enhance student understanding of science content areas, and also encourage improvement of critical thinking and inquiry-based problem solving (*NGSS* Lead States, 2013).

Both the *Framework for K-12 Science Education* and the *NGSS* address the Theory of Evolution as a core area of science (NSTA, 2017). Performance expectations for teaching about the Theory of Evolution at the high school level in the *NGSS* are identified in the following Life Science disciplinary core ideas: HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, and HS-LS4-5 (*NGSS* Lead States, 2013). The *NGSS* performance expectations regarding the Theory of Evolution require the mastery of evidence of common ancestry and diversity, natural selection, and adaptation. Students who show understanding of the Theory of Evolution should be able to: 1) communicate that the Theory of Evolution is supported by empirical evidence; 2) construct an explanation for the evidence supporting the process of evolution; 3) apply statistics and probability to support explanations for genetic variability; 4) construct an explanation for natural selection and adaptation; and 5) evaluate the evidence concerning changes in the environment and natural selection (*NGSS* Lead States, 2013). The *NGSS* also emphasize the Theory of Evolution as a unifying concept because of its importance across science disciplines such as astronomy, biology, geology and anthropology (NSTA, 2013).

Implementation of State Standards in the Classroom Curriculum

Documents such as *Science for All Americans* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), the *NSES* (NRC, 1996), and the *NGSS* (*NGSS* Lead States, 2013) have served to facilitate State Departments of Education in developing their science standards (Mead and Mates, 2009). However, research suggests that even if state standards do address the instruction of the Theory of Evolution, some science educators are still resistant to teaching it (Mead & Mates, 2009; Moore, 2002).

Several studies have explored the teaching of the Theory of Evolution in the classroom: Nehm and Schonfeld (2007) surveyed preservice secondary biology teachers who participated in a 14-week course designed to identify misconceptions about the Theory of Evolution. Nehm and Schonfeld (2007) found that while participants demonstrated an increase in their content knowledge of the Theory of Evolution through the course, the majority of participants still preferred that anti-evolutionary ideas be taught because of their personal beliefs.

Moore (2007) surveyed undergraduate students attending a university in Minnesota to determine if they were taught about the Theory of Evolution in high school. Moore (2007) found that while 54% of students who attended a public high school reported their high school biology teachers taught only about evolution, three percent of the students reported being taught only about creationism, 22% reported being taught about evolution and creationism, while 21% reported being taught neither evolution nor creationism. Moore (2007) concluded that while a majority of biology teachers teach about the Theory of Evolution, the teaching of creationism is still occurring. Similar to this finding, Berkman et al. (2008) explored the teaching of the Theory of Evolution in the classroom and concluded that while a majority of biology teachers teach evolution, 12% to 16% of the nation's biology teachers support the teaching of creationism. Roughly, one in eight biology teachers reported teaching creationism or intelligent design as a valid explanation for the creation of life (Berkman et al., 2008). Although the majority of teachers claimed to view the Theory of Evolution as the central theme to biology, they also admitted to devoting only one or two class periods to this scientific concept.

Moore and Cotner (2009) surveyed undergraduate students enrolled in an introductory biology course at a university in Minnesota to see if they were taught about evolution or creationism. Similar to the findings of Berkman et al. (2008), Moore and Cotner (2009) found that while 64% of high school biology teachers taught about evolution and not creationism, over 25% taught both evolution and creationism. Moore and Kraemer (2005), who also surveyed high school biology teachers, found a majority of the teachers taught about evolution and not creationism; however, 20% of the teachers identified to teaching creationism in addition to evolution.

The studies discussed above indicate that while the Theory of Evolution is being predominately taught in the public schools, creationism is also being taught. There are many factors suggested to influence the teaching of the Theory of Evolution in the classroom. Mead and Mates (2009) and Moore (2002) concluded that creationism is being included in the science curriculum due to teachers' religious beliefs, political beliefs, or the misconceptions they may hold concerning the Theory of Evolution. Asghar, Wiles, and Alters (2007) explored conceptions of the Theory of Evolution held by preservice elementary teachers and concluded that participants who did not intend to include the Theory of Evolution in their future curriculum attributed the resistance to the teacher's own lack of understanding of the Theory of Evolution. Moore and Kraemer (2005) surveyed selected biology teachers in Minnesota and found those who did not teach the Theory of Evolution also held low acceptance for the Theory of Evolution.

Additionally, Moore and Kramer (2005) found that many participants wanted to avoid potential issues that would arise from students, parents, and members of the public if the Theory were taught. Moore and Kraemer (2005) also found that many of the biology teachers who taught creationism were unaware of the legality issues concerning teaching creationism in the classroom. These findings suggest that although the science education community may advocate for the teaching of the Theory of Evolution, teachers' personal views and preferences towards inclusion of the Theory may influence the implementation of the Theory of Evolution in the classroom.

The Teaching of the Theory of Evolution in Oklahoma

This study explored acceptance of the Theory of Evolution held by undergraduate students attending a state university in Oklahoma. Therefore, in order to fully understand the results of the study, it is important to recognize the potential Oklahoma high school science standards that the study participants may have been exposed to prior to entering college. When analyzing the inclusion of the Theory of Evolution in the Oklahoma state science standards, several studies have claimed that Oklahoma holds poor science standards (Lerner, 2000; Lerner, Goodenough, Lynch, Schwartz & Schwartz, 2012; Mead & Mates, 2009). For example, Lerner et al. (2012) conducted an exploratory study on state science standards and found the Oklahoma science standards, which at the time were known as the Priority Academic Student Skills (PASS; OSDE, 2010), to be less than satisfactory. After finding only one reference to natural selection and zero references to the term evolution, Lerner et al. (2012) stated,

> The Oklahoma science standards are simply not OK. Woefully little science content appears, and what is present is often flat out wrong, oddly worded, or not

up to grade level. It is difficult to see how any curriculum that emerged from these standards (assuming that one could accomplish that task on such a basis) would not be fatally flawed. (p. 145)

In 2013, the *NGSS* were developed to better reflect what students should know about science and how students best learn science (*NGSS* Lead States, 2013). However, Oklahoma's legislature met the *NGSS* with much resistance because of the State's anti-evolution political agenda (Moore, Tank, Glancy & Kersten, 2015). Since 2006, twelve anti-evolution bills have been introduced in the Oklahoma legislature (AIBS, 2016). Although 11 out of the 12 have died before reaching the senate, the strong resistance by a small group of individuals, towards the teaching of the Theory of Evolution in the science classroom has led Oklahoma to be known for its anti-evolution movement (AIBS, 2016).

The latest example of the anti-evolution movement in the Oklahoma legislature was a recent bill proposed to the Senate in January of 2017. Oklahoma State Senator Josh Brecheen, who is one of the main proponents of the anti-evolution resistance within the Oklahoma legislature, sponsored an anti-evolution bill, Senate Bill 393 (Branch, 2017a). If passed, it would have encouraged Oklahoma science teachers to address and explore scientific controversies in the classroom such as creationism (Branch, 2017a). Although the Senate passed the bill in March of 2017, the bill failed to receive a vote on the floor of the House of Representatives (Branch, 2017b). The Oklahoma legislature did not consider it again in the next legislative session.

The current Oklahoma Academic Standards for Science (OAS-S), were adopted by the Oklahoma Board of Education in March of 2014 and signed into law in June of 2014 (OSDE, 2014). The development of these standards required input from groups of individuals from across the state (OSDE, 2014). An executive committee, a writing committee, a draft committee, and focus groups were all utilized during the development process. The executive committee was comprised of four individuals who were considered to be highly qualified in the field of science. These individuals were also part of the writing committee. Members of the writing committee were selected through an application process, and included 37 representatives from K-12 education, higher education, and career technology working alongside scientists, engineers, parents, and community members from across the State (OSDE, 2014). The draft committee was also selected through an application process and was comprised of 21 representatives from K-12 education, higher education, and career technology working alongside scientists, engineers, parents, and community members from across the state. In addition to the draft committee, focus groups of over 500 educators and community members reviewed the draft version and provided feedback to the writing committee. Under heavy influence from the anti-evolution legislature, the OAS-S does not include the phrase "Theory of Evolution" or the term "evolution" (OSDE, 2014). However, the OAS-S does address the major concepts associated with the Theory of Evolution, such as social interactions and group behavior, variation of traits, evidence of common ancestry and diversity, natural selection, and adaptation (OSDE, 2014). Although the omission of the Theory of Evolution in state standards does not necessarily prohibit the teaching of the Theory, it may lead to less time and money being spent on the teaching of the Theory of Evolution (Watts, Levit & Hoßfeld, 2016). This is disadvantageous to science education as students are prevented the chance to understand a scientific theory which continues to lead to the understanding of much of the living world (Watts et al., 2016).

Undergraduate Acceptance of the Theory of Evolution

To assess undergraduates' acceptance of the Theory of Evolution, many studies have used the Measurement of the Acceptance of the Theory of Evolution (MATE) instrument (Rutledge & Warden, 1999). While the MATE was originally developed to assess high school teachers' acceptance of the Theory of Evolution, the MATE has also been validated as a reliable instrument to assess acceptance of the Theory of Evolution held by biology teachers (Rutledge & Warden, 1999), undergraduate students (Rutledge & Sadler, 2007), and random sampling of individuals who were attending a science museum (Barone et al., 2014). The MATE is a twenty-item, Likert-scale questionnaire that explores six concepts of evolution: process of evolution, scientific validity of evolutionary theory, evolution of humans, evidence of evolution, scientific community's view of evolution, and age of the earth (Rutledge & Sadler, 2007). Another instrument used to assess undergraduates' acceptance of the Theory of Evolution is the Inventory of Student Evolution Acceptance (ISE-A; Nadelson & Southerland, 2012). The ISE-A is a 24 item, Likert-scale instrument that was designed to address macroevolution, microevolution, and human evolution (Nadelson & Southerland, 2012). The ISE-A has been validated for high school students and undergraduate college students (Nadelson & Southerland, 2012).

The results of the research literature exploring undergraduates' acceptance of the Theory of Evolution are contradictory. Ingram and Nelson (2006) administered a modified MATE instrument to 255 undergraduate students enrolled at a large midwest university and found that 65% accepted the Theory of Evolution. Moore and Cotner (2009) reported similar findings when they administered the MATE instrument to 728 undergraduate students enrolled in an introductory biology course at a university in Minnesota. The study reported 74% of biology majors and 66.5% of non-biology majors accepted the Theory of Evolution (Moore & Cotner, 2009). Gibson and Hoefnagels (2015), who also utilized the MATE instrument with 304 undergraduate students, explored the influence of an evolution-education teaching approach (tree thinking) on undergraduates' acceptance of the Theory of Evolution. Prior to the intervention, Gibson and Hoefnagels (2015) found participants' mean acceptance to be of moderate to high acceptance. After the intervention, participants' acceptance improved to overall high acceptance (Gibson & Hoefnagels, 2015).

Contradictory to the above studies, Rutledge and Sadler (2007) utilized the MATE instrument to survey 61 students enrolled in sections of a non-majors biology course at Middle Tennessee State University and found their sample of undergraduates to hold an overall low acceptance of the Theory of Evolution. Manwaring, Jensen, Gill and Bybee (2015) explored acceptance of the Theory of Evolution held by a Mormon population and administered the MATE to 1,104 undergraduate students attending Brigham Young University. The researchers found a majority of participants to hold moderate acceptance of the Theory of Evolution. Rissler, Duncan and Caruso (2014) also used the MATE to explore acceptance held by 2,999 undergraduate students attending the University of Alabama and found the general population to hold low acceptance. Nadelson and Hardy (2015) utilized the ISE-A instrument and found undergraduate students attending a university in the western United States to hold a moderate acceptance.

While research studies exploring undergraduate students attending a university in Oklahoma could not be identified, Yates and Marek (2013) explored 76 Oklahoma high school biology teachers' conceptions of biological evolution using the Biological Evolution Literacy Survey (BEL; Yates & Marek, 2011). They found an average of 23% of participants held misconceptions of the Theory of Evolution, and the overall group held a 72.9% rate of understanding. Yates and Marek (2013) concluded that if teachers do not hold an informed understanding of the Theory of Evolution, they are less likely to present it in their class.

Such contradiction in the literature suggests there is a need for more research exploring undergraduates' acceptance of the Theory of Evolution. Furthermore, research is needed that explores acceptance of the Theory of Evolution held by undergraduates attending a university in Oklahoma, as research on this topic was not identified.

Variables That Influence Acceptance of the Theory of Evolution

Despite strong support of the Theory of Evolution from the science education community and national science organizations, the Theory of Evolution is still met with much resistance from the general public (Armenta & Lane, 2010; Baker, 2013; Miller et al., 2006; Nadelson & Hardy, 2015; Newport, 2006; Rutledge & Warden, 1999). In a cross-national study of the United States and nine other European countries, Miller et al. (2006) concluded that one in three American adults rejects the Theory of Evolution, "which is a significantly higher proportion than found in any western European country" (p. 765). Many studies have been conducted to explore variables that influence acceptance of the Theory of Evolution (e.g., Barone et al., 2014; Lombrozo et al., 2008; Nadelson & Hardy, 2015). The following section provides a brief review of the variables that have been identified in the research literature to influence acceptance of the Theory of Evolution. The variables discussed include: political views, major, exposure to teaching of creationism, exposure to teaching of the Theory of Evolution, gender, religion, knowledge of the Theory of Evolution, and understanding of nature of science.

Political views. Political views have shown to be a consistent predictor for determining acceptance of the Theory of Evolution. Studies consistently agree that individuals who hold more conservative political views are more likely to reject the Theory of Evolution than those who hold more liberal political views (Baker, 2013; Cotner et al., 2010; Lombrozo et al, 2008; Mazur, 2004; Nadelson & Hardy, 2015). One explanation for this consistent finding is that individuals with conservative views are more likely to attend church regularly than those who hold liberal views, and Americans who attend church regularly are more likely to reject the Theory of Evolution (Baker, 2013; Newport, 2008). Additionally, Nadelson and Hardy (2015) found that undergraduates with conservative political views held lower levels of trust in science and scientists than those with more liberal political views, suggesting skepticism of science and scientists may explain the lower acceptance levels of the Theory of Evolution.

Religion. Along with political views, religious beliefs have also shown to be one of the most consistent predictors when determining acceptance of the Theory of Evolution (Baker, 2013; Barone et al., 2014; Coyne, 2012; Nadelson & Hardy, 2015). Since the Theory of Evolution contradicts the Biblical accounts of human creation, those who hold religious beliefs have shown to hold low acceptance of the Theory of Evolution when compared to those who do not hold religious beliefs (Rissler et al., 2014). Baker (2013) conducted a random, national survey to over 1,600 participants and found religiosity and religious denomination to influence acceptance of the Theory of Evolution. When exploring religiosity, Baker (2013) also found those who frequently attend religious events hold a lower acceptance of the Theory of Evolution than those who do not frequently attend religious events. Miller et al. (2006) found that those individuals who claim to have a strong belief in a personal God, and who pray frequently, are less likely to accept the Theory of Evolution when compared to individuals who are less involved in prayer. Lombrozo et al. (2007) and Nadelson and Hardy (2015) both explored acceptance of the Theory of Evolution held by undergraduate students and also found religiosity to be significantly and negatively correlated with acceptance of the Theory of Evolution. Heddy and Nadelson (2012) explored acceptance of the Theory of Evolution at a global level, and also explored acceptance of the Theory of Evolution in America (Heddy & Nadelson, 2013). Both studies found religiosity to have a significant negative correlation with acceptance. In terms of religious denomination, Baker (2013) found Catholics, Jews, mainline Protestants, and those who are not religious to be more likely to accept the Theory of Evolution than evangelicals (Baker, 2013). When comparing acceptance of the Theory of Evolution among different church denominations, Barone et al. (2014) found the lowest acceptance held by those who identified as non-denominational, and the highest acceptance held by those who identified as Catholic. It should be noted that those who claimed to have no religious affiliation scored the highest acceptance (Barone et al., 2014). In summary, the research literature consistently identifies religion as a predictor for acceptance of the Theory of Evolution.

Major. When exploring the influence of declared college major on the acceptance of the Theory of Evolution, Moore and Cotner (2009) and Peker et al. (2010)

identified that biology majors have a higher acceptance level compared to non-biology majors. Rissler et al. (2014) found science majors in general have higher acceptance levels than non-science majors. Contradictory to these results, Nadelson and Hardy (2015) explored differences in acceptance of the Theory of Evolution held by undergraduates who were enrolled in an introductory psychology course and found no significant differences among the participants' different majors, including science majors.

Exposure to the teaching of evolution and creationism. The controversy between the teachings of the Theory of Evolution and creationism has been an issue for American public schools since the early 1900s (Armenta & Lane, 2010). However, when exploring the influence of such teachings on acceptance of the Theory of Evolution, the results are conflicting. Moore and Cotner (2009) sampled freshmen undergraduate students enrolled in an introductory biology course and found that students who were taught both creationism and the Theory of Evolution in high school science courses were less likely to accept the Theory of Evolution than those who were taught only about the Theory of Evolution. Rissler et al. (2014) surveyed undergraduate students at the University of Alabama and also found that students who were taught both creationism and the Theory of Evolution in high school science courses were less likely to accept the Theory of Evolution than those who were taught only about the Theory of Evolution. However, Verhey (2005) surveyed undergraduate students enrolled in an introductory biology course and found no significant differences in acceptance of the Theory of Evolution among students who were taught only about the Theory of Evolution, taught only about creationism, or taught both creationism and the Theory of Evolution.

Gender. Results are limited and inconsistent when comparing males' acceptance of the Theory of Evolution to females' acceptance. Peker et al. (2010) surveyed undergraduates at a university in Turkey and found a significant difference in acceptance of the Theory of Evolution between genders, with females holding higher acceptance than males. In contrast, Barone et al. (2014) surveyed participants at a museum and found no significant difference in acceptance of the Theory of Evolution between genders. Nadelson and Hardy (2015) surveyed undergraduate students and also found no significant difference in acceptance of the Theory of Evolution between genders.

Knowledge of evolution content. When exploring acceptance of the Theory of Evolution, the influence of one's knowledge of the Theory of Evolution is a variable that has been often explored. Using instruments to assess knowledge of the Theory of Evolution, such as the Knowledge of Evolution Exam (KEE; Cotner et al., 2010) and the Measure of Understanding of Macroevolution (MUM; Nadelson & Southerland, 2010), several studies have suggested a positive relationship between knowledge and acceptance of the Theory of Evolution. Brown and Scott (2016), Cotner et al. (2010), Nadelson and Southerland (2010), and Shtulman and Calabi (2008) all explored acceptance of the Theory of Evolution held by undergraduate students and concluded that as students' knowledge of the Theory of Evolution increases, their acceptance of the Theory increases as well. Supportive of these studies, Barone et al. (2014) also found this relationship to exist when exploring museum participants, rather than undergraduates. Barone et al. (2014) found participants' knowledge of evolutionary terms to be the most significant predictor variable for identifying their acceptance of the Theory of Evolution. Contrary to these studies, Sinatra et al. (2003) explored undergraduates' acceptance of the Theory of Evolution and found no significant relationship between content knowledge and acceptance. Similarly, Brem, Ranney and Schindel (2003) and Nadelson and Hardy (2015) explored acceptance of the Theory of Evolution held by undergraduate students and found that improving student understanding of the Theory of Evolution is not sufficient enough to influence his/her acceptance of the Theory.

Nature of science. Another variable that has shown to influence acceptance of the Theory of Evolution is the understanding of nature of science (NOS; Lombrozo et al., 2008). This relationship has been shown to exist among secondary science teachers (Nehm & Schonfeld, 2007), preservice teachers (Allmon, 2011), high school students (Cavallo & McCall, 2008), and undergraduate college students (Carter & Wiles, 2014; Lombrozo et al., 2008). However, a gap exists in the research that specifically targets undergraduate students in their freshmen year of college, especially those freshmen attending universities in Oklahoma. This gap in the literature was the inspiration behind the purpose of this study. Before discussing the relationship between undergraduate freshmen's acceptance of the Theory of Evolution and views they hold about NOS, it is important to first articulate a clear understanding of the term "nature of science" (NOS), and the importance it holds in science education. The next section of this chapter expands on: 1) what is NOS; 2) the importance of NOS in science education; 3) a historical look at the views of NOS held by students and educators; and 4) the inclusion of NOS in state standards, specifically in Oklahoma.

Nature of Science (NOS)

What is Nature of Science?

Nature of science (NOS) is a concept that is not easy to understand, and there is not one universal definition for the term (Abd-El-Khalick & Lederman, 2000). NOS typically refers to the "epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, 1992, p. 331). However, to provide a better understanding of NOS for K-12 educators, specific aspects of NOS are referenced (Lederman et al., 2002). These aspects have been identified in science reform documents such as *Science for All Americans* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996). While the specific aspects of NOS addressed may vary in the research literature depending on the focus of the research study, the following bullets identify the aspects that are typically referred to when addressing NOS in K-12 education (Angle, unpublished; Lederman et al., 2002):

- **Empirical Nature of Science:** Science is a way of knowing about natural phenomena that is partially based on data (both quantitative and qualitative) collection from direct observations of events or evidence of their occurrence. Empirical evidence does not prove, but rather supports or refutes scientific claims.
- **Tentative Nature of Science**: Scientific knowledge, such as theories and laws, is reliable, durable, and well established, but it is not the absolute truth. Scientific understanding can change in light of new evidence, ideas, advances in technology, or the re-interpretation of existing evidence.

- **Inferential Nature of Science**: Science is not just based on observations alone, but also on inferences derived from observations. Observations are descriptive statements about natural phenomena, which are derived from using the human senses or extensions of the senses. Inferences, on the other hand, are statements about natural phenomena that are made from man's interpretation of these observations (science is a human endeavor).
- **Nature of Scientific Theories**: Scientific theories are well-confirmed, supported, established, and durable sets of general statements that can successfully explain and predict natural phenomena. Scientific theories will not eventually become a law, and some theories are used to explain laws. Also, due to the tentative nature of science, a scientific theory can change in light of new evidence.
- **Nature of Scientific Laws**: Scientific laws are statements or descriptions of quantitative patterns or relationships and are developed to understand observable natural phenomena. A law is not formed from a scientific theory. Also, due to the tentative nature of science, a scientific law can change in light of new evidence.
- **Creative and Imaginative Nature of Science**: Human creativity and imagination play a major role in science and are involved in all aspects of science. There is more to science than structure, controls, and rational activity. Scientists utilize creativity when developing experiments or exploring explanations.
- **Theory-Laden Nature of Science**: Science is not strictly objective in nature. Because science is a human endeavor, it is also subjective in nature. Objectivity may be explained using physical evidence (e.g., existence of dinosaurs through

fossils, radiometric dating, or geologic layers). Subjectivity may be the result of biases generated from differences in scientists' theoretical or disciplinary training, cultural background, preconceived ideas, and personal experiences. Such biases influence how data are perceived and utilized to draw conclusions. To reduce biases caused by subjectivity, the peer review process is utilized.

- **Social and Cultural Embeddedness of Science**: Science is universal (e.g., the metric system or the periodic table), yet culture and society play a major role in how science is conducted and what type of science is conducted. Science is affected by many elements of the culture in which it is embedded. Such factors include, but are not limited to, politics, socioeconomic factors, philosophy, and religion. For example, if there is an area of science that is not favored due to cultural beliefs, funding for research in that area may be limited, which could result in lack of research and restricted advancements in that area.
- **Role of Scientific Models**: A scientific model is an interpretation of natural phenomena that allows for predictions about similar situations/phenomena. Scientific models may be conceptual, graphical, mathematical, operational, theoretical, etc. When used to develop scientific theories and laws, scientific models can change as new evidence becomes present or knowledge is re-interpreted.
- **Differences and Relationships Between Theories and Laws**: Scientific laws are statements that describe natural phenomena. Scientific theories are well-confirmed and established sets of general statements, which can successfully explain and predict relevant natural phenomena. While both theories and laws can

change in light of new evidence, theories do not eventually become laws, because theories and laws are different components of ways to perceive scientific knowledge. Further, theories may be used to explain laws.

Science Literacy and NOS

Since 1985, achieving science literacy has been part of K-12 science education (AAAS, 1990). Science literacy refers to "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic cultural affairs, and economic productivity" (NRC, 1996, p. 22). Science literacy consists of: a) the knowledge of important scientific facts, concepts, and theories; b) content knowledge, understanding and conducting of scientific inquiry; and c) an understanding of NOS, along with its impact and role in society (AAAS, 1990). Helping students develop adequate understandings of NOS has been an ongoing objective for science education, primarily due to its influence when achieving science literacy (AAAS, 1990, 1993; Lederman, Lederman, & Antink, 2013). While NOS is embedded within the content knowledge and inquiry process of science, understanding NOS as a separate entity is important because it explains how science knowledge is generated (AAAS, 1990). Through a clear understanding of the aspects of NOS, an individual is able to better understand how science knowledge is generated, and also better understand why scientific knowledge is deemed as reliable (AAAS, 1990).

NOS Assessments

Although nature of science (NOS) has been advocated as an important objective of science education for over 100 years (Central Association of Science and Mathematics Teachers, 1907), instruments used to assess NOS understandings were not developed until the 1950s (Lederman, 2007). Examples of the early instruments used to measure NOS understandings include: The Science Attitude Questionnaire (Wilson, 1954), the Facts About Science Test (Stice, 1958), and the Science Attitude Scale (Allen, 1959). While these instruments claimed to assess understandings of NOS, the validity of the instruments were challenged on the basis that most of the items on the instrument actually focused on the learners' understanding of science processes or attitudes towards science rather than the epistemology of science (Lederman, 2007).

In the 1960s, researchers began to develop instruments to assess specific aspects of NOS (Lederman, 2007). To easily score large numbers of learners, these newly developed instruments consisted of Likert-scale, multiple-choice, and forced answer (agree/disagree) formats (Lederman et al., 1998). The Likert instruments included the Conceptions of Scientific Theories Test (COST; Cotham & Smith, 1981) – a 40 item instrument developed to assess teachers' understandings of NOS; the Views of Science Test (VOST; Hillis, 1975) – a 40 item instrument developed to assess secondary students' understandings of NOS; and the Nature of Scientific Knowledge Scale (NSKS; Rubba, 1976) – a 48 item instrument developed to assess secondary students' understandings of NOS. The multiple-choice assessments included the Test on Understanding Science (TOUS; Cooley & Klopfer, 1961) - a 60 item instrument developed to assess high school students' understandings of NOS, and the Nature of Science Test (NOST; Billeh & Hansen, 1975) - a 60 item instrument developed to assess teachers' understandings of NOS. The forced-choice instruments include the Science Process Inventory (SPI; Welch, 1967) - a 135 item (agree/disagree) instrument developed to assess student understandings of NOS; the Wisconsin Inventory of Science Processes (WISP; Scientific

Literacy Research center, 1967) – a 93 item (accurate/inaccurate/not understood) instrument developed to assess high school students' understandings of NOS; and the Nature of Science Scale (NOSS; Kimball, 1968) – a 29 item (agree/disagree/neutral) developed to assess scientists' and science teachers' understandings of NOS.

While these instruments are considered to be valid and reliable measures of understandings of NOS (Lederman, Wade, & Bell; 1998), they have been critiqued and challenged for the following issues: first, developers of the standardized instruments assume that participants will interpret the instruments in the same manner as the developers (Lederman, 2007; Lederman et al., 2002); second, standardized instruments reflect the hidden biases and views of the developers (Lederman, 2007; Lederman et al., 2002); and third, while these standardized assessments provide insight into a learner's understandings of NOS, the information gained from the assessments is limited due to the small number of select responses participants are able to choose from (Lederman, 2007; Lederman et al., 1998; Liang et al., 2006). It has been suggested that these issues could potentially lead to misinformed and inaccurate results (Lederman, 2007).

A common criticism of the standardized NOS format was that the instruments only measured a small range of students' knowledge about NOS by requiring the learner to choose from forced choice answers (Lederman, 2007). In response to this criticism, Aikenhead and Ryan (1992) developed the Views on Science-Technology-Society (VOSTS), a 114 multiple-choice item instrument. The instrument was different from the earlier NOS instruments because it provided forced-choice answers that were much more broad, as they were developed based on the analysis of 50-80 paragraphs written by Canadian students in grades 11 and 12. Each paragraph responded to two statements representing opposing sides of a NOS issue (Aikenhead & Ryan, 1992). These authors then used the responses to develop the items for the VOSTS instrument. By providing a broader range of options to choose from, this new type of format helped alleviate the concern of inaccurate results that were found with the earlier, forced-choice NOS assessments (Lederman et al., 1998). However, critics still question the validity of this standardized format, claiming that even with the broader options, some participants may have views that cannot be represented (Lederman, 2007; Lederman et al., 2002; Liang et al., 2006).

To further address the issues that were identified with using standardized / quantitative NOS assessments, a group of researchers developed open-ended NOS assessments. These qualitative instruments allowed participants to provide descriptive responses using their own wording (Lederman et al., 2002). These series of instruments, known as the Views of Nature of Science (VNOS) questionnaires, consist of 6 different forms: VNOS-A (Lederman & O'Malley, 1990), VNOS-B (Abd-El-Khalick et al., 1998), VNOS-C (Abd-El-Khalick, 1998), VNOS-D (Lederman & Khishfe, 2002), VNOS-D+ (Lederman et al., 2002), and the VNOS-E (Lederman, 2007). The VNOS questionnaires vary in length and in the level of terminology used in the writing prompts. The terminology used is very purposeful as each questionnaire was written for a specific audience. All VNOS questionnaires intend to be accompanied by follow-up interviews from sample participants. Lederman and O'Malley (1990) started the personal follow-up interviews as a mechanism for allowing participants the opportunity to clarify any misunderstandings, which may not have been identified through the written assessment (Lederman & O'Malley, 1990). Concerns regarding how to interpret, and then score any open-ended response further supports the need for open-ended interviews (Lederman et al., 2002; Lederman & O'Malley, 1990).

Abd-El-Khalick et al. (1998) revised some of the VNOS-A questions in order to develop an instrument that would better assess the understandings of NOS held by preservice secondary science teachers. Known as the VNOS-B, this questionnaire is also to be used in congruence with follow-up interviews. However, with this instrument, researchers found their interpretations of participants' views, and the actual views expressed in the interviews, were consistent. The researchers concluded that when using this instrument, interviewing 15-20% of participants is enough to determine an overall understanding of the preservice secondary science teachers' knowledge of NOS (Abd-El-Khalick et al., 1998).

The VNOS-C questionnaire was developed by Abd-El-Khalick (1998) through modifications and expansion of the VNOS-B questionnaire. Using a panel of experts, individual questions on the VNOS-B instrument were once again modified, which resulted in the development of the VNOS-C questionnaire. The VNOS-C instrument has been used to assess views of NOS held by college undergraduates and graduates, and preservice secondary science teachers (Abd-El-Khalick, 1998). The main difference between the VNOS-B and the VNOS-C is that the VNOS-C explores two additional NOS aspects: social and cultural embeddedness, and the existence of a universal scientific method (Lederman et al., 2002).

Three other versions of the VNOS have also been developed. These three versions include the VNOS-D, the VNOS-D+, and the VNOS-E. The VNOS-D and D+ were developed using focus groups made up of teachers and their students (Lederman, 2007). The VNOS-E was developed to assess views of NOS held by younger students in grades K-3 (Lederman, 2007).

While the VNOS instruments have been claimed as the most widely used NOS assessment tools today, the open-ended, interview method does not come without concerns (Liang et al., 2002). The VNOS questionnaires have shown to be valid and reliable when exploring understandings of NOS, however, the VNOS-B and VNOS-C are lengthy, and they can take over an hour to complete (Lederman, 2007). Additionally, the open-ended responses can be challenging for students who do not have experience in expressing their understandings through an open-ended format of testing (Liang et al., 2006). Another critique is that the time required to conduct follow-up interviews is impractical when seeking to assess the NOS understandings of a large sample size (Liang et al., 2006).

To address the concerns of the VNOS questionnaire, and with the goal of providing a valid and reliable instrument that could assess views of NOS of large sample sizes, Liang et al. (2006) developed the Student Understandings of Science and Scientific Inquiry (SUSSI). This instrument is primarily a quantitative assessment with a qualitative component using a combination of Likert-scale and constructed response questions (Liang et al., 2006). The SUSSI is categorized into six themes derived from NOS aspects identified through the NOS literature (AAAS, 1990, 1993; Lederman et al., 2002; NRC, 1996). The six themes included in the SUSSI are: 1) observations and inferences, 2) the tentative nature of scientific theories, 3) scientific laws and theories, 4) social and cultural influence on science, 5) imagination and creativity in scientific investigations, and 6) methodology in science investigations (Liang et al., 2006). The

SUSSI questionnaire includes four Likert-scale questions and one open-ended question for each of the six themes. This quantitative/qualitative format provides opportunity for the researcher to identify misconceptions held by the participants that could have been missed by simply analyzing the Likert-scale responses (Liang et al., 2006). In addition, to aid in the reliability of the SUSSI instrument, the developers provide a scoring rubric to help eliminate discrepancies that could occur if more than one researcher scores the data.

Views of NOS

Over the past 50 years, research in science education has consistently identified four findings relevant to K-12 education: 1) K-12 and undergraduate students hold naïve views about NOS (Abd-El-Khalick, 2006; Abd-El-Khalick & Lederman, 2000; Akerson & Hanuscin, 2007; Dogan & Abd-El-Khalick, 2008; Ibrahim, Buffler, & Lubbin, 2009; Khishfe, 2008; Liang et al., 2008; Miller et al., 2009; Urhahne et al., 2011); 2) preservice teachers hold naïve views about NOS (Abd-El-Khalick, 2005; Abd-El-Khalick & Akerson, 2009; Akerson, Morrison & McDuffie, 2006; Hanuscin, Akerson, & Phillipson-Mower, 2006; Irez, 2006); 3) science educators hold naïve views about NOS (Dogan & Abd-El-Khalick, 2008; Irez, 2006; Liu & Lederman, 2007; Southerland, Johnston, & Sowell, 2006); and 4) developing informed views of NOS is difficult for students, pre-service teachers, and science educators (Abd-El-Khalick et al., 1998; Abd-El-Khalick & Akerson, 2004; Bell, Blair, Crawford, & Lederman, 2003; Lederman, 1999). Since NOS has been identified as an important goal of science education, researchers have explored why naïve views are often prevalent (Lederman, 2007).

When exploring why students, preservice teachers, and science educators often hold naïve views of NOS, there is a large body of research that suggests naïve understandings of NOS are generally attributed to misconceptions about the aspects of NOS (e.g., tentative nature of science, scientific theories and law, the empirical nature of science) (Bell et al., 2002; Lederman, 1992). The following are examples of misconceptions commonly identified in the research literature:

- **Empirical NOS:** observations, evidence, or facts are used to prove that science is either right or wrong (Abd-El-Khalick & Akerson, 2004; Liu & Lederman, 2007);
- **Tentativeness NOS**: science is absolute and does not change (Bell et al., 2002; Dogan & Abd-El-Khalick, 2008; Irez, 2006);
- **Inferential NOS:** evidence about science can only be collected if it is seen and observed through the physical senses; scientific evidence cannot be inferred (Abd-El-Khalick & Akerson, 2009; Dogan & Abd-El-Khalick, 2008);
- **Relationship between scientific theories and scientific laws**: scientific theories will become a law when they are proven to be true with enough evidence (Liu & Lederman, 2007; Nehm & Schonfeld, 2007; Parker, Krockover, Eichinger, & Lasher-Trapp, 2008; Southerland et al., 2006);
- **Creative and Imaginative NOS**: there is little creativity and imagination in science, and there is an orderly, step-wise procedure that all scientists follow, commonly known as "The Scientific Method" (Abd-El-Khalick & Akerson, 2009; Akerson & Hanuscin, 2007; Dogan & Abd-El-Khalick, 2008; Hanuscin et al., 2006; Ibrahim et al., 2009; Irez, 2006; Southerland et al., 2006);

- **Theory-laden NOS**: science is strictly objective with no subjectivity involved (Lin & Chiu, 2004; Liu & Lederman, 2007); and
- **Social and Cultural Embeddedness in NOS**: a scientist's cultural background plays little role in the interpretation of data (Akerson et al., 2006; Liu & Lederman, 2007).

It is important to note that the misconceptions discussed above are not only held by students, but also by science educators (Abd-El-Khalick & Akerson, 2004). These widespread naïve conceptions are concerning to the science community as science educators cannot adequately teach about NOS when they themselves have limited knowledge about NOS (Abd-El-Khalick & Lederman, 2000; Akerson et al., 2006). Liu and Tsai (2008) identified that undergraduate students who were science education majors held more misconceptions regarding NOS than when compared to science majors or non-science majors. Their findings led the researchers to suggest that science educators could be transmitting misconceptions to science education students.

NOS in State Standards

Prior to the 1990s, inclusion of NOS in state standards was inconsistent as some states included aspects of NOS and other states briefly mentioned NOS (McComas, Lee, & Sweent, 2009). With the release of the *Benchmarks for Science Literacy* (AAAS, 1993) and the *National Science Education Standards* (NRC, 1996), which included general NOS recommendations, inclusion of NOS in state standards improved slightly (McComas & Nouri, 2016). Further, the release of *Next Generation Science Standards (NGSS* Lead States, 2013) also included recommendations for NOS (*NGSS* Lead States, 2013). The *NGSS* document is developed through performance expectations that each include three dimensions: content, crosscutting concepts, and science and engineering practices. While not identified as one of the three dimensions, inclusion of NOS is identified for some of the performance expectations. Further, in Appendix H, the *NGSS* document provides a research-supported rationale and a NOS matrix that explicitly addresses specific NOS content for K-12 curriculum. McComas and Nouri (2016) advocate for the inclusion of NOS in the *NGSS* and challenge that the inclusion should be even greater, with NOS being included as its own dimension. The focus and support of NOS in the *NGSS* document is beneficial for inclusion of NOS in state standards as the *NGSS* document can be used to help develop state curriculum and assessments (McComas & Nouri, 2016). As of November 2017, 19 states and the District of Columbia have adopted the *NGSS* (NSTA, 2017). Oklahoma is one of the states that have not adopted the *NGSS*. When reviewing Oklahoma's current state science standards, the Oklahoma Academic Standards for Science (OSDE, 2014), some of the NOS aspects were included and discussed (e.g., models and empirical evidence), but explicit references to NOS was not identified. Furthermore, literature exploring the teaching and/or learning of NOS in Oklahoma was not identified.

Undergraduate Views of NOS

As university faculty are challenged with the need to enhance student achievement of science literacy in order to better prepare students for the United States work force, there has been an increase in research exploring NOS in undergraduate education (Miller, Montplaisir, Offerdahl, Cheng, & Ketterling, 2010). Abd-El-Khalick and Lederman (2000) found that prior to a History of Science course, a majority of participants held naïve views about several aspects of NOS such as the tentativeness of science, role of inferences in science, and relationship between theories and laws. Similar to Abd-El-Khalick and Lederman (2000), Abd-El-Khalick (2005) and Miller et al. (2010) found that college students, regardless of their major, also held naïve views of NOS on some aspects of NOS. In all three studies, the most common misconception held by participants was the understanding that a scientific theory will eventually become a scientific law (Abd-El-Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Miller et al., 2010).

Liu and Tsai (2008) surveyed 220 freshmen undergraduate students and found similar results to the above studies. The researchers compared the views that science majors (pure science and science education) and non-science majors held about NOS. Liu and Tsai (2008) found that science majors held more naïve views concerning the theory-laden and the social and cultural influences of NOS than non-science majors. Additionally, Liu and Tsai (2008) found that science education majors held the most naïve views of NOS and suggest this finding is due to science education majors being subjected to an environment in which scientific knowledge is described as objective and universal. On the contrary, Karakas (2008) explored 52 undergraduate students enrolled in a biology course and found no differences in views of NOS among the science majors, non-science majors, and undecided group of undergraduate students.

Research suggests that a majority of undergraduates hold the same naïve views of NOS that are held by most K-12 students and science educators (Abd-El-Khalick & Lederman, 2000; Abd-El-Khalick, 2005; Liu & Tsai, 2008; Miller et al., 2010). Additionally, the misconceptions of NOS found to exist among undergraduate students are consistent with the misconceptions that have been found among K-12 students (e.g., Akerson & Hanuscin, 2007; Dogan & Abd-El-Khalick, 2008) and science educators (e.g., Dogan & Abd-El-Khalick, 2008; Irez, 2006; Liu & Lederman, 2007). When exploring views of NOS held by undergraduates in Oklahoma, research literature could not be identified. The gap in the research literature invites researchers to explore NOS understandings held by undergraduate students, specifically those attending universities in Oklahoma.

Conclusion

There are five main points that can be established from the research literature regarding the acceptance of the Theory of Evolution and views of NOS: 1) acceptance of the Theory of Evolution is important for advancement in the STEM workforce (Heddy & Nadelson, 2012; Gould, 2002; Nadelson & Southerland, 2010); 2) acceptance of the Theory of Evolution in America is met with much resistance largely due to religious views and misconceptions held by the general public (Armenta & Lane, 2010; Barone et al., 2014; Nadelson & Hardy, 2015; Rutledge & Warden, 1999); 3) improving views of NOS has been suggested to positively influence acceptance of the Theory of Evolution (Allmon, 2011; Scharmann & Harris, 1992; Lombrozo et al., 2008; Verhey, 2005); 4) naïve views of NOS are held by K-12 and undergraduate students (Akerson & Hanuscin, 2007; Dogan et al., 2008; Ibrahim et al., 2009; Khishfe, 2008; Liang et al., 2008; Miller et al., 2009; Urhahne et al., 2011), preservice teachers (Abd-El-Khalick & Akerson, 2009; Akerson et al., 2006; Hanuscin et al., 2006; Irez, 2006), and science educators (Dogan & Abd-El-Khalick, 2008; Irez, 2006; Liu & Lederman, 2007; Southerland et al., 2006); and 5) research is limited when exploring undergraduates' acceptance of the

Theory of Evolution and views of NOS (Lombrozo et al., 2008), especially in the state of Oklahoma.

Theoretical Framework

The Theory of Conceptual Ecology is often used as a theoretical framework when exploring acceptance of the Theory of Evolution (Anthanasiou and Papadopoulou, 2012; Demastes-Southerland, Good, & Peebles, 1995; Deniz, Donnelly, & Yilmaz, 2008; Großschedl, Konnemann, & Basel, 2014). Developed in 1982 by Posner, Strike, Hewson, and Gertzog, the Theory of Conceptual Ecology addresses the holistic process an individual undergoes when transitioning from a naïve understanding of a concept to an informed understanding (Diessa, 2002). Further, the Theory of Conceptual Ecology explores variables that influence learners' understanding of a concept (Athanasiou & Papadopoulou, 2012; Diessa, 2002). Cobern (1996) suggested exploring the following variables when focusing on a conceptual change: epistemological and cognitive factors, worldview, religion, gender, ethnicity, and science views. By exploring variables that influence a particular conceptual understanding, researchers are also able to identify factors that could influence the conceptual change (Cobern, 1996).

Since the Theory of Conceptual Ecology is a constructivist framework that explores how variables influence the learning of a concept, the Theory of Conceptual Ecology has been applied to exploring the acceptance of the Theory of Evolution (Anthanasiou and Papadopoulou, 2012; Demastes-Southerland et al., 1995; Deniz et al., 2008; Großschedl et al., 2014). The Theory of Conceptual Ecology not only allows the individual's acceptance of the Theory of Evolution to be identified, but it also allows researchers to explore variables that influence the acceptance of the Theory of Evolution

(Deniz, et al., 2008; Großschedl et al., 2014). Demastes-Southerland et al. (1995) proposed five essential components that should be considered when exploring acceptance of the Theory of Evolution through the Theory of Conceptual Ecology: 1) prior conceptions related to the understanding of the Theory of Evolution; 2) scientific orientation (degree to which the learner organizes his/her life around scientific activities); 3) view of the nature of science; 4) view of the biological world in fundamental terms rather than aesthetic terms; and 5) religious orientation. Through this holistic approach, researchers are able to identify the acceptance of the Theory of Evolution, and also understand how certain demographic variables influences that acceptance (Deniz et al., 2008; Großschedl et al., 2014).

This study was developed through the lens of the Theory of Conceptual Ecology to explore variables that influence acceptance of the Theory of Evolution. The suggestions of Cobern (1996) and Demastes-Southerland et al. (1995) regarding specific variables to explore were taken into consideration. This study explored the influence of undergraduates' demographic variables (e.g., gender, religion, political views), as well as their views of nature of science, on their acceptance of the Theory of Evolution.

Summary

This chapter provided an in-depth review of the literature concerning acceptance of the Theory of Evolution and views of NOS. The purpose of this chapter was to enhance the significance of this study by providing the pertinent background information of the topics explored. Also, this chapter described the theoretical framework that was used as the driving force behind the purpose of the study.

CHAPTER III

METHODOLOGY

Chapter III discusses the methodology used for this descriptive, survey-based research study. The purpose of this study was to explore the acceptance of the Theory of Evolution and views of Nature of Science (NOS) held by undergraduate freshmen students attending a university in Oklahoma. This chapter identifies the six research questions explored, describes the surveys used to collect data, and addresses the survey distribution.

Research Questions

Research Question #1: *What is the current level of acceptance of the Theory of Evolution held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #2: *Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?*

Research Question #3: *What are the current views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #4: *Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?*

Research Question #5: *Does a relationship exist between acceptance of the Theory of Evolution and views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #6: *If a relationship is found to exist, how do specific demographic variables moderate the relationship between participants' acceptance of the Theory of Evolution and their views of NOS?*

Population and Sample

The sample population for this study included students who had just graduated high school and were entering their freshmen year of college at a research university in Oklahoma. Upon IRB approval, the participating University's Institutional Research and Information Management (IRIM) provided the e-mails for all undergraduate freshmen enrolled at the University for the fall 2016 semester. The IRIM database was utilized, which allowed for a mass email to be sent to the 3,972 incoming freshmen enrolled for the fall 2016 semester. All 3,972 students were sent a recruitment email (see Appendix A) that included a brief description of what the study entailed and the importance of the study. Additionally, to further encourage a large sample size, the email informed participants that upon completion of the survey there would be an opportunity to enter a drawing for a $100 Amazon e-gift card. To conclude the email, a link to the online Qualtrics survey was provided.

Survey Dissemination

The online survey was created through the use of Qualtrics, an online survey development program. The survey included three sections. The first section included a consent form (see Appendix B), which acknowledged participants' rights and provided assurance that privacy and information would be protected. Each participant was required to electronically sign the consent form before being admitted into the second section of the survey. This ensured each participant was over the age of 17 (per IRB regulations), and it also confirmed that each participant had freely and voluntarily given permission to participate in the study.

The second section of the survey explored participants' demographics. The following thirteen items were included in the demographic section: 1) school classification (freshman, sophomore, junior, senior); 2) STEM (science, technology, engineering, or math) major (yes or no); 3) gender (male, female, transgender, or prefer not to respond); 4) high school community (rural, urban, suburban); 5) religious beliefs (conservative, middle-of-the-road, liberal/progressive, I am not religious); 6) religiosity (very important, somewhat important, not too important, not important at all, I do not hold religious beliefs); 7) political views (conservative, middle-of-the-road, liberal); 8) 2016 presidential candidate choice (Gary Johnson, Hillary Clinton, Donald Trump, Jill Stein); 9) participant's explanation of their answer to question 8 (open response); 10) number of science courses taken in high school (0, 1-2, 3-4, 5-6, 7+); 11) exposure to the teaching of the Theory of Evolution in high school (Yes or No); 12) exposure to the teaching of creationism in high school (Yes or No); and 13) tuition status (instate, out-of-state, international).

The third section of the survey assessed the participants' acceptance of the Theory of Evolution and their views of NOS through the use of two previously validated instruments. The *Measurement of the Acceptance of The Theory of Evolution* (MATE) (Rutledge & Warden, 1999) (see Appendix C) was used to assess participants' acceptance of the Theory of Evolution. The *Student Understanding of Science and Scientific Inquiry* (SUSSI) (Liang et al., 2006) (see Appendix D) was used to assess participants' views of Nature of Science. A more detailed description of both instruments will be included in the instrumentation section of this chapter.

When determining how to administer the items on the survey, participant survey fatigue was accounted for. Participant survey fatigue is an effect that has previously shown to cause error in results as participants may perform better on whichever section is administered first (Hillmer, 2016). For example, if the SUSSI items had been administered first, followed by the MATE items, potential error due to fatigue could occur as the participant's fatigue may have led them to perform differently when completing the SUSSI items than when completing the MATE items. To prevent such error from occurring, the "randomized order" setting provided through the Qualtrics application was implemented. This setting combined the items for both instruments and distributed the items in a randomized order. Also, the randomized order was different for each participant. For example, one participant may have received five MATE items back to back, while another participant may have received two SUSSI items, a MATE item, a SUSSI item, and a MATE item. Although participants may have performed better at the beginning of survey when compared to their performance at the end of the survey, this randomized order allowed the potential error to be accounted for.

Once participants completed the survey, they were given the opportunity to click on a link that would direct them to a separate Qualtrics page to enter a drawing for a $100 Amazon e-gift card. By directing participants to a separate Qualtrics page, personal identification could not be tracked to the individual's responses given on the survey.

This method allowed for a drawing to be held for an e-gift card, while securing the anonymity and privacy of each participant. After the allotted time to complete the survey had ended (one month), the names entered for the drawing were exported from Qualtrics and imported onto a Microsoft Excel spreadsheet. A randomization Microsoft Excel tool was utilized on the data set, which allowed one name to randomly be selected from the sample. The first name selected was sent an email enclosing the awarded $100 Amazon e-gift card.

Demographics

The demographic variables explored in this study were chosen either because they were identified by the research literature to influence the acceptance of the Theory of Evolution, or because of the researcher's own interest of a variable's influence on acceptance of the Theory of Evolution. Those variables suggested by the research literature to influence acceptance of the Theory of Evolution included: STEM major (Moore & Cotner, 2009; Peker et al., 2010; Rissler et al., 2014), gender (Peker et al., 2010), religious beliefs (e.g., Baker, 2013; Barone et al., 2014), religiosity (Lombrozo et al., 2008; Nadelson & Hardy, 2015), political views (e.g., Baker, 2013; Cotner et al., 2010; Lombrozo et al., 2008; Nadelson & Hardy, 2015), number of science courses taken (Brown & Scott, 2016; Cotner et al., 2010; Nadelson & Southerland, 2010; Shtulman & Calabi, 2008), and exposure to the teaching of the Theory of Evolution/creationism in high school (Moore & Cotner, 2009; Rissler et al., 2014). The demographic variables chosen based on the researcher's personal interest included school classification, high school community, presidential candidate/explanation, and tuition status. Further descriptions of each demographic variable are provided below:

School classification. This demographic variable was used as a control for the study. The population sample of this study focused on undergraduate freshmen and this question ensured the responses used for data analysis were obtained from freshmen students only.

STEM major. This demographic variable was included to compare acceptance of the Theory of Evolution and views of NOS between students who had self-identified as a STEM major (science, technology, engineering, or math) and students who had self-identified as a non-STEM major. Previous research exploring differences in acceptance of the Theory of Evolution among majors is inconclusive. Moore & Cotner (2009), Peker et al. (2010), and Rissler et al. (2014) found significant differences between STEM major and non-STEM majors, while Nadelson & Hardy (2015) found no difference to exist. The varying results in the literature indicated a need to include this demographic variable in the study.

Gender. This demographic variable was included because previous studies exploring differences in acceptance of the Theory of Evolution among genders have shown to be inconclusive. Peker et al. (2010) found females to hold higher acceptance than males, whereas Barone et al. (2014) found no differences to exist. The varying results in the literature indicated a need to include this demographic variable in the study. For inclusivity purposes, the researcher deemed a bi-categorization of gender as inappropriate and included 'transgender' along with 'male' and 'female'. Participants were also given the option to not disclose their gender.

High school community. Since Oklahoma is a state that supports a large number of communities, the researcher sought to explore the difference in acceptance of the

Theory of Evolution and views of NOS among those who attended rural, suburban, and urban high school communities. One purpose of the study was to provide results that could develop useful implications for high school and college educators. By including all three categories, significant findings of the study would not be limited to Oklahoma educators of just one type of high school community.

Religious beliefs. This demographic variable was perhaps the most important one to explore when evaluating acceptance of the Theory of Evolution, as religious beliefs have shown to have the most negative influence of acceptance of the Theory of Evolution (Coyne, 2012). However, since the focus of this study was not to explore the influence of religious beliefs on acceptance of the Theory of Evolution and views of NOS, the researcher sought to keep the categories for the religion demographic variable very general. This meant that instead of exploring differences among the different religious affiliations, the researcher sought to explore religion from a general level. Since there are many ways that religious beliefs can be explored through survey research, methods used by similar studies were examined to determine the most appropriate way to categorize this variable. Cotner et al. (2010) conducted a study exploring undergraduates' religious beliefs and knowledge of the Theory of Evolution. Cotner et al. (2010) asked participants to identify their religious beliefs as conservative, middle-of-the-road, liberal, or not religious at all. This categorization was deemed as appropriate and adopted as the categorization of religious views for this study.

Religiosity. Religion has shown to have the most negative influence of acceptance of the Theory of Evolution (Coyne, 2012). Although there are many ways to evaluate religiosity (e.g., how often a person prays per day, how often a person attends church per week), this variable was included to determine how important the participants viewed their religious beliefs to be. Therefore, participants were asked to rate how important religion was on the following ordinal scale: very important, somewhat important, not too important, not important at all, I do not hold religious beliefs.

Political views. Like religious views, political views are also a consistent predictor for determining acceptance of the Theory of Evolution. Studies continuously suggest that individuals who hold more conservative political views are more likely to reject the Theory of Evolution than those who hold more liberal political views (Barone et al., 2014; Cotner et al., 2010; Lombrozo et al., 2008; Mazur, 2004; Nadelson & Hardy, 2015). This study asked participants to identify their political views as conservative, middle-of-the-road, or liberal.

Presidential candidate choice/explanation. Originally, participants were asked to further describe their political views by identifying their choice for the 2016 Presidential Election. Participants were also asked to explain their choice. These two questions were originally included in the survey to further explore the influence of political views on acceptance of the Theory of Evolution and views of NOS. However, prior to data analysis, the researcher decided to eliminate these two questions after determining that the political view demographic variable, which asked their specific political view (liberal, middle-of-the road, conservative), was sufficient enough for the goal of the study.

Number of science courses taken. This demographic variable was included in the study because of the researcher's personal interest in this variable's influence on acceptance of the Theory of Evolution and views of NOS. While studies analyzing the influence of evolution content knowledge on student acceptance of the Theory of Evolution have produced contradictory results, the researcher of this study wanted to explore if students who took more science classes in high school would demonstrate a higher acceptance for the Theory of Evolution, and also hold more informed views of NOS, than students who took fewer science classes in high school. To evaluate this variable, participants were asked to identify the number of science courses taken in high school through the following ordinal scale: 0, 1-2, 3-4, 5-6, 7+.

Exposure to the teaching of the evolution and creationism in high school. This demographic variable was included because previous studies exploring the influence of the teachings of the Theory of Evolution and creationism in the classroom on acceptance of the Theory of Evolution were shown to be inconclusive, which indicated a need to include this demographic variable in the study. Moore & Cotner (2009) found students who were taught about both the Theory of Evolution and creationism in high school were less likely to accept the Theory of Evolution as undergraduates in college than those who were taught only about the Theory of Evolution. A similar study by Verhey (2005) found no significant differences between those who were taught about the Theory of Evolution, those who were taught about creationism, and those who were taught about both. In this study, participants were asked to choose "Yes" or "No" when asked if they had been taught about the Theory of Evolution in high school. They were also asked to choose "Yes" or "No" when asked if they had been taught about creationism in high school.

Tuition status. This demographic variable was included to identify students who attended high school in the state of Oklahoma and students who attended high school in a different state or a different country. This study focused on science education in the State of Oklahoma, so it was important to identify if participants were in-state, out-of-state, or international students.

Instrumentation

The survey administered for this study included items from two different instruments. The *Measurement of the Acceptance of the Theory of Evolution* (MATE) (Rutledge & Warden, 1999) was used to explore participants' acceptance of the Theory of Evolution. The *Student Understanding of Science and Scientific Inquiry* (SUSSI) (Liang et al., 2006) was used to explore participants' views of NOS.

The MATE Instrument

The *Measurement of the Acceptance of the Theory of Evolution* (MATE) (see Appendix C) was originally developed in response to the need for a "valid and reliable, homogenous, multi-item instrument to assess teacher acceptance of evolutionary theory" (Rutledge & Warden, 1999, p. 13). The instrument was designed to measure personal acceptance of the Theory of Evolution, rather than knowledge of the Theory, and was validated using a sample of high school biology teachers (Rutledge and Warden, 1999). The MATE has also been shown to be a valid and reliable instrument to assess university students' acceptance of evolution (Rutledge & Sadler, 2007), and the acceptance of evolution held by a sample of individuals who were visiting a museum (Barone et al., 2014).

The MATE is a twenty-item, Likert-scale questionnaire and was selected for this study due to its strong reliability (Cronbach's alpha of .94) for measuring the acceptance of the Theory of Evolution among non-biology major undergraduate students (Rutledge and Sadler, 2007). Six concepts are explored in the MATE instrument: process of evolution, scientific validity of evolutionary theory, evolution of humans, evidence of evolution, the scientific community's view of evolution, and age of the earth (Rutledge & Sadler, 2007). The high internal consistency of the six concepts allowed for one overall score of acceptance of the Theory of Evolution to be identified. Participants rated their agreement or disagreement to the MATE items using a five-point Likert scale. Items 1, 3, 5, 8, 11, 12, 13, 16, 18, and 20 are positively phrased items, meaning a 1 = strongly disagree and a 5 = strongly agree. Items 2, 4, 6, 7, 9, 10, 14, 15, 17, and 19 are negatively phrased statements, meaning a 1 = strongly agree and a 5 = strongly disagree. This reversal of score meaning had to be accounted for when scoring the MATE and is addressed below.

Scoring of the MATE

Prior to scoring the MATE, the reliability of the instrument for the use with this study's sample was determined. The Cronbach's alpha was used to measure the internal consistency of the instrument, which describes the extent to which all the items in an instrument measure the same concept or construct (Tavakol & Dennick, 2011). If the internal consistency is shown to be greater than .7, the data is assumed to have acceptable internal consistency and an overall score can be generated for the instrument. Reliability was achieved with a Cronbach's score of .95, which suggested that the data could be scored in such a way that participants' overall acceptance of the Theory of Evolution could be identified through one mean score.

Once reliability of the MATE was confirmed for use of the instrument with the study's sample, the scoring process began. First, to account for the negatively phrased items, a reverse coding was performed in SPSS, so the scores for the negatively phrased items indicated the same meanings as the scores for the positively phrased items. To do this, the scores for the negatively phrased items were modified as follows: scores of a 5 were changed to a 1, scores of a 4 were changed to a 2, scores of a 3 remained the same, scores of a 2 were changed to a 4, and scores of a 1 were changed to a 5. This allowed for a consistency in score meaning so that a score of a 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; and 5 = strongly agree.

Next, for each participant, the scores for each of the 20 MATE items were added together, which resulted in one MATE score for each participant. Each participant had a potential score ranging from 20-100. Based on an initial pilot study of the MATE, Rutledge (1996) developed the following scale for acceptance of the Theory of Evolution: very high acceptance (89-100), high acceptance (77-88), moderate acceptance (65-76), low acceptance (53-64), and very low acceptance (20-52). Once the individual scores were calculated, a mean score was identified to determine an average acceptance level of the Theory of Evolution for the entire sample.

Statistical Analysis of MATE Scores

The MATE instrument was used to explore the following research questions:

Research Question #1: *What is the current level of acceptance of the Theory of Evolution held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #2: *Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?*

To address Research Question #1, the descriptive statistics were calculated based on all MATE scores. This produced the average acceptance level of the Theory of

Evolution held by the sample, as well as the distribution of the sample. To address Research Question #2, a t-test, an ANOVA, or a Spearman bivariate correlation was utilized, depending on the independent variable being explored. To determine if a significant difference existed in the means of the MATE scores between two groups (e.g., taught about creationism: yes or no), a t-test was used. To determine if a significant difference existed in the means of the MATE scores between three or more groups (e.g., high school community: rural, urban, suburban), an ANOVA was used. If the demographic variable was grouped on an ordinal number scale instead of a categorical scale (e.g., number of science classes taken prior: 0, 1-2, 3-4, 5-6, 7+) a Spearman's correlation (r_2) was used to account for the non-normal distribution.

If a significant difference was identified through the t-test, an ANOVA, or Spearman's correlation, the effect size was also calculated. Thalheimer and Cook (2002) state, "Whereas statistical tests of significance tell us the likelihood that experimental results differ from chance expectations, effect-size measurements tell us the relative magnitude of the experimental treatment" (p. 2). In other words, the effect size emphasizes the size of the significant difference (Thalheimer and Cook, 2002). For significant t-tests, Cohen's *d* was used to calculate the effect size. Cohen (1988) suggests $d = .2$ is a small effect, $d = .5$ is a moderate effect, and $d = .8$ is a large effect. For significant ANOVA, the ETA squared (η^2) was used to calculate effect size. Cohen (1988) suggests $\eta^2 = .01$ is a small effect, $\eta^2 = .059$ is a moderate effect, and $\eta^2 = .138$ is a large effect. For the Spearman correlations (r_2), reporting the r_2 value was sufficient as a correlation is an effect size. The results of the data analysis of the MATE are discussed in Chapter IV.

The SUSSI Instrument

The *Student Understanding of Science and Scientific Inquiry* (SUSSI) is primarily a quantitative Likert-scale instrument, which also includes a qualitative component through constructed-response items. The SUSSI was originally developed in response to the need for an effective, standardized tool to be used for a large-scale assessment of views of NOS (Liang et al., 2006). The SUSSI was built using a combination of the Views on Science-Technology-Society (VOSTS) (Aikenhead & Ryan, 1992) and the Views of Nature of Science Questionnaires (VNOS) (Lederman et al., 2002). A more detailed description of the development of the SUSSI can be found in Chapter II.

The SUSSI was designed to explore six aspects of NOS that were chosen based on their emphasis in science education reform documents and empirical NOS studies (e.g., AAAS, 1990, 1993; Aikenhead & Ryan, 1992; Lederman et al., 2002; NRC, 1996; NSTA, 2000). The six NOS aspects addressed in the SUSSI are: 1) Observations and Inferences; 2) Tentative Nature of Scientific Theories; 3) Scientific Laws and Theories; 4) Social and Cultural Influence on Science; 5) Imagination and Creativity in Scientific Investigations; and 6) Methodology in Scientific Investigations. It is important to note, for terminology purposes, the developers of the SUSSI use the term "theme" for the components of NOS, instead of the commonly referred term "aspect" (Liang et al., 2006, p. 12). Therefore, any subsequent discussion concerning the SUSSI will utilize the term "theme" when addressing the specific components of NOS. A complete description of each theme can be found in Chapter II.

Each of the six NOS themes addressed in the SUSSI are explored through four Likert-scale items and one constructed-response item. Participants rated their agreement or disagreement to the twenty-four Likert-scale items on a five-point scale. Items 1A, 1D, 2A, 2B, 2C, 3D, 4B, 4C, 5A, 5B, 6A, and 6D are positively phrased items, meaning a participant's answer of 1 = strongly disagree and 5 = strongly agree. Items 1B, 1C, 2D, 3A, 3B, 3C, 4A, 4D, 5C, 5D, 6B, 6C are negatively phrased statements, meaning a participant's answer of 1 = strongly agree and a 5 = strongly disagree. This reversal of score meaning was accounted for when scoring the SUSSI and is addressed below. A scoring taxonomy, which was provided by the developers of the instrument, was used to help the researcher establish consistent scoring for the constructed-response items. For each NOS theme, the scoring taxonomy provided examples of informed, transitional, and naïve responses, which allowed for the scores on the constructed-response answers to be scored objectively and consistently. This scoring taxonomy was used to give quantitative values to participants' qualitative, constructed-response answers.

When exploring NOS instruments, the SUSSI was identified by the researcher of this study as the most appropriate instrument to use to explore participants' views of NOS for several reasons. First and foremost, student participation was a major concern for this study. The SUSSI was selected based on the assumption that a 24-item Likert-scale format combined with only six open-ended items would be more appealing to complete for undergraduate freshmen students than a completely open-ended response format, as found in the VNOS instruments (Lederman et al., 2002), hence increasing the chances of a larger sample size. Second, the 24-item Likert-scale format combined with six open-ended items allowed for a quantitative analysis of a large sample size, while still providing qualitative analysis through six open-ended responses. The availability of the constructed-response allowed for misconceptions to be addressed, which may have not been identified through the Likert responses alone. Third, a scoring guide and taxonomy rubric accompanied the SUSSI to improve accuracy and consistency when scoring the open-ended responses. Finally, the SUSSI instrument explores the themes of NOS that are continuously addressed in NOS literature (Liang et al., 2006), as described in Chapter II.

Scoring of the SUSSI

The reliability of the SUSSI instrument was identified using Cronbach's alpha. The instrument showed to have an internal consistency of Cronbach's .71, meaning the SUSSI was unidimensional for views of NOS. However, since each of the six NOS themes assessed participants' views of NOS through a set of four Likert-scale items and one constructed-response item, the internal consistency among the Likert scores of each theme was also evaluated. These values, which are reported in Chapter IV and discussed in Chapter V, required separate analysis of the Likert scores and the constructed-response scores. The following methods are described by the scoring of the Likert items first, followed by the scoring of constructed-response items.

Scoring of the SUSSI likert items. To account for the negatively phrased items of the SUSSI instrument, reverse coding was performed in SPSS. This process reversed the negatively phrased items to have the same numerical meanings as the scores for the positively phrased items. To do this, the scores for the negatively phrased items were modified as follows: scores of a 5 were changed to a 1, scores of a 4 were changed to a 2, scores of a 3 remained the same, scores of a 2 were changed to a 4, and scores of a 1 were changed to a 5. This allowed for a consistency in score meaning so that any score of 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; and 5 = strongly agree.

Next, an overall score for the Likert items, per theme, was generated. For each theme, there were four Likert items. Participants could receive a score of a 1, 2, 3, 4 or 5 on each of the Likert items, based on their answer to the item. Naïve answers received a score of 1 and informed answers received a score of 5. For example, Likert item B for the NOS theme *Scientific Laws and Theories* stated, "Unlike theories, scientific laws are not subject to change." The scores for this item were as follows: strongly agree = 1; agree = 2; undecided = 3; disagree = 4; and strongly disagree = 5. This scoring process took place for each of the four Likert items, for each NOS theme. If the participant scored a 1, 2, or 3 on all four Likert items, he/she received an overall Likert score of 1 for that theme, which indicated a naïve view. If the participant scored a 1, 2, or 3 on at least one item, but also a 4 or 5 on at least one item, he/she received an overall Likert score of 2 for that theme, indicating a transitional view. If the participant scored a 4 or 5 on all four Likert items, he/she received an overall Likert score of 3 for that theme, which indicated an informed view. This process was completed for the Likert section of each of the six NOS themes.

Scoring of the SUSSI constructed-response items. Two steps took place in the scoring of the constructed-response items. The first step included providing each constructed-response item with a numerical score based on the view reflected through the response. The scoring rubric provided by Liang et al. (2006) (see Appendix D) was used to score the responses, and each constructed-response answer was given a score of not classifiable (0), naïve view (1), transitional view (2), or informed view (3).

The second step in scoring the constructed-response items was coding the data. This process took place based on recommendations provided by Saldana (2008) and

Merriam and Tisdell (2015). Saldana states "A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (p. 3). Coding is a cyclic process that typically takes place in two cycles. The first cycle of coding results in words, sentences, or mass text that have significance (Saldana, 2008). The second cycle of coding uses the initial codes to generate common categories, themes, and/or concepts (Saldana, 2008). Guidance in the coding process was also taken from Merriam and Tisdell (2015) who suggest: 1) all data used in the study must be able to be placed into the identified themes; 2) themes should be exclusive enough that data can only fit into one theme; 3) the naming of the theme should be specific enough to accurately identify what is being reflected by the data; and 4) subcategories should be used so that all themes are on the same level of abstraction.

Using the recommendations for coding provided by Saldana (2008) and Merriam and Tisdell (2015), the following methods were used to code the constructed-responses in the data: Before organizing the data into themes, the responses for each NOS theme were organized by view (naïve, transitional, and informed). Responses that identified as 'not classifiable' were not incorporated in the theming process. Next, as each response was read, common concepts/misconceptions/terms were identified for each NOS theme in the form of a list. From this list, common themes were developed. If a concept/misconception/term reappeared five or more times in the responses, it was identified as a common theme. The specific concepts/misconceptions/terms that emerged as themes differed for each of the six NOS themes assessed through the SUSSI. The developed coded themes for each of the six NOS themes are further discussed in Chapter IV.

Statistical Analysis of the SUSSI SCORES

The SUSSI instrument was used to explore the following research questions:

Research Question #3: *What are the current views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #4: *Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?*

To address Research Question #3, “What are the current views of nature of science held by undergraduate freshmen enrolled at a research university in Oklahoma?”, participants’ mean Likert score and mean constructed-response score for each theme was calculated. Since the Likert scores and constructed-response scores could not be evaluated as one overall view of NOS due to low internal consistency, each of six NOS themes were analyzed individually. In other words, the low internal consistency prevented one overall NOS score from being obtained, as well as one overall score to be determined for each of the six themes. To clarify, each of the six themes produced participants’ mean Likert-scale SUSSI score and mean constructed-response SUSSI score.

To address Research Question #4, “Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?”, a t-test, an ANOVA, or a Spearman bivariate correlation was utilized, depending on the independent variable being explored. To determine if a significant difference existed in the means of the SUSSI scores between two groups (e.g., taught about creationism: yes or no), a t-test was used. To determine if a significant difference existed in the means of the SUSSI scores between three or more groups (e.g., high school community: rural, urban, suburban), an ANOVA was used. If the demographic variable was grouped on an ordinal number scale instead of a categorical scale (e.g., number of science classes taken prior: 0, 1-2, 3-4, 5-6, 7+) a Spearman correlation test was used to account for the non-normal distribution. The effect size was also calculated for those variables with significant differences, as described for the MATE instrument. The above procedure was conducted twice for each of the six NOS themes: once between each theme's overall mean Likert score and each of the demographic variables and once between each theme's overall mean constructed-response score and each of the demographic variables.

Relationship Between Acceptance of the Theory of Evolution and Views of NOS

The third part of this study explored the relationship between acceptance of the Theory of Evolution and views of NOS held by the sample population. Several studies have shown a significant relationship between acceptance of the Theory of Evolution and the views of NOS (Allmon, 2011; Scharmann & Harris, 1992; Lombrozo et al., 2008; Verhey, 2005). This relationship has been supported for secondary science teachers (Nehm & Schonfeld, 2007), high school students (Cavallo & McCall, 2008), and undergraduate college students (Lombrozo et al., 2008). However, this study sought to contribute to the gap in the research literature exploring if a relationship exists between undergraduate freshmen's acceptance of the Theory of Evolution and their views of NOS.

Statistical Analysis

Using the data collected from the MATE instrument and the SUSSI instrument, the following research questions were explored:

Research Question #5: *Does a relationship exist between acceptance of the Theory of Evolution and views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?*

Research Question #6: *If a relationship is found to exist, how do specific demographic variables moderate the relationship between participants' acceptance of the Theory of Evolution and their views of NOS?*

To answer Research Question #5, a bivariate correlation was performed between the MATE scores and the mean Likert scores and constructed-response scores for each of the six NOS themes assessed on the SUSSI. The results from the analysis are discussed in Chapter IV. Research Question #6 was unable to be explored based on the statistical results provided for Research Question #5. This is discussed more in depth in Chapter IV.

Summary

Chapter III described the methodology that was used to guide this research study. The research questions and demographic variables explored were clearly defined. The administered survey was thoroughly described, as well as the development and usage of the two instruments. Further, this chapter provided descriptions of the statistical analysis that took place for each research question. The results of each statistical analysis will be presented in the next chapter.

CHAPTER IV

RESULTS

The purpose of this study was to explore the acceptance of the Theory of Evolution and views of Nature of Science (NOS) held by undergraduate freshmen enrolled at a research university in Oklahoma. Additionally, this study investigated the relationship between participants' acceptance of the Theory of Evolution and their views of NOS. This chapter presents the results of the study in four sections: the first section provides the descriptive statistics of the study; the second section addresses participants' acceptance of the Theory of Evolution; the third section addresses participants' views of NOS; and the fourth section of this chapter addresses the relationship between participants' acceptance of the Theory of Evolution and their views of NOS.

Results Section 1: Descriptive Statistics

Response Rate

Data analysis was based on participants' responses to the survey described in Chapter 3. The population for this study consisted of undergraduate freshmen enrolled at a research university in Oklahoma during the 2016-2017 school year. Of the 3,972 recruitment emails distributed, a total of 645 participants began the survey, and 377 participants fully completed the survey. One of these 377 identified as not being a freshman, and since the study focused on freshmen students only, his/her data was removed from SPSS data analysis. This made for a completed response rate of 9.49%, and a total original sample size of 376 participants.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) program, version 24, was used for the data analysis process. The first step in the analysis was to import the data into SPSS from the online Qualtrics program, which was used to collect the survey data. Any data provided by a participant who did not complete the entire survey was eliminated from the study. Any data provided by a participant who classified him/herself as not a freshman was also excluded from the study. Further, in regard to the gender variable, one participant identified as being transgender and one participant chose not to disclose their gender; because of the low sample size for these two groups, their data was removed when analyzing the gender variable.

Demographic Variables

After data collection, the original survey's demographic questions were re-evaluated for their inclusion in the data set analysis. Participants' responses to demographic questions number 8 (choice of presidential candidate) and number 9 (explanation for question 8) were removed from the study because of redundancy to question 7 (participants' political views: conservative, middle-of-the-road, or liberal). A goal of the research study was to explore if participants' political views influenced their acceptance of the Theory of Evolution and their views of NOS. After reviewing the data, the researcher determined that the results to Question 7 met the goal sufficiently, even with the removal of the data for questions 8 & 9. All other demographic variables were retained for data analysis.

The demographic data included in the study consisted of 1) school classification, 2) STEM/non-STEM major, 3) gender, 4) high school community, 5) religious views, 6) importance of religion, 7) political views, 8) science classes taken in high school, 9) exposure to the teaching of evolution in high school, 10) exposure to the teaching of creationism in high school, and 11) tuition status. Table 1 presents the frequencies and percentages of participants' self-identification of each demographic variable.

Table 1

Frequency and Percentage of Participants for Each Demographic Variable

	Sample (n = 376)	
Variable	Frequency	Percentage
STEM Major		
Yes	259	68.9%
No	117	31.1%
Gender		
Male	172	45.7%
Female	202	53.7%
Transgender	1	.3%
Prefer Not to Respond	1	.3%
High School Community		
Rural	109	29.0%
Urban	83	22.1%
Suburban	184	48.9%
Religious Views		
Conservative	114	30.3%
Middle-of-the-road	108	28.7%
Liberal	59	15.7%
I am not religious.	96	25.3%
Importance of Religion		
Very important	134	35.6%
Somewhat important	100	26.6%
Not too important	48	12.8%
Not important at all	33	8.8%
I do not hold religious beliefs.	61	16.2%

Political Views		
Conservative	118	31.4%
Middle-of-the-road	163	43.4%
Liberal	95	25.3%
Science Classes Taken in High School		
1-2	6	1.6%
3-4	239	63.6%
5-6	108	28.7%
7+	23	6.1%
Teaching of Evolution in High School		
Yes	296	78.7%
No	80	21.3%
Teaching of Creationism in High School		
Yes	108	28.7%
No	268	71.3%
Tuition Status		
In-state	260	69.1%
Out-of-state	116	30.9%
International	0	0%

Results Section 2: Acceptance of the Theory of Evolution

Research Question #1: *What is the current level of acceptance of the Theory of Evolution held by undergraduate freshmen enrolled at a research university in Oklahoma?* Research Question #2: *Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?*

To address the Research Question #1, the reliability of the MATE instrument was assessed. Results indicated strong internal consistency (α = .95). Since high internal consistency/reliability was identified, scale scores of the MATE were calculated by summing responses on all items to determine the sample's overall acceptance of the Theory of Evolution. Scaling allows a potential range of scores between 20-100.

According to a scaling rubric developed for the MATE (Rutledge & Warden, 1999), a score of 20-52 suggests a very low acceptance, 53-64 suggests a low acceptance, 65-76 suggests a moderate acceptance, 77-88 suggests a high acceptance, and 89-100 suggests a very high acceptance. Participants' MATE scores ranged from the low score of 32 to the high score of 100, with a mean score of 71.70 (*SD*=15.49). This suggested the participants held an overall moderate acceptance of the Theory of Evolution.

Results for Each MATE Item

The MATE instrument is composed of 20 Likert-scale items that assess participants' understandings of the following six concepts of the Theory of Evolution: process of evolution, scientific validity of evolutionary theory, evolution of humans, evidence of evolution, scientific community's view of evolution, and age of the earth (Rutledge & Sadler, 2007). For each item, the participant could choose strongly agree (SA), agree (A), undecided (UD), disagree (D), or strongly disagree (SD). Table 2 provides the percentages of participants' responses for each of the MATE items. Discussion of participants' results for each MATE item is provided in the next chapter.

Table 2

Percentages of Participants' Responses to Individual MATE Items

	Percent Response (*n* = 376)				
Item	SA	A	UD	D	SD
1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.	26.3	37.5	18.1	9.8	8.2
2. The theory of evolution is incapable of being scientifically tested.	6.4	18.6	24.7	37.8	12.5
3. Modern humans are the product of evolutionary processes that have occurred over millions of years.	25	30.3	19.7	12.2	12.8

4. The theory of evolution is based on speculation and not valid scientific observation and testing.	3.5	18.4	18.9	38.8	20.5
5. Most scientists accept evolutionary theory to be a scientifically valid theory.	18.4	56.4	20.7	4.0	.5
6. The available data are ambiguous (unclear) as to whether evolution actually occurs.	6.9	20.5	21.8	38.6	12.2
7. The age of the earth is less than 20,000 years.	3.5	5.6	30.1	25.5	35.4
8. There is a significant body of data that supports evolutionary theory.	21.3	40.2	21.3	15.2	2.1
9. Organisms exist today in essentially the same form in which they always have.	4.0	14.6	13.3	40.4	27.7
10. Evolution is not a scientifically valid theory.	6.6	12.0	19.9	33.8	27.7
11. The age of the earth is at least 4 billion years.	24.7	35.1	29.5	5.3	5.3
12. The current evolutionary theory is the result of sound scientific research and methodology.	12.8	45.5	29.5	9.8	2.4
13. Evolutionary theory generates testable predictions with respect to the characteristics of life.	9.3	50.0	26.9	11.4	2.4
14. The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.	12.2	13.0	14.1	26.1	34.6
15. Humans exist today in essentially the same form in which they always have.	11.2	18.6	17.3	31.6	21.3
16. Evolutionary theory is supported by factual historical and laboratory data.	14.6	44.1	23.4	11.7	6.1
17. Much of the scientific community doubts if evolution occurs.	2.1	9.3	26.6	41.2	20.7

18. The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms.	20.2	45.5	19.7	9.8	4.8
19. With few exceptions, organisms on earth came into existence at about the same time.	8.0	21.8	26.1	27.1	17.0
20. Evolution is a scientifically valid theory.	24.7	38.8	21.5	8.8	6.1

Exploring the Influence of Demographic Variables on MATE Scores

Research Question #2 stated, "Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?" For each demographic variable explored, there were two to five options for participants to self-identify. For example, when exploring gender, participants could identify as male, female, transgender, or prefer not to respond. When conducting the statistical analysis for the MATE results, the mean MATE score for each option, of each demographic variable, was first identified. Statistical analysis (t-test/Analysis of Variance (ANOVA)/correlation) was then conducted to determine if significant differences occurred between/among the mean MATE scores for each option, within each demographic variable. This process was performed for each demographic variable. If a significant difference was identified between/among the options, the demographic variable was suggested to significantly influence acceptance of the Theory of Evolution. There were several demographic variables in which significant differences in the mean MATE scores were found to exist. Table 3 provides the mean MATE scores and standard deviations for each of the options within the demographic variables. Table 4 provides the statistical test results for each demographic variable.

Table 3

MATE Means and Standard Deviations for Each Demographic Variable

Demographic Variable	Group	Frequency	*M*	*SD*
STEM Major	Yes	259	72.11	15.89
	No	117	69.74	16.20
Gender	Male	172	73.06	17.14
	Female	202	69.83	14.86
High School Community	Rural	109	68.35	15.91
	Urban	83	71.70	16.09
	Suburban	184	73.02	15.86
Religious Views	Conservative	114	58.51	13.64
	Middle-Of-Road	108	70.14	12.77
	Liberal	59	77.46	12.77
	Not	96	84.43	10.67
Religion Importance	Very	134	60.04	14.59
	Somewhat	100	70.27	12.38
	Not Too Much	48	77.85	10.71
	Not Important	33	84.33	9.34
	No Religion	61	86.00	10.42
Political Views	Conservative	118	61.17	15.49
	Middle-Of-Road	163	72.29	13.56
	Liberal	95	82.48	12.24
Science Classes Taken	1 - 2	6	72.83	13.88
	3 - 4	239	69.13	16.23
	5 – 6	108	74.21	15.05
	7+	23	80.87	13.51
Taught About Evolution	Yes	296	72.28	15.77
	No	80	68.03	16.51
Taught About Creationism	Yes	108	68.54	17.34
	No	268	72.51	15.32
Tuition Status	In-State	260	70.81	16.68
	Out-Of-State	116	72.64	14.37

Table 4

Demographic Variables and Their Significance to Acceptance of the Theory of Evolution

Variable	Statistics Results
STEM Major	t(374) = 1.34, ns
Gender	t(372) = 1.95, p = .05
High School Community	F(2,373) = 2.96, p = .05
Religious Views	F(3,372) = 79.09, p < .001
Religion Importance	r_s = .63, p < .001
Political Views	F(2,373) = 62.54, p < .001
Science Classes Taken	r_s = .19, p < .001
Taught About Evolution	t(374) = 2.12, p = .04
Taught About Creationism	t(374) = -2.19, p = .03
Tuition Status	t(374) = -1.02, ns

Stem major. An independent t-test was conducted to compare the mean MATE scores between those who identified as declaring a STEM major and those who identified as declaring a non-STEM major. There was no significant difference in the mean MATE scores between STEM majors (*M* = 72.11, *SD* = 15.89) and non-STEM majors (*M* = 69.74, *SD* = 16.20); t(374) = 1.34, *p* = .18. These results suggested participants' declared major did not influence their acceptance of the Theory of Evolution.

Gender. An independent t-test was conducted to compare the mean MATE scores between males and females. While transgender was also an option, only one participant identified as transgender. The low sample size resulted in his/her data not being used for analysis when exploring the influence of gender. There was a significant difference in the mean MATE scores between males (*M* = 73.06, *SD* = 17.14) and females (*M* = 69.83, *SD* = 14.85); t(372) = 1.95, *p* = .05. However, the effect size (*d* =

.20) indicated small practical significance. These results suggested participants' gender did not substantially influence their acceptance of the Theory of Evolution.

High school community. An ANOVA was conducted to compare the mean MATE scores among the different high school communities: rural, urban, and suburban. The ANOVA identified a significant difference among the mean MATE scores: $F(2,373) = 2.96$, $p = .05$. Table 5 provides the ANOVA summary table. Post hoc analysis using a Tukey HSD identified a significant difference in mean MATE scores between the rural and suburban groups ($p = .04$), but not between the rural and urban groups ($p = .32$), or the urban and suburban groups ($p = .81$). Table 6 provides the means and standard deviations for each group. Further, the effect size ($\eta^2 = 0.02$) indicated small practical significance. These results suggested participants' high school community did not substantially influence their acceptance of the Theory of Evolution.

Table 5

ANOVA Summary Table for High School Community

	SS	df	Mean Square	F	Sig.
Between	1502.70	2	751.35	2.96	.05
Within	94575.17	373	253.55		
Total	96077.87	375			

Table 6

Means and Standard Deviations for Groups of High School Community

Group	Frequency	*M*	*SD*
Rural	109	68.35	15.9
Urban	83	71.70	16.09
Suburban	184	73.01	15.86

Religious views. An ANOVA was conducted to compare the mean MATE scores among the different religious views: conservative, middle-of-the-road, liberal, and not religious. The ANOVA identified a significant difference among the mean MATE scores: $F(3,372) = 79.09$, $p < .001$. Table 7 provides the ANOVA summary table. Post hoc analysis using a Tukey HSD identified all pairwise comparisons were significantly different ($p < .01$). Participants with conservative religious views held significantly lower acceptance of the Theory of Evolution when compared to acceptance from the other three groups. Participants with middle-of-the-road political views held significantly lower acceptance of the Theory of Evolution when compared to acceptance of those who held liberal religious views and also those who were not religious. Participants with liberal religious views held significantly lower acceptance of the Theory of Evolution than those who identified as not being religious. The largest difference in acceptance of the Theory of Evolution occurred between participants who held conservative religious views and participants who identified as not being religious. Table 8 provides the means and standard deviations for each group. Further, the effect size ($\eta^2 = 0.40$) indicated a large practical significance. These results suggested participants' religious views substantially influenced their acceptance of the Theory of Evolution.

Table 7

ANOVA Summary Table for Religious Views

	SS	df	Mean Square	F	Sig.
Between	37414.52	3	12471.51	79.09	.001
Within	58663.36	372	157.70		
Total	96077.88	375			

Table 8

Means and Standard Deviations for Groups of Religious Views

Group	Frequency	*M*	*SD*
Conservative	114	58.51	13.64
Middle-Of-The-Road	108	70.14	12.77
Liberal	59	77.46	12.77
Not Religious	96	84.43	10.67

Importance of religion. Since importance of religion was measured on an ordinal scale (very important, somewhat important, not too important, not important at all, I do not hold religious beliefs) rather than a nominal scale, an ANOVA could not be used. Instead, the level of importance of religion was correlated with scores on the MATE. A two-tailed non-parametric correlation analysis generated a Spearman's correlation of .63. Evans (1996) suggests using these correlation levels for the following absolute value of r_s (Spearman's correlation): .00 - 19 = very weak; .20 - .39 = weak; .40 - 59 = moderate; .60 - .79 = strong; and .80 - 1.0 = very strong correlation. The Spearman's correlation test result of $r_s = .63$, $p < .01$ determined a strong correlation between religiosity and scores on the MATE. This suggested as importance of religion decreases, acceptance of the Theory of Evolution increases. This result suggested that participants' religiosity substantially influenced their acceptance of the Theory of Evolution.

Political views. An ANOVA was conducted to compare the mean MATE scores among the different political views: conservative, middle-of-the-road, and liberal. The ANOVA identified a significant difference among the mean MATE scores: $F(2,373) = 62.54$, $p < .001$. Table 9 provides the ANOVA summary table. Post hoc analysis using a Tukey HSD identified that all pairwise comparisons were significantly different ($p < .01$).

Participants with conservative political views held significantly lower mean MATE scores than participants with middle-of-the-road or liberal political views. Additionally, participants with middle-of-the-road political views held significantly lower mean MATE scores than participants who held more liberal political views. The largest difference in mean MATE scores occurred between participants who held conservative political views and participants who held liberal political views. Those with conservative political views held the lowest acceptance of the Theory of Evolution and those with liberal political views held the highest acceptance. Table 10 provides the means and standard deviations for each group. Further, the effect size ($\eta^2 = 0.25$) indicated large practical significance. These results suggested that participants' political views substantially influenced their acceptance of the Theory of Evolution.

Table 9

ANOVA Summary Table for Political Views

	SS	df	Mean Square	F	Sig.
Between	24128.12	2	12064.07	62.54	.001
Within	71949.74	373	192.90		
Total	96077.86	325			

Table 10

Means and Standard Deviations for Groups of Political Views

Group	Frequency	M	*SD*
Conservative	118	61.17	15.49
Middle-Of-The-Road	163	72.29	13.56
Liberal	95	82.47	12.24

Science classes taken in high school. When examining differences in MATE scores and number of science classes taken in high school, a Spearman's correlation of

.19 was produced. While this value is statistically significant at $p < .01$, the relationship had a very weak correlation of $r_2 = .19$. These results suggested that the number of science classes taken in high schools did not substantially influence participants' acceptance of the Theory of Evolution.

Exposure to the teachings of evolution and/or creationism. An independent t-test was conducted to compare the mean MATE scores between those who were taught about the Theory of Evolution in their high school science classes and those who were not. There was a significant difference in the mean MATE scores for those taught about evolution (M = 72.28, SD = 15.77) and those who were not taught about the evolution (M = 68.03, SD = 16.51); t(374) = 2.11, p = .04. However, the effect size (d = .26) indicated small practical significance. These results suggested that participants' prior exposure to the teachings of the evolution did not substantially influence their acceptance of the Theory of Evolution.

An independent t-test was conducted to compare the mean MATE scores between those who were taught about creationism in their high school science classes and those who were not taught about creationism. There was a significant difference in the mean MATE scores for those taught about creationism (M = 68.54, SD = 17.34) and those who were not (M = 72.51, SD = 15.32); t(374) = -2.19, p = .03. However, the effect size (d = .24) indicated small practical significance. These results suggested that participants' prior exposure to the teachings of creationism did not substantially influence their acceptance of the Theory of Evolution. Significant differences were found when comparing the mean MATE scores between those who were taught about evolution (M = 72.28, SD = 15.77) and those who were taught about creationism (M = 68.54, SD =

17.34); t(400) = -2.05, p =. 04. The effect size (*d* = .23) indicated small practical significance. These results suggested that participants' prior exposure to the teachings of the evolution or creationism did not substantially influence their acceptance of the Theory of Evolution.

Tuition status. An independent t-test was conducted to compare the mean MATE scores between those who were identified as having in-state tuition status and those who identified as having out-of-state tuition status. There was a not a significant difference between the mean MATE scores for those who were in-state (*M* = 70.81, *SD* = 16.68) and those who were out-of-state (*M* = 72.64, *SD* = 14.37); t(374) = -1.02, *p* = .31. These results suggested participants' tuition status did not influence their acceptance of the Theory of Evolution.

Summary of the MATE Analysis

In summary, participants' identified STEM/non-STEM major and tuition status did not significantly influence their acceptance of the Theory of Evolution. While participants' gender, high school community, and teachings of evolution/creationism in the high school classroom did significantly influence their acceptance of the Theory of Evolution, the calculated effect size suggested the influence was not substantial. Participants' religious views, level of importance of religion, and political views did significantly influence their acceptance of the Theory of Evolution, and the effect size suggested the influence was substantial.

Results Section 3: Views of Nature of Science

Research Question #3: *What are the current views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?* Research Question #4: *Are* *there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?*

Research Question #3 was addressed by participant responses to the Student Understanding of Science and Scientific Inquiry (SUSSI) instrument (Liang et al., 2006). The analysis began with an evaluation of the dimensionality of the SUSSI instrument when combining the Likert scores and constructed-response scores for each of the six NOS themes (Theme 1: *Observations and Inferences*, Theme 2: *Tentative Nature of Scientific Theories*, Theme 3: *Scientific Laws and Theories*, Theme 4: *Social and Cultural*, Theme 5: *Imagination and Creativity in Scientific Investigations*, and Theme 6: *Methodology in Scientific Investigations*). Results indicated a moderate internal consistency (**α** = .71). However, since each of the six NOS themes assessed participants' views of NOS through a set of four Likert-scale items and one constructed-response item, the internal consistency among the four Likert items, for each theme, was also evaluated. As shown in Table 11, a low internal consistency was identified among the Likert scores for each of the six NOS themes, except *Imagination and Creativity in Scientific Investigations*. Discussion regarding this low reliability is provided in Chapter V.

Table 11

Reliability of Likert Items for Each NOS Theme

Theme	Reliability (**α**)
1: Observations and Inferences	.57
2: Tentative Nature of Scientific Theories	-.14
3: Scientific Laws and Theories	.26
4: Social and Cultural	.61
5: Imagination and Creativity in Scientific Investigations	.78
6: Methodology in Scientific Investigations	.40

This chapter presents the results by each of the six NOS themes, with the Likert analysis reported first, followed by the constructed-response analysis. Note: this chapter only reports the results of the study. For a complete description of the scoring process utilized for the Likert items and the constructed-response items, refer to chapter III. Further discussion of these results can be found in Chapter V.

Before addressing the individual results of the six NOS themes, a summary of participants' views (naïve, transitional, informed) for all six NOS themes is presented in Table 12. Supported by the identified low reliability (see Table 11), the Likert findings differ from the constructed-response findings. The overall Likert scores suggested most participants (51% or more) held 'transitional' views of all six NOS themes except *Observations and inferences*, in which 48.7% held 'transitional' and 48.9% held 'informed' views. The overall constructed-response scores, however, suggested most participants (50% or more) held 'transitional' views of *Observations and Inferences*, *Social and Cultural Influence on Science,* and *Imagination and Creativity in Scientific Investigations*; 'informed' views of the *Tentative Nature of Scientific Theories;* and 'naïve' views of *Scientific Laws and Theories* and *Methodology in Scientific Investigations*. This suggested when assessed through forced-choice items, participants reflected more informed views of NOS, and when assessed through open-response items, the participants reflected more naive views. These results are further explored through each of the six NOS themes presented below.

Table 12

A Summary of the Likert and Constructed-Response Percentages Scored for Each Theme

	Likert - % Responses*			Constructed - % Responses		
Theme	Naïve	Transitional	Informed	Naïve	Transitional	Informed
1: *Observations and Inferences*	2.4	48.7	48.9	18.9	50.0	23.1
2: *Tentative Nature of Scientific Theories*	2.4	56.9	40.4	15.9	31.3	44.4
3: *Scientific Laws and Theories*	32.7	67.0	.3	84.0	1.6	5.1
4: *Social and Cultural Influence on Science*	11.2	60.9	27.9	16.2	69.1	7.4
5: *Imagination and Creativity in Scientific Investigations*	30.6	55.9	13.9	22.3	67.8	1.9
6: *Methodology in Scientific Investigations*	6.1	85.6	8.2	50.0	32.4	8.5

** Not all NOS themes will sum to 100 percent since not all participants provided relevant responses and therefore were not categorized.*

Theme 1: Observations and Inferences

Likert items. When analyzing participants' views of *Observations and Inferences* through the Likert items, 2.4% of participants scored 'naïve', 48.7% scored 'transitional', and 48.9% scored 'informed'. Participants' mean Likert score for *Observations and Inferences* was 2.5, which suggested participants held an overall 'transitional' to 'informed' view when assessed through Likert items. Table 13 provides a summary of participants' scores on each of the Likert items for *Observations and Inferences.* Over 70% of participants reflected an informed view that scientists' prior knowledge plays a role in their observations and inferences, which can lead scientists to have different observations and interpretations of the same event. Over 30% of participants, however, either strongly agreed, agreed, or were undecided that scientists' observations will be the same because scientists are objective, and observations are facts. These Likert results suggested that while most participants held informed views of *Observations and Inferences*, some participants held the misconception that scientists' observations of the same event would be the same because observations are objective.

Table 13

Percentages of Participants' Likert Answers for Observations and Inferences

	Percentages of Participants' Answers				
Likert Item	SA	A	UD	D	SD
A. Scientists' observations of the same event may be different because the scientists' prior knowledge may affect their observations.	23.1	64.1	8.8	3.2	.8
B. Scientists' observations of the same event will be the same because scientists are objective.	1.9	11.7	21.8	54.3	10.4
C. Scientists' observations of the same event will be the same because observations are facts.	1.9	14.6	12.8	54.5	16.2
D. Scientists may make different interpretations based on the same observations.	27.1	64.6	5.6	2.1	.5

Constructed-response items. The SUSSI constructed-response item for *Observations and Inferences* states, "With examples, explain why you think scientists' observations and interpretations are the same OR different" (Liang et al., 2006, p. 28). When scoring this constructed-response item, Liang et al. (2006) provided the following description for what participants should know concerning *Observations and Inferences*:

> Science is based on both observations and inferences. Observations are descriptive statements about natural phenomena that are directly accessible to

human senses (or extensions of those senses) and about which observers can reach consensus with relative ease. Inferences are interpretations of those observations. Perspectives of current science and the scientist guide both observations and inferences. Multiple perspectives contribute to valid multiple interpretations of observations. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of *Observations and Inferences* did not provide a classifiable view for *Observations and Inferences* (e.g., "no comment," "aidjksjld," "next"). Participants who received a naïve score (1) identified they did not know the answer or denoted an understanding that observations and inferences had the same meaning. Participants who received a transitional score (2) indicated that observations and differences were different, but, they either did not provide an informed explanation as to why they are different, or a misconception was identified in their explanation. Participants who received an informed score (3) indicated why observations and inferences are different and provided an example as to what would cause scientists' observations and inferences to be different (e.g. cultural background, biases, religious beliefs). Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of *Observations and Inferences* through the constructed-response item, 8.2% of participants scored 'not applicable', 18.9% scored 'naïve', 50% scored 'transitional', and 23.1% scored 'informed'. Participants' mean constructed-response score for *Observations and Inferences* was 1.9, which suggested participants held an overall 'naïve' to 'transitional' view when assessed through a constructed-response item. Table 14 provides common themes identified in participants' constructed-response answers for *Observations and Inferences*. 50% of participants were able to identify that observations and inferences are different, but many participants did not identify what causes them to be different. 23.7% of participants stated, "…because everyone interprets things differently." 23.1% of participants referenced a scientist's culture, background, previous experience, etc., as factors that influence observations and inferences. The constructed-response results suggested that most participants held naïve/transitional views about *Observations and Inferences,* lacking not the understanding that observations and inferences are different, but rather why and what causes them to be different. Further, few participants held informed views of *Observations and Inferences.*

Table 14

Common Themes for Observations and Inferences Constructed-Response Answers

Scored View	Response	Frequency	Percentage Within Same NOS View	Percentage Within Total Sample (N=376)
(1) Naïve (n = 71)	Observations and Inferences are different only when the methods used by the scientists are different.	23	32.4%	6.1%
	Observations and inferences are the same because scientists conduct science in the same way; when the experiment is replicated, they will get the same results.	14	19.7%	3.7%
(2) Transitional (n = 188)	Observations and Inferences are different because	89	47.3%	23.7%

	everyone interprets things differently.			
	Observations and Inferences are different because scientists have different opinions.	22	11.7%	5.9%
	Observations and Inferences are different, but they should be the same.	12	6.4%	3.2%
	Observations and Inferences are different because cultures are different (no further explanation provided).	9	4.8%	2.4%
	Observations are what scientists see and interpretations explain what they see.	9	4.8%	2.4%
(3) Informed (n = 87)	Scientists' prior knowledge and/or past experiences play a role in their observations and inferences.	30	34.5%	8%
	Scientists' cultural environments and/or their backgrounds play a role in their observations and inferences.	25	28.7%	6.6%
	Scientists' "biases" play a role in their observations and inferences.	17	19.5%	4.5%
	Scientists' personal beliefs play a role in	6	6.9%	1.6%

	their observations and inferences.				

Theme 2: Tentative Nature of Scientific Theories

Likert items. When analyzing participants' views of the *Tentative Nature of Scientific Theories* through the Likert items, 2.4% of participants scored 'naïve', 56.9% scored 'transitional', and 40.4% scored 'informed'. Participants' mean Likert score for the *Tentative Nature of Scientific Theories* was 2.4, which suggested participants held an overall 'transitional' to 'informed' view when assessed through Likert items. Table 15 provides a summary of participants' scores on the Likert items for the *Tentative Nature of Scientific Theories.* Over 80% of participants reflected views that scientific theories can change in light of new evidence. 50% of participants, however, indicated a view that scientific theories will not change if they are based on accurate experimentation. The Likert results suggested that while most participants held informed views of the *Tentative Nature of Scientific Theories,* many also held the misconception that scientific theories will not change if they are based on accurate experimentation.

Table 15

Percentages of Participants' Likert Answers for Tentative Nature of Scientific Theories

	Percentages of Participants' Answers				
Likert Item	SA	A	UD	D	SD
A. Scientific theories are subject to on-going testing and revision.	23.1	64.1	8.8	3.2	.8
B. Scientific theories may be completely replaced by new theories in light of new evidence.	34.8	52.9	8.8	3.2	.3
C. Scientific theories may be changed because scientists reinterpret existing observations.	18.4	66.2	10.9	4.3	.3

D. Scientific theories based on accurate experimentation will not be changed.	20.2	11.2	18.6	47.3	2.7

Constructed-response items. The SUSSI constructed-response item for the *Tentative Nature of Scientific Theories* states, "With examples, explain why you think scientific theories do not change OR how (in what ways) scientific theories may be changed" (Liang et al., 2006, p. 28). When scoring this constructed-response item*,* Liang et al. (2006) provided the following description for what participants should know concerning the *Tentative Nature of Scientific Theories*:

> Scientific knowledge is both tentative and durable. Having confidence in scientific knowledge is reasonable while realizing that such knowledge may be abandoned or modified in light of new evidence or reconceptualization of prior evidence and knowledge. The history of science reveals both evolutionary and revolutionary changes. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of the *Tentative Nature of Scientific Theories* did not provide a classifiable view (e.g., "no comment," "aidjksjld," "next"). Participants who received a 'naïve' score (1) identified they did not know the answer, theories do not change, or theories are always changing. Participants who received a 'transitional' score (2) identified theories can change but did not provide an explanation, or a misconception was identified in their explanation. For example, many participants who scored 'transitional' (12.7%) projected a view that a scientific theory could change because it is not proven, like a law. Although these participants identified that scientific theories could change, they held the misconception that a law is proven and cannot change. Participants who received an 'informed' score

(3) identified theories can change in light of new evidence, and provided examples (e.g., improved technology, evidence, data). Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of the *Tentative Nature of Scientific Theories* through the constructed-response item, 8.2% of participants scored 'not applicable', 15.9% scored 'naïve', 31.3% scored 'transitional', and 44.4% scored 'informed'. Participants' mean constructed-response score for the *Tentative Nature of Scientific Theories* was 2.3, which suggested participants held an overall 'transitional' to 'informed' view when assessed through constructed-response items. Table 16 provides the common themes identified in participants' constructed-response answers for the *Tentative Nature of Scientific Theories*. There were three main misconceptions identified in participants' constructed-response answers for the *Tentative Nature of Scientific Theories*: 1) Theories do not change; 2) Scientific theories always change or are easily changed; and 3) Scientific theories can change because they are not proven like laws. The constructed-response results suggested many participants held informed views of *Tentative Nature of Scientific Theories,* but many participants also held misconceptions towards how and why scientific theories could change.

Table 16

Common Themes for Tentative Nature of Scientific Theories Constructed-Response Answers

View	Response	Frequency	Percentage Within Same NOS Theme	Percentage Within Total Sample (N= 376)
(1) Naïve (n = 60)	Theories do not change.	33	55%	8.8%

	Theories are always changing.	24	40%	6.4%
2) Transitional (n = 118)	Theories can easily be changed.	78	66.1%	20.7%
	Theories can change because they are not proven like laws.	15	12.7%	4%
	New scientific methods provide different results and cause a theory to change.	9	7.6%	2.4%
	Theories can change based on the interpretation of the theory.	6	5.1%	1.6%
(3) Informed (n = 167)	Theories may change in light of new evidence (provided examples but did not mention the reliability of a scientific theory).	147	88.6%	39.1%
	Theories are reliable but can change in light of new evidence.	18	10.8%	4.8%

Theme 3: Scientific Laws and Theories

Likert items. When analyzing participants' views of *Scientific Laws and Theories* through the Likert items, 32.7% of participants scored 'naïve', 67.0% scored 'transitional', and .3% scored 'informed'. Participants' mean Likert score for *Scientific Laws and Theories* was 1.7, which suggested participants held an overall 'naïve' to 'transitional' views when assessed through Likert items. Table 17 provides a summary of participants' scores on the Likert items for *Scientific Laws and Theories.* The Likert results identified that a majority of participants held several misconceptions about *Scientific Laws and Theories.* Over 50% of participants strongly agreed/agreed that: 1) scientific theories already exist in the natural world and are uncovered through scientific investigation; 2) scientific laws do not change; 3) scientific laws are theories that have been proven; and 4) scientific theories do not explain scientific laws. The misconceptions identified in the Likert answers were further supported by the participants' constructed-response answers (see Table 18). The Likert results suggested most participants held misconceptions concerning *Scientific Laws and Theories.*

Table 17

Percentages of Participants' Likert Answers for Scientific Laws and Theories

	Percentages of Participants' Answers				
Likert Item	SA	A	UD	D	SD
A. Scientific theories exist in the natural world and are uncovered through scientific investigations.	13.3	63.0	18.4	4.3	1.1
B. Unlike theories, scientific laws are not subject to change.	17.0	39.1	15.2	24.7	4.0
C. Scientific laws are theories that have been proven.	25.0	54.8	9.0	7.4	3.7
D. Scientific theories explain scientific laws.	7.7	41.0	26.3	20.7	4.3

Constructed-response items. The SUSSI constructed-response item for *Scientific Laws and Theories* stated, "With examples, explain the nature of and difference between scientific theories and scientific laws" (Liang et al., 2006, p. 28). When scoring this constructed-response item, Liang et al. (2006) provided the following description for what participants should know concerning *Scientific Laws and Theories*:

> Both scientific laws and theories are subject to change. Scientific laws describe generalized relationships, observed or perceived, of natural phenomena under certain conditions. Scientific Theories are well-substantiated explanations of some aspect of the natural world. Theories do not become laws even with additional evidence; they explain laws. However, not all scientific laws have accompanying explanatory theories. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of *Scientific Laws and Theories* did not provide a classifiable view (e.g., "no comment," "aidjksjld," "next"). Participants who received a 'naïve' score (1) identified they did not know the answer, or they acknowledged there is a difference between a scientific theory and a scientific law, but a misconception was identified in their description of the difference. For example, many participants (47.3%) identified the difference between a scientific theory and a scientific law is that a law is proven, and a theory is not proven. Participants who received a 'transitional' score (2) indicated that scientific laws describe occurrences of natural phenomena while scientific theories are used to explain occurrences of the natural world, but a misconception(s) was identified in their response. For example, one participant wrote, "Laws are always true no matter how many times they are repeated whereas theories are explanations of the cause to an effect." While the participant acknowledged that scientific theories are explanations of occurrences, he/she also reflected a misconception in their understanding of a scientific law. Participants who received an 'informed' score (3) indicated that scientific laws describe occurrences of natural phenomena while scientific theories are used to explain occurrences of the natural world. Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of *Scientific Laws and Theories* through the constructed-response item, 9.3% of participants scored 'not applicable', 84.0% scored 'naïve', 1.6% scored 'transitional', and 5.1 % scored 'informed'. Similar to the mean Likert score for *Scientific Laws and Theories*, the participants' mean constructed-response score was a 1.2, which suggested participants held an overall 'naïve' to 'transitional' view when assessed through a constructed-response item. Table 18 provides the common themes identified in participants' constructed-response answers for *Scientific Laws and Theories*. The misconceptions identified through the constructed-response answers for *Scientific Laws and Theories* were the same misconceptions identified in the Likert results. The constructed-response results suggested most participants (over 84%) held naïve views about *Scientific Laws and Theories*, as well as many misconceptions.

Table 18

Common Themes for Scientific Laws and Theories Constructed-Response CR Answers

View	Response	Frequency	Percentage Within Same NOS Theme	Percentage Within Total Sample (N = 376)
(1) Naïve (n = 316)	Laws are proven, and theories cannot be proven.	178	56.3%	47.3%
	Laws are facts and theories are hypotheses or guesses.	42	13.3%	11.2%
	Theories can change, and laws are set in stone because they are fact.	29	9.2%	7.7%

	Theories will eventually become laws when they are proven.	27	8.5%	7.%2
	Laws have more evidence than theories.	6	1.9%	1.6%
(2) Transitional (n = 6)	Scientific laws describe occurrences of natural phenomena while scientific theories are used to explain occurrences of the natural world, but a misconception(s) was identified in their response.	6	100%	1.6%
(3) Informed (n = 19)	Scientific laws describe occurrences of natural phenomena while scientific theories are used to explain occurrences of the natural world.	19	100%	5.1%

Theme 4: Social and Cultural Influence on Science

Likert items. When analyzing participants' views of *Social and Cultural Influence on Science* through the Likert items, 11.2% of participants scored 'naïve', 60.9% scored 'transitional', and 27.9% scored 'informed'. Participants' mean Likert score for *Social and Cultural Influence on Science* was 2.2, which suggested participants held an overall 'transitional' to 'informed' view when assessed through Likert items. Table 19 provides a summary of participants' scores on the Likert items for *Social and Cultural Influence on Science.* While the majority of participants (over 50%) held informed views of *Social and Cultural Influence on Science,* several participants held naïve views. 20% of participants strongly agreed or agreed that science is not influenced by society and culture and 22% strongly agreed or agreed that all cultures conduct science in the same way. The Likert results suggested that while most participants held informed views of *Social and Cultural Influence on Science,* some participants held the misconception that science is objective and not influenced by society and culture.

Table 19

Percentages of Participants' Likert Answers for Social and Cultural Influence on Science

	Percentages of Participants' Answers				
Likert Item	SA	A	UD	D	SD
A. Scientific research is not influenced by society and culture because scientists are trained to conduct pure, unbiased studies.	3.7	16.8	16.8	51.3	1.4
B. Cultural values and expectations determine what science is conducted and accepted.	15.2	50.0	19.9	12.8	2.1
C. Cultural values and expectations determine how science is conducted and accepted.	15.4	49.5	16.0	16.8	2.4
D. All cultures conduct scientific research the same way because science is universal and independent of society and culture.	4.3	18.4	20.2	44.1	13.0

Constructed-response items. The SUSSI constructed-response item for *Social and Cultural Influence on Science* stated, "With examples, explain how society and culture affect OR do not affect scientific research" (Liang et al., 2006, p. 28). When scoring this constructed-response item*,* Liang et al. (2006) provided the following description for what participants should know concerning *Social and Cultural Influence on Science*:

> Scientific knowledge aims to be general and universal. As a human endeavor, science is influenced by the society and culture in which it is practiced. Cultural values and expectations determine what and how science is conducted, interpreted, and accepted. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of *Social and Cultural Influence on Science* did not provide a classifiable view (e.g., "no comment," "aidjksjld," "next"). Participants who received a 'naïve' score (1) identified they did not know the answer, or they indicated society and culture do not play a role in science. Participants who received a 'transitional' score (2) indicated society and culture do play a role in science but only mentioned one aspect of that role. For instance, many participants (15.7%) identified that society and culture influence what topics are explored in research but did not address how society and culture influence how research is interpreted and/or conducted. Participants who received an 'informed' score (3) identified that society and culture can influence all aspects of research, such as the topics that are explored, how research is conducted (e.g. funding), and the interpretation of research. Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of *Social and Cultural Influence on Science* through the constructed-response items, 7.2% of participants scored 'not applicable', 16.2% scored 'naïve', 69.1% scored 'transitional', and 7.4% scored 'informed'. Participants' mean constructed-response score for *Social and Cultural Influence on Science* was a 1.9, which suggested participants held an overall 'naïve' to 'transitional' view when assessed through a constructed-response item. Table 20 provides the common themes identified in participants' constructed-response answers for *Social and Cultural Influence on Science*. Similar to the Likert results, 16.2% participants held the misconception that science is not influenced by society and culture. 69.1% of participants acknowledged that science is influenced by society and culture but specified only one or two areas of science that are influenced. 7.4% of participants identified that society and culture can influence all areas of science. The constructed-response results suggested most of the participants held transitional views about *Social and Cultural Influence on Science* and few participants held informed views.

Table 20

Common Themes for Social and Cultural Influence on Science Constructed-Response Answers

View	Response	Frequency	Percentage Within Same NOS Theme	Percentage Within Total Sample (N = 376)
(1) Naïve (n = 61)	Society and culture do not play a role in science because scientists stick to the facts OR participant referenced to "The Scientific Method."	49	80%	13%
	Scientists are not influenced by society and culture because they are trained to only be objective.	7	11.5%	1.9%
(2) Transitional (n = 260)	Society and culture influence what type of research is conducted.	59	22.7%	15.7%

	Religion influences research.	56	21.5%	14.9%
	Personal beliefs, morals, and ethics influence research.	42	16.2%	11.2%
	Society and culture influence how research is interpreted.	41	15.8%	10.9%
	Society and culture influence how research is conducted / funding available.	15	5.8%	4.0%
	Technology influences research.	13	5%	3.5%
(3) Informed (n = 28)	Society and culture can influence all aspects of research, such as the topics that are explored, how research is conducted (e.g. funding), and the interpretation of research.	28	100%	7.4%

Theme 5: Imagination and Creativity in Scientific Investigations

Likert items. When analyzing participants' views of *Imagination and Creativity in Scientific Investigations* through the Likert items, 30.6% scored 'naïve', 55.9% scored 'transitional', and 13.9% scored 'informed'. Participants' mean Likert score for *Imagination and Creativity in Scientific Investigations* was 1.8, which suggested participants held an overall 'naive to 'transitional' view when assessed through Likert items. Table 21 provides a summary of participants' scores on the Likert items for *Imagination and Creativity in Scientific Investigations.* Like *Scientific Theories and*

Laws, a majority of participants held misconceptions concerning *Imagination and Creativity in Scientific Investigations.* 30% strongly agreed or agreed that scientists use their imagination and creativity to collect data. 42% strongly agreed or agreed that scientists use their imagination and creativity to analyze and interpret data. Over 25% held the understanding that scientists do not use their imagination and creativity because science is objective and requires logical reasoning. The Likert results suggested that while many participants held informed views about *Imagination and Creativity in Scientific Investigations*, many participants held the view that creativity and science is not used in science.

Table 21

Percentages of Participants' Likert Answers for Imagination and Creativity in Scientific Investigations

	Percentages of Participants' Answers				
Likert Item	SA	A	UD	D	SD
A. Scientists use their imagination and creativity when they collect data.	3.2	27.7	22.1	35.4	11.7
B. Scientists use their imagination and creativity when they analyze and interpret data.	7.4	34.8	22.6	27.7	7.4
C. Scientists do **not** use their imagination and creativity because these conflict with their logical reasoning.	6.9	18.1	22.9	43.4	8.8
D. Scientists do **not** use their imagination and creativity because these can interfere with objectivity.	7.2	20.7	23.9	38.6	9.6

Constructed-response items. The SUSSI constructed-response item for *Imagination and Creativity in Scientific Investigations* stated, "With examples, explain how and when scientists use imagination and creativity OR do not use imagination and creativity (Liang et al., 2006, p. 29). When scoring this constructed-response item, Liang et al. (2006) provided the following description for what participants should know concerning *Imagination and Creativity in Scientific Investigations*:

> Science is a blend of logic and imagination. Scientific concepts do not emerge automatically from data or from any amount of analysis alone. Inventing hypotheses or theories to imagine how the world works and then figuring out how they can be put to the test of reality is as creative as writing poetry, composing music, or designing skyscrapers. Scientists use their imagination and creativity throughout their scientific investigations. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of *Imagination and Creativity in Scientific Investigations* did not provide a classifiable view (e.g., "no comment," "aidjksjld," "next"). Participants who received a 'naïve' score (1) indicated they did not know the answer or that scientists do not use creativity or imagination when conducting science. Participants who received a 'transitional' score (2) indicated that creativity and imagination do play a role in science, but specified they are only used in one or two areas of science (e.g., to develop hypothesis or to interpret results). Participants who received an 'informed' score (3) identified creativity and imagination can be used in all areas of science. Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of *Imagination and Creativity in Scientific Investigations* through the Likert items, 8% of participants scored 'not applicable', 22.3% scored 'naïve', 67.8% scored 'transitional', and 1.9% scored 'informed'. Similar to the mean Likert score for *Imagination and Creativity in Scientific Investigations,* participants' mean constructed-response score was 1.9, which suggested participants held an overall 'naïve' to 'transitional' view when assessed through constructed-response items. Table 22 provides a summary of participants' scores on the constructed-response items for *Imagination and Creativity in Scientific Investigations.* 8% of participants identified that imagination and creativity is not used in science because science is objective. 67.8% of participants held the view that imagination and creativity is used in science but identified that it is only used in one area of research (e.g., interpretation or design), and not all areas. 1.9% of participants indicated an informed view that imagination and creativity is used in all areas of science. The constructed-response results suggested most participants held misconceptions concerning *Imagination and Creativity in Scientific Investigations*.

Table 22

Common Themes for Imagination and Creativity in Scientific Investigations Constructed-Response Answers

View	Response	Frequency	Percentage Within Same NOS Theme	Percentage Within Total Sample (N = 376)
(1) Naïve (n = 84)	Imagination and Creativity are not used in science because scientists only use facts.	16	19.0%	4.3%
	If scientists used imagination and creativity, the results would not be accurate/correct.	10	11.9%	2.7%
	Imagination and Creativity are not used	5	5.95%	1.3%

	in science because all scientists use "The Scientific Method".			
(2) Transitional (n = 255)	Imagination and Creativity are only used to design experiments.	98	38.4%	26.1%
	Imagination and Creativity are only used to interpret data.	61	23.9%	16.2%
	Imagination and Creativity are only used to develop theories.	40	15.7%	10.6%
	Imagination and Creativity are only used when conducting experiments (e.g., collecting data)	23	9.0%	6.1%
	Imagination and Creativity are only used when deciding how to display the results.	5	2.0%	1.3%
	Imagination and Creativity are added by scientists' beliefs/bias.	5	2.0%	1.3%
(3) Informed (n = 7)	Creativity and imagination can be used in all areas of science.	7	100%	1.9%

Theme 6: Methodology in Scientific Investigations.

Likert items. When analyzing participants' views of *Methodology in Scientific Investigations* through the Likert items, 6.1% scored 'naïve', 85.6% scored 'transitional', and 8.2% scored 'informed'. Participants' mean Likert score for *Methodology in Scientific Investigations* was 2.0, which suggested participants held an overall ‘transitional’ view when assessed through Likert items. Table 23 provides a summary of participants’ scores on the Likert items for *Methodology in Scientific Investigations.* The Likert results for *Methodology in Scientific Investigations* were found to be conflicting. For example, 80% of participants strongly agreed or agreed that scientists use many different methods to conduct science, but 50% of the participants also strongly agreed or agreed that science is only conducted by a step-by-step scientific method. Further, 44% of participants strongly agreed or agreed that when science is conducted via “the scientific method”, the results are true and accurate. The Likert results suggested that while a majority of the participants held the view that scientists conduct science using many different methods, half of the participants held the misconception that “the scientific method” is the best method for scientists to use.

Table 23

Percentages of Participants’ Likert Answers for Methodology in Scientific Investigations

		Percentages of Participants’ Answers			
Likert Item	SA	A	UD	D	SD
A. Scientists use different types of methods to conduct scientific investigations.	24.2	55.1	10.9	8.5	1.3
B. Scientists follow the same step-by-step scientific method.	9.8	40.4	17.3	30.1	2.4
C. When scientists use the scientific method correctly, their results are true and accurate.	6.1	38.0	31.4	21.0	3.5
D. Experiments are not the only means used in the development of scientific knowledge.	16.2	59.3	13.8	9.8	.8

Constructed-response items. The SUSSI constructed-response item for *Methodology in Scientific Investigations* stated, "With examples, explain whether scientists follow a single, universal scientific method OR use different types of methods (Liang et al., 2006, p. 29). When scoring this constructed-response item, Liang et al. (2006) provided the following description for what participants should know concerning *Methodology in Scientific Investigations*:

> Scientists conduct investigations for a wide variety of reasons. Different kinds of items suggested different kinds of scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding. There is no single universal step-by-step scientific method that all scientists follow. Scientists investigate research with prior knowledge, perseverance, and creativity. Scientific knowledge is gained in a variety of ways including observation, analysis, speculation, library investigation and experimentation. (p. 30)

Participants who received a 'not applicable' score (0) for their understanding of *Methodology in Scientific Investigations* did not provide a classifiable view (e.g., "no comment," "aidjksjld," "next"). Participants who received a 'naïve' score (1) indicated they did not know the answer or that there is only one universal method that scientists use to conduct science. Participants who received a 'transitional' score (2) indicated there are different methods but they did not explain their answer, or they identified that although different methods are used to conduct science, these methods are still variations from "The Scientific Method." Participants who received an 'informed' score (3) identified that science can be conducted in many different ways. Additionally, responses that received a score of (3) contained no misconceptions.

When analyzing participants' views of *Methodology in Scientific Investigations* through the constructed-response items, 9% of participants scored 'not applicable', 50% scored 'naïve', 32.4% scored 'transitional', and 8.5% scored 'informed'. Participants' mean constructed-response score for *Methodology in Scientific Investigations* was 1.5, which suggested participants held an overall 'naïve' to 'transitional' view when assessed through a constructed-response item. Table 24 provides the common themes identified in participants' constructed-response answers for *Methodology in Scientific Investigations*. Similar to the findings of the Likert items, 50% of participants held the view that there is only one way to do science, or they referenced "the scientific method". Many of those who acknowledged science is conducted through many different methods also suggested "the scientific method" should be used or did not explain why different methods are used. Further, 8.5% of participants reflected informed views of *Methodology in Scientific Investigations* and identified that the type of research being investigated should determine the type of scientific method utilized. The constructed-response results suggested that many participants held naïve/transitional views and many misconceptions about *Methodology in Scientific Investigations.*

Table 24

Common Themes for Methodology in Scientific Investigations Constructed-Response Answers

View	Response	Frequency	Percentage Within Same NOS Theme	Percentage Within Total Sample (N = 376)
(1) Naïve (n = 188)	There is only one way to conduct science.	98	52.1%	26.1%

	All scientists use "The Scientific Method" to conduct science.	90	47.9%	23.9%
(2) Transitional (n = 122)	There is not one universal method because every culture has its own way of conducting research.	22	18.9%	5.9%
	Science can be conducted in different ways, but most scientists follow, "The Scientific Method".	21	17.2%	5.6%
(3) Informed (n = 32)	Science can be conducted in many different ways.	32	100%	8.5%

Conclusion

The results of the SUSSI Likert items and constructed-response items suggested that for all six of the NOS themes, few participants held informed views and most participants held naïve or transitional views. Further, many common misconceptions were identified through the constructed-responses answers. Discussion concerning these findings, for both the Likert items and the constructed-response items, is provided in Chapter V.

Exploring the Influence of Demographic Variables on SUSSI Scores

Research Question #4 asked, "*Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen*?" For each of the six NOS themes assessed in the SUSSI, statistical analyses utilizing SPSS software were conducted to explore differences in the mean Likert and constructed-response scores, for each of the ten demographic variables explored in this current study. The following results are presented in two sections: the first section provides the statistical results for those NOS themes that did not identify any significance differences in the Likert scores/constructed-response scores between/among the demographic variables. The second section provides the statistical results for those NOS themes that identified significance differences in the Likert scores/constructed-response scores between/among the demographic variables.

Insignificant Results

When analyzing statistical differences between/among the demographic variables for the Likert scores and the constructed-response scores of each NOS theme, no statistical differences were identified *for Theme 1: Observations and Inferences*, or for *Theme 3: Scientific Laws and Theories*. Table 25 provides the statistical results for *Observations and Inferences*. Table 26 provides the statistical results for *Scientific Laws and Theories*. These findings are further discussed in the next chapter.

Table 25

Statistical Analysis for Theme 1: Observations and Inferences

Demographic Variables	Likert-Scale t, F, or correlation value	Constructed-Response t, F, or correlation
STEM Major	t(374) = 1.73, ns	t(374) = .56, ns
Gender	t(372) = -1.44, ns	t(372) = .76, ns
High School Community	F(2, 373) =.01, ns	F(2, 373) = .70, ns
Religious Views	F(3, 372) = .02, ns	F(3, 372) = .44, ns
Religion Importance	r_2 = -.03, ns	r_2 = -.002, ns
Political Views	F(2, 373) = .92, ns	F(2, 373) = .36, ns
Science Classes Taken	r_2 = .08, ns	r_2 = .04, ns
Taught about Evolution	t(374) = .41, ns	t(374) = 1.87, ns
Taught about Creationism	t(374) = .78, ns	t(374) = -.58, ns

Tuition Status	t(374) = .20, ns	t(374) = .58, ns

Table 26

Statistical Analysis for Theme 3: Scientific Laws and Theories

Demographic Variables	Likert-Scale t, F, or correlation	Constructed-Response t, F, or correlation
STEM Major	t(374) = .71, ns	t(374) = .56, ns
Gender	t(372) = .48, ns	t(372) = .90, ns
High School Community	F(2, 373) = .34, ns	F(2, 373) = .39, ns
Religious Views	F(3, 372) = 1.45, ns	F(3, 372) = 1.21, ns
Religion Importance	r_2 =.02, ns	r_2 =.01, ns
Political Views	F(2, 373) = .90, ns	F(2, 373) = 1.62, ns
Science Classes Taken	r_2 =.06, ns	r_2 =.05, ns
Taught about Evolution	t(374) = 1.34, ns	t(374) = .43, ns
Taught about Creationism	t(374) = -.95, ns	t(374) = -1.76, ns
Tuition Status	t(374) = .79, ns	t(374) = .55, ns

Significant Results

When analyzing statistical differences between/among the demographic variables for the Likert scores and the constructed-response scores of each NOS theme, statistical differences were identified for the *Tentative Nature of Scientific Theories*, *Social and Cultural Influence on Science*, *Imagination and Creativity in Scientific Investigations*, and *Methodology in Scientific Investigations*. The statistical findings for each of these NOS themes are presented below.

Theme 2: Tentative nature of scientific theories. When exploring the mean Likert scores for the *Tentative Nature of Scientific Theories*, significant differences were found to exist among the number of science classes taken in high school. When exploring the mean constructed-response scores for the *Tentative Nature of Scientific Theories*, significant differences were found to exist between gender, among high school community, between those who were taught about creationism in high school and those who were not. Table 27 provides the statistical results for the *Tentative Nature of Scientific Theories*.

Table 27

Statistical Analysis for Theme 2: Tentative Nature of Scientific Theories

Demographic Variables	Likert-Scale t, F, or correlation value	Constructed-Response t, F, or correlation value
STEM Major	t(374) = -.16, ns	t(374) = 1.04, ns
Gender	t(372) = .37, ns	t(372) = 2.09, p = .04
High School Community	F(2, 373) = .14, ns	F(2, 373) = 4.50, p = .01
Religious Views	F(3, 372) = .57, ns	F(3, 372) = 1.63, ns
Religion Importance	r_2 = -.04, ns	r_2 = .05, ns
Political Views	F(2, 373) = .09, ns	F(2, 373) = 2.40, ns
Science Classes Taken	r_2 = -.11, $p < .05$	r_2 = .06, ns
Taught about Evolution	t(374) = 1.30, ns	t(374) = 1.39, ns
Taught about Creationism	t(374) = -.68, ns	t(374) = -2.14, p = .03
Tuition Status	t(374) = 1.21, ns	t(374) = .10, ns

Science classes taken in high school. A significant correlation was found when examining differences in the Likert scores of the *Tentative Nature of Scientific Theories* and number of science classes taken in high school. A Spearman's correlation of -.11 was produced. While this value is statistically significant at $p < .05$, it had a very weak correlation. These results suggested the number of science classes participants took in high school did not substantially influence their Likert score when addressing the *Tentative Nature of Scientific Theories*.

Gender. An independent t-test was conducted to compare the mean constructed-response scores for the *Tentative Nature of Scientific Theories* between males and females. Males scored significantly higher (M = 2.27, SD = .89) than females (M = 2.02, SD = 1.01); t(372) = 2.09, p = .04. However, the effect size (d = .26) indicated small practical significance. These results suggested participants' gender did not substantially influence their constructed-response answer when addressing the *Tentative Nature of Scientific Theories*.

High school community. An ANOVA was conducted to compare the constructed-response scores for the *Tentative Nature of Scientific Theories* among the different high school communities: rural, urban, and suburban. The ANOVA identified a significant difference among the mean constructed-response scores: F(2, 373) = 4.50, p = .01. Table 28 provides the ANOVA summary table. Post hoc analysis using a Tukey HSD identified a significant difference in mean constructed-response scores between the urban and suburban groups (p = .02), but not between the rural and urban groups (p = .80), or the rural and suburban groups (p = .08). Table 29 provides the means and standard deviations for each group. Further, the effect size ($\eta^2 = 0.02$) indicated small practical significance. These results suggested participants' high school community did not substantially influence their constructed-response answers when addressing the *Tentative Nature of Scientific Theories*.

Table 28

ANOVA Summary Table for High School Community

	SS	df	Mean Square	F	Sig
Between	8.13	2	4.07	4.50	.01
Within	337.48	373	.91		
Total	345.61				

Table 29

Means and Standard Deviations for Groups of High School Community

Group	M	*SD*
Rural	2.02	.95
Urban	1.93	1.02
Suburban	2.27	.92

Exposure to the teachings of creationism. An independent t-test was conducted to compare the mean constructed-response scores for the *Tentative Nature of Scientific Theories* between those who were taught about creationism in high school and those who were not. Those who were taught about creationism scored significantly lower (M = 1.95, SD = .96) than those who were not taught about creationism (M = 2.12, SD = .95); t(374) = -2.14, p = .03. However, the effect size (d = .18) indicated small practical significance. These results suggested participants' exposure to the teaching of creationism in high school did not substantially influence their constructed-response answer when addressing the *Tentative Nature of Scientific Theories*.

Theme 4: Social and cultural influence on science. When exploring the mean Likert scores for *Social and Cultural Influence on Science*, no significant differences were found to exist. When exploring the mean constructed-response scores for *Social and Cultural Influence on Science*, significant differences were found to exist among the number of science classes taken in high school. Table 30 provides the statistical results for *Social and Cultural Influence on Science*.

Table 30

Statistical Analysis for Theme 4: Social and Cultural Influence on Science

Demographic Variables	Likert-Scale t, F, or correlation value	Constructed-Response t, F, or correlation value
STEM Major	t(374) = .30, ns	t(374) = 1.61, ns
Gender	t(372) = .86, ns	t(372) = 1.36, ns
High School Community	F(2, 373) = .70, ns	F(2, 373) = 2.42, ns
Religious Views	F(3, 372) = .59, ns	F(3, 372) = .11, ns
Religion Importance	r_2 =-.03, ns	r_2 =.02, ns
Political Views	F(2, 373) = .08, ns	F(2, 373) = .78, ns
Science Classes Taken	r_2 =.08, ns	r_2 =.15, p = .004
Taught about Evolution	t(374) = .71, ns	t(374) = .46, ns
Taught about Creationism	t(374) = 1.50, ns	t(374) = -.66, ns
Tuition Status	t(374) = -.29, ns	t(374) = .35, ns

Number of science classes taken in high school. When examining differences in mean constructed-response scores for *Social and Cultural Influence on Science* and the number of science classes taken in high school, a Spearman's correlation of .15 was produced. While this value is statistically significant at p = .004, the relationship had a very weak correlation of r_2 = .15. These results suggested participants' number of science classes taken in high school did not substantially influence their constructed-response when addressing *Social and Cultural Influence on Science.*

Theme 5: Imagination and creativity in scientific investigations. When exploring the mean Likert scores for *Imagination and Creativity in Scientific*

Investigations, significant differences were found to exist among high school community and number of science classes taken in high school. When exploring the mean constructed-response scores for *Imagination and Creativity in Scientific Investigations*, no significant differences were found to exist. Table 31 provides the statistical results for *Imagination and Creativity in Scientific Investigations*.

Table 31

Statistical Analysis for Theme 5: Imagination and Creativity in Scientific Investigations

Demographic Variables	Likert-Scale t, F, or correlation value	Constructed-Response t, F, or correlation value
STEM Major	t(374) = -.16, ns	t(374) = 1.94, ns
Gender	t(372) = .88, ns	t(372) = 1.35, ns
High School Community	F(2, 373) = 3.94, p = .02	F(2, 373) = 2.64, ns
Religious Views	F(3, 372) = .29, ns	F(3, 372) = .50, ns
Religion Importance	r_2 =.04, ns	r_2 =-.05, ns
Political Views	F(2, 373) = 1.36, ns	F(2, 373) = .24, ns
Science Classes Taken	r_2 =.11, $p < .05$	r_2 =.10, ns
Taught about Evolution	t(374) = 1.84, ns	t(374) = 1.51, ns
Taught about Creationism	t(374) = .95, ns	t(374) = -1.16, ns
Tuition Status	t(374) = -.13, ns	t(374) = -1.07, ns

High school community. An ANOVA was conducted to compare the Likert-scores for *Imagination and Creativity in Scientific Investigations* among the different high school communities: rural, urban, and suburban. The ANOVA identified a significant difference among the mean Likert scores: F(2, 373) = 3.94, p = .02. Table 32 provides the ANOVA summary table. Post hoc analysis using a Tukey HSD identified a significant difference in mean Likert scores between the rural and suburban groups (p =

.02), but not between the rural and urban groups (*p* = .17), or the urban and suburban groups (*p* = .84). Table 33 provides the means and standard deviations for each group. Further, the effect size ($\eta^2 = 0.02$) indicated small practical significance. These results suggested participants' high school community did not substantially influence their Likert answers when addressing *Imagination and Creativity in Scientific Investigations*.

Table 32

ANOVA Summary Table for High School Community

	SS	df	Mean Square	F	Sig
Between	3.2	2	1.60	3.94	.02
Within	151.90	373	.41		
Total	155.11	375			

Table 33

Means and Standard Deviations for High School Community

Group	*M*	*SD*
Rural	1.68	.60
Urban	1.86	.65
Suburban	1.9	.65

Number of science classes taken in high school. When examining differences in mean constructed-response scores for *Imagination and Creativity in Science* and the number of science classes taken in high school, a Spearman's correlation of .11 was produced. While this value is statistically significant at $p < .05$, the relationship had a very weak correlation of $r_2 = .11$. These results suggested participants' number of science classes taken in high school did not substantially influence their constructed-response when addressing *Imagination and Creativity in Science.*

Theme 6: Methodology in scientific investigations. When exploring the mean Likert scores for *Methodology in Scientific Investigations*, no significant differences were found to exist. When exploring the mean constructed-response scores for *Methodology in Scientific Investigations*, significant differences were found to exist between those who were taught about the Theory of Evolution in high school and those who were not. Table 34 provides the statistical results for *Methodology in Scientific Investigations.*

Table 34

Statistical Analysis for Theme 6: Methodology in Scientific Investigations

Demographic Variables	Likert-Scale t, F, or correlation value	Constructed-Response t, F, or correlation value
STEM Major	t(374) = .14, ns	t(374) = 1.35, ns
Gender	t(372) = -.61, ns	t(372) = -1.06, ns
High School Community	F(2, 373) = .37, ns	F(2, 373) = .40, ns
Religious Views	F(3, 372) = .58, ns	F(3, 372) = 1.31, ns
Religion Importance	r_2 =-.05, ns	r_2 = -.10, ns
Political Views	F(2, 373) = 1.64, ns	F(2, 373) = .57, ns
Science Classes Taken	r_2 =.06, ns	r_2 = .03, ns
Taught about Evolution	t(374) = -.43, ns	t(374) = 2.26, *p* = .02
Taught about Creationism	t(374) = -.70, ns	t(374) = -1.13, ns
Tuition Status	t(374) = -.75, ns	t(374) = -.16, ns

Exposure to the teachings of evolution. An independent t-test was conducted to compare the mean constructed-response scores for *Methodology in Scientific Investigations* between those who were taught about the Theory of Evolution in high school and those who were not. There was a significant difference in the scores for those who were taught about evolution (*M* = 1.5, *SD* = .77) and those who were not (*M* = 1.23, *SD* = .73); t(374) = 2.26, *p* = .02. However, the effect size (*d* = .29) indicated small practical significance. These results suggested participants' exposure to the teachings of the evolution in high school did not substantially influence their constructed-response answer when addressing *Methodology in Scientific Investigations.*

Results Section 4: Relationship Between Acceptance of Evolution and Views of NOS

Research Question #5: *Does a relationship exist between acceptance of the Theory of Evolution and views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?* Research Question #6: *If a relationship is found to exist, how do specific demographic variables moderate the relationship between participants' acceptance of the Theory of Evolution and their views of NOS?*

To explore Research Questions #5 and #6, Pearson correlations were obtained between the mean MATE score and the mean Likert score for each NOS theme, as well as between the mean MATE score and the mean constructed response score for each NOS theme. Table 35 shows the Pearson correlation values.

Table 35

Pearson Correlations Between MATE score and the SUSSI Likert (LS) and Constructed-Response (CR) Scores

	LS1	CR1	LS2	CR2	LS3	CR3	LS4	CR4	LS5	CR5	LS6	CR6
Correl.	.09	.08	-.03	.18**	.19**	.16**	.00	.12*	.07	.11*	.00	-.01

*$p < .05$ **$p < .01$

No significant correlations were found to exist between the MATE scores and the SUSSI Likert/constructed-response scores for *Theme 1: Observation and Inferences* or *Theme 6: Methodology in Scientific Investigations*. When exploring *Theme 2: Tentative Nature of Scientific Theories*, a weak, positive correlation was found between the MATE scores and the constructed-response scores only (r = .18, $p < .01$). When exploring

Theme 3: Scientific Laws and Theories, a weak, positive correlation was found to exist between the MATE scores and the Likert-scale scores (r =.19, p <. 01) and the constructed-response scores (r =.16, $p < .01$). When exploring *Theme 4: Social and Cultural Influence on Science*, a weak, positive correlation was found to exist between the MATE scores and the constructed-response scores (r =.12, $p = .02$). Further, when exploring *Theme 5: Imagination and Creativity in Scientific Investigations*, a very weak, positive correlation was found between the MATE scores and the constructed-response scores (r =.11, $p = .03$). These results suggested there is not a substantially significant relationship between the MATE scores and the SUSSI scores.

Research Question #6 asked, "If a relationship is found to exist, how do specific demographic variables moderate the relationship between the acceptance of the Theory of Evolution and views of NOS?" Since the few significant correlations were identified as weak correlations, the researcher did not further explore how the demographic variables moderated the relationship between the acceptance of the Theory of Evolution and the views of NOS.

Summary

The purpose of this study was to explore the acceptance of the Theory of Evolution and views of NOS held by freshmen undergraduates attending a research university in Oklahoma. Further, this study explored if a relationship existed between participants' acceptance of the Theory of Evolution and their views of Nature of Science. The results presented in this chapter suggested participants held moderate acceptance of the Theory of Evolution, as well as many naïve/transitional views of NOS. Also, a relationship between participants' acceptance of the Theory of Evolution and their views of NOS was not found to exist. Further discussion of these findings, along with implications for future research, is provided in Chapter V.

CHAPTER V

DISCUSSION OF RESULTS

The purpose of this study was to explore the acceptance of the Theory of Evolution and the views of Nature of Science (NOS) held by undergraduate freshmen enrolled at an Oklahoma research institution. Additionally, this study investigated the relationship between participants' acceptance of the Theory of Evolution and their views of NOS. This chapter discusses how the findings of this study can be of consideration for science educators in regard to implementation of the Theory of Evolution and/or NOS in their curriculum. This chapter is presented in the following four sections: 1) participants' acceptance of the Theory of Evolution; 2) participants' understandings of NOS; 3) the relationship between participants' acceptance of the Theory of Evolution and their views of NOS; and 4) implications for future research.

Discussion Section 1: Acceptance of the Theory of Evolution

Participants' Overall Acceptance of the Theory of Evolution

This study used the *Measurement of the Acceptance of the Theory of Evolution* (MATE) (Rutledge & Warden, 1999) instrument to assess 376 freshmen undergraduates' acceptance of the Theory of Evolution. With potential score ranges between 20-100, participants held a mean score of 71.7. According to the Level of Acceptance Scale, which is provided with the MATE instrument, participants held an overall moderate acceptance of the Theory of Evolution. These results are consistent with studies by Manwaring et al. (2015), who explored acceptance of the Theory of Evolution held by undergraduates of a Mormon population, and Nadelson and Hardy (2015), who also explored acceptance of the Theory of Evolution held by undergraduate students enrolled in a psychology course. Both studies found their participants to hold a moderate acceptance of the Theory of Evolution. However, the results of this current study were inconsistent to Rissler et al. (2014) and Rutledge and Sadler (2007), who identified that students who attend universities in the southern part of the United States are more likely to hold overall low acceptance of the Theory of Evolution.

The findings of this current study, in which most participants held a moderate or high acceptance of the Theory of Evolution, could be encouraging for college science educators as it suggests that despite the majority of the American public holding low acceptance of the Theory of Evolution, some American students are entering their college science classes holding moderate or high acceptance of the Theory of Evolution (Miller et al., 2006). Undergraduate acceptance of the Theory of Evolution is an important goal to achieve since the mechanisms of the Theory of Evolution are used to explain many of the advancements in science, technology, agriculture, and medicine in today's world (Heddy & Nadelson, 2012; Gould, 2002; Miller, 2006; Nadelson & Southerland, 2010). Therefore, it is important to identify if, and why, undergraduate students hold low acceptance of the Theory of Evolution, so that insight can be provided with how to enhance undergraduate acceptance of the Theory of Evolution. The following section will discuss the findings of this study in regard to these undergraduates' acceptance of the Theory of Evolution.

Demographic Variables with Insignificant Findings

To further explore participants' acceptance of the Theory of Evolution, the influence of specific demographic variables on acceptance of the Theory of Evolution were investigated. For each demographic variable explored, there were two to five options for participants to self-identify. For example, when exploring gender, participants could identify as "male," "female," "transgender," or "prefer not to respond," and when exploring high school community, participants could identify as "rural," urban," or "suburban." When conducting the statistical analysis for the MATE results, the mean MATE scores for each demographic variable was first identified. Statistical analysis (t-test/Analysis of Variance (ANOVA)/correlation) was then conducted to determine if significant differences occurred between/among the mean MATE scores for each option, within each demographic variable. This process was performed for each demographic variable. Demographic variables found to have *insignificant* differences included: identified major (science, technology, engineering, or mathematics [STEM] vs. non-STEM), gender, high school community, number of science classes taken in high school, exposure to the teachings of evolution and creationism in high school science classes, and whether the participant was classified as an in-state or out-of-state student. Demographic variables found to have significant differences included: religious beliefs, importance of religion, and political views. The following discussion is presented for each of the ten demographic variables explored.

Major. This study did not find participants' identified major (STEM vs. non-STEM) to significantly influence their acceptance of the Theory of Evolution. These results are consistent with Moore and Cotner (2009) and Nadelson and Hardy (2015), who also explored undergraduate students' acceptance of the Theory of Evolution and did not find significant differences among college majors. However, Rissler et al. (2014) identified that college science majors held a higher acceptance level than non-science majors. Peker et al. (2010) found that biology majors held a higher acceptance level of the Theory of Evolution when compared to non-biology majors.

While this study only explored acceptance of the Theory of Evolution held by undergraduate freshmen students, an implication for future research would be to explore if seniors in college held different levels of acceptance of the Theory of Evolution when compared to freshmen. This change of sample population would allow researchers to better explore the influence of declared major on students' acceptance of the Theory of Evolution. By comparing acceptance of those who had yet to complete their degree course work (freshmen) to those who had completed their degree course work (seniors) it would provide more insight of the influence of declared major on acceptance of the Theory of Evolution.

Gender. This study did not find significant differences in the acceptance of the Theory of Evolution between males and females. These results are consistent with Nadelson and Hardy (2015) who also explored acceptance of the Theory of Evolution held by undergraduate students and found no differences to exist in acceptance of the Theory of Evolution between males and females. This current study also has similar results to Barone et al. (2014), who explored acceptance of the Theory of Evolution held by males and females attending a museum and also found no difference between genders. However, the results of this current study differ from those found by Peker et al. (2010), who found that undergraduate females held a higher acceptance of the Theory of Evolution than undergraduate males. The limited number of studies exploring gender as a predictor for acceptance of the Theory of Evolution indicates there is a need for further research exploring the relationship.

High school community. This study did not find significant differences in the acceptance of the Theory of Evolution among participants who were entering college from a rural, suburban, or urban high school community. Research exploring the influence of the type high of school community on undergraduates' acceptance of the Theory of Evolution is limited. However, Mazur (2005), who analyzed national surveys exploring American citizens' views of the Theory of Evolution, found Americans who lived in rural areas were more likely to reject the Theory of Evolution compared to individuals who lived in urban areas.

Number of science classes taken. This study did not find significant differences in acceptance of the Theory of Evolution among the number of science classes taken in high school. Research exploring the influence of number of science classes taken on acceptance of the Theory of Evolution appears to be limited. Although this study did not explore participants' understanding/knowledge of the Theory of Evolution, many studies have found that as students' knowledge of the Theory of Evolution increases, so does their acceptance of the Theory of Evolution (Barone et al., 2014; Brown & Scott, 2016; Cotner et al., 2009, Nadelson & Southerland, 2010; Shtulman & Calabi, 2008).

Exposure to the teachings of evolution and creationism. This study did not find significant differences in acceptance of the Theory of Evolution between participants who were taught about the Theory of Evolution in their high school science classes and participants who were not. This study also did not find significant differences in acceptance of the Theory of Evolution between participants who were taught about creationism in their high school science classes and participants who were not. However, significant differences in acceptance were found to exist between participants who were taught about the Theory of Evolution and participants who were taught about creationism. Although the effect size was small, participants who were taught about the Theory of Evolution scored significantly higher on the MATE than those who were taught about creationism. Verhey (2005) explored differences in acceptance of the Theory of Evolution among undergraduate students and found no significant differences among students who had prior learning of the Theory of Evolution, creationism, or both. However, similar to this current study, Moore and Cotner (2009) and Rissler et al. (2014) found undergraduate students who had been taught about creationism in high school held a lower acceptance of the Theory of Evolution than those who were taught about the Theory of Evolution.

Moore and Cotner (2009) and Rissler et al. (2014) suggest undergraduates' level of acceptance of the Theory of Evolution is associated with the inclusion of evolution or creationism in the high-school biology course. When looking at the differences in the teaching of evolution/creationism between those attending the university on in-state and out-of-state tuition, 77% of in-state participants and 84% of out-of-state participants acknowledged they had been taught about the Theory of Evolution in their high school classes. Many science education organizations strongly support the teaching of the Theory of Evolution in school (e.g., NABT, 2011; AAAS, 2006; NSTA, 2013). Therefore, from a science education perspective, the results of this current study are encouraging, as they suggest that over 75% of the participants, both in-state and out-of-state, are being taught about the Theory of Evolution in their high school science classes.

When exploring the incorporation of creationism in the Oklahoma high school science curriculum, 32% of in-state participants and 22% of out-of-state participants acknowledged they had been taught about creationism. This is interesting because the teaching of creationism in the American public-school science classroom is illegal in the United States (U.S. Constitution). Berkman & Plutzer (2011), Moore (2002), and Rutledge & Mitchell (2002) all explored the teaching of the Theory of Evolution and creationism in American public schools and found that despite the Supreme Court rulings against the teachings of creationism, many public-school educators continue to implement it in their classrooms. This is problematic as the teaching of creationism is not based on scientific evidence, and therefore holds no value in the science classroom. Also, even if creationism were taught alongside the Theory of Evolution, Moore (2007) suggests it still encourages students to develop a misconception that scientific theories are mere speculations that are not based on rigorous scientific evaluations. To better understand the influence of the teaching of the Theory of Evolution and creationism on undergraduates' acceptance of the Theory of Evolution, more research is needed to explore the influence of these teachings in the science classrooms of Oklahoma's public schools.

In-state / out-of-state tuition status. This study did not find significant differences in acceptance of the Theory of Evolution between students who were attending the University on an in-state tuition status and those who were attending on an out-of-state tuition status. However, this specific demographic question, which intended to assess if participants graduated from an Oklahoma high school, did not ask participants to identify the exact state he/she graduated high school from. An implication for future research would be to ask participants to identify the state they graduated high school from and explore differences in acceptance of the Theory of Evolution among those states. This would better allow researchers to explore the influence of states' high school science curriculum on undergraduates' acceptance of the Theory of Evolution.

Demographic Variables with Significant Findings

Political views. This study found significant differences in acceptance of the Theory of Evolution among participants' political views. Those who identified with conservative political views held the lowest acceptance of the Theory of Evolution while those who identified with liberal political views held the highest acceptance. These findings are similar to other studies that also found individuals who hold more conservative political views as more likely to reject the Theory of Evolution than those who hold more liberal political views (Baker, 2013; Cotner et al., 2009; Lombrozo et al., 2008; Mazur, 2004; Nadelson & Hardy, 2015). When exploring why individuals with conservative political views also tend to hold a lower acceptance of the Theory of Evolution, literature suggests that individuals with conservative views are more likely to attend church regularly, compared to individuals who hold liberal views (Baker, 2013; Newport, 2008). Research also suggests that Americans who attend church regularly are more likely to reject the Theory of Evolution (Baker, 2013; Newport, 2008). Nadelson and Hardy (2015), who explored why individuals with conservative views tend to hold lower acceptance than individuals with liberal views, found that undergraduates with conservative political views also held lower levels of trust in science and scientists. Nadelson and Hardy (2015) suggest that student views of nature of science (NOS) affect their level of trust in science and scientists, thus potentially influencing individuals' acceptance of the Theory of Evolution. This current study did not explore participants' views towards science and scientists but exploring these views could be an implication for future research. More discussion concerning the relationship between political views, religious beliefs, and acceptance of the Theory of Evolution is further discussed below.

Religious views and religiosity. Significant differences in acceptance of the Theory of Evolution among participants' religious views were also found in this study. Participants who held conservative religious beliefs held lower levels of acceptance of the Theory of Evolution compared to participants who held liberal religious beliefs. Individuals who identified as not being religious held the highest acceptance of the Theory of Evolution. The findings of this current study are not surprising as religion is identified as one of the most consistent predictors when determining acceptance of the Theory of Evolution (Barone et al., 2014; Coyne, 2012; Rissler et al., 2014). Coyne (2012) compared the results of different studies that explored global acceptance of the Theory of Evolution. He suggested that America is one of the most religious countries and Americans also hold the lowest acceptance of the Theory of Evolution. Coyne (2012) stated, "…but there is much evidence that America's resistance to evolution is truly a byproduct of America's extreme religiosity" (p. 2655). Similarly, Miller et al.

(2006) compared acceptance of the Theory of Evolution among individuals from 34 countries and identified that individuals from the United States held the second to lowest acceptance of the Theory of Evolution. Miller et al. (2006) concluded that the effect of religious beliefs on acceptance of the Theory of Evolution was nearly twice as much in the United States, as compared to nine other European countries.

While this current study explored the influence of participants' religious beliefs on acceptance of the Theory of Evolution at a broad level (conservative, middle-of-the-road, or liberal), other studies have explored the influence of religion through religious denomination. Barone et al. (2014) explored acceptance of the Theory of Evolution held by a sample of museum visitors and found those who identified as non-denominational Christians held the lowest acceptance of the Theory of Evolution while those who did not identify with a denomination held the highest acceptance. Rissler et al. (2014) explored the acceptance of the Theory of Evolution held by undergraduate students attending a university in the southern United States, and found that participants who identified as belonging to a Christian denomination held lower acceptance of the Theory of Evolution than those who identified with a non-Christian denomination, or identified as not religious. Baker (2014) surveyed the American public and found that Catholics, Protestants, and those who identified as not religious were more than twice as likely to accept the Theory of Evolution than evangelicals. According to a Pew Research Study (2014), which assessed the religious views of 35,000 Americans from all 50 states, more than 70% of the sample identified as belonging to the Christian denomination. Out of that 70%, 25.4% identified as being Evangelical Protestant. Research literature consistently suggests that those who identify with a Christian denomination are more likely to reject the Theory of Evolution (Miller et al., 2006; Rissler et al., 2014).

This current study also explored the influence of religiosity on acceptance of the Theory of Evolution. Participants rated importance of religion on a scale from "very important" to "not important at all". This current study identified that as the importance of religion increased, acceptance of the Theory of Evolution decreased. When exploring the relationship between participants' religiosity and their acceptance of the Theory of Evolution, religiosity has been measured in different ways. For example, Baker (2013), Barone et al. (2014) and Rissler et al. (2014) explored religiosity by the number of times participants attended church; Miller et al. (2006) explored religiosity by how often participants prayed; and Heddy and Nadelson (2012, 2013) explored religiosity by participants' importance of religion by participants' identifying with "yes," "no," "don't know," or "refuse to answer the question." However, despite how participants' religiosity was defined, the studies above, as well as this current study, all suggest that as religiosity increases, acceptance of the Theory of Evolution decreases. Explanations for why religiosity negatively correlates with acceptance of the Theory of Evolution are discussed below.

Religious beliefs, political views, and acceptance of the theory of evolution. The results of this current study found that the participants who held conservative religious beliefs and conservative political views also hold lower levels of acceptance of the Theory of Evolution when compared to those with liberal religious beliefs and liberal political views. When exploring the relationship between American's religious beliefs and their political views, a 2014 Gallup Poll found that Americans who identified as being "very religious" were more likely to identify with the Republican party while those who identified as being "moderately religious" or "not religious" were more likely to identify with the Democratic party (Newport, 2014). A Pew Research study (2014) explored the relationship between Americans' religious beliefs and their political views and found individuals who acknowledged to "believe in God with absolute certainty" were more likely to identify with the Republican Party. Those who acknowledged to "not believe in God" were more likely to identify with the Democratic Party. Another Pew Research study (2013) explored the relationship between the American public's views on evolution and their religious beliefs and political views. The study concluded that 48% of the 1,983 Americans polled were those who identified with the Republican Party and also held low acceptance of the Theory of Evolution. Research studies consistently suggest that individuals with religious beliefs are more likely to hold conservative political views and reject the Theory of Evolution (e.g., Newport, 2014; Pew Research Center, 2013).

When exploring why individuals with conservative religious beliefs and conservative political views also tend to hold a lower acceptance of the Theory of Evolution, literature suggests individuals with conservative religious views are more likely to attend church regularly than those who hold liberal religious views (Baker, 2013; Newport, 2008). Research also suggests that Americans who attend church regularly are more likely to reject the Theory of Evolution (Baker, 2013; Newport, 2008). Also, religiosity correlates with the tendency to vote Republican and to reject the Theory of Evolution due to contradictions of the Biblical account of human creation (Cotner et al., 2010; Lombrozo et al., 2008; Rissler et al., 2014). Miller et al. (2006) stated, "The concept of the evolution of humans from earlier forms of life is unacceptable to biblical literalists and causes concern even among some holders of less conservative religious views" (p. 765). Similar to the suggestions of Miller et al. (2006), the findings of this current study found supportive evidence that many of those with conservative religious beliefs and conservative political views held literal views of the Biblical account of creation. For instance, out of the 25.2% of participants who agreed or strongly agreed that the *Theory of Evolution cannot be correct since it disagrees with the Biblical account of creation*, 70% held conservative religious views and 60% held conservative political views. Out of the 25% of participants who disagreed or strongly disagreed that *modern humans are the product of evolutionary processes that have occurred over millions of years*, 67% held conservative religious beliefs and 60% held conservative political views. Out of the 29.8% of participants who agreed or strongly agreed that *humans exist today in essentially the same form in which they always have*, 61% held conservative religious beliefs and 52% held conservative political views. These results suggest that while the majority of participants in this current study held moderate or high acceptance of the Theory of Evolution, many of those who held low acceptance also held conservative religious beliefs and conservative political views. Further, those who held conservative religious beliefs and conservative political views also held low acceptance of the MATE statements that indicated a contradiction of the Biblical accounts of creation.

It is a goal of science education to help students understand that science only attempts to explain the occurrences of the natural world, not the supernatural world (e.g., religious beliefs) (Lederman et al., 2002). The results of this study found those who identified with conservative religious beliefs and conservative political views held lower acceptance of the Theory of Evolution and were more likely to score low acceptance on the MATE statements that contradicted the Biblical account of creation. Therefore, the findings of this study may suggest that many students, particularly those with conservative religious beliefs, are unable to hold onto their religious beliefs while also accepting the scientific data used to explain the processes of the Theory of Evolution. While research shows this is a common occurrence (Cotner et al., 2010; Lombrozo et al., 2008; Rissler et al., 2014), research also suggests that holding an informed view of the nature of science (NOS) is linked to the ability to compartmentalize between one's religious beliefs and the processes of the Theory of Evolution (NAS, 1998). Interestingly, this current study, which also explored participants' understandings of NOS, did not find significant differences in views of NOS among the different religious beliefs/political views. Further, a relationship between participants' acceptance of the Theory of Evolution and their views of NOS was not identified. More discussion on the relationship between participants' acceptance of the Theory of Evolution and their views of NOS is provided towards the end of this chapter.

Validity of the theory of evolution. Although the majority of the participants' in this current study held a moderate or high acceptance of the Theory of Evolution, there were two MATE statements in which almost half of the participants reflected a low acceptance. Interestingly, these two statements both assessed the validity of the evidence supporting the Theory of Evolution. Nearly half of the participants (49%) agreed or were undecided that *the Theory of Evolution is incapable of being scientifically tested.* Additionally, nearly half of the participants (49%) agreed or were undecided that *the available data are ambiguous (unclear) as to whether evolution actually occurs.* While

Moore and Cotner (2009) and Gibson and Hoefnagels (2015) found their samples of undergraduates to hold high acceptance of the scientific validity of the Theory of Evolution, Lombrozo et al. (2008) found many of their undergraduate participants also held low acceptance of the validity of the Theory of Evolution. Lombrozo et al. (2008) suggest that students will be more likely to accept the Theory of Evolution if they hold informed understandings of the scientific processes that a theory must undergo prior to being identified as a “scientific theory.” For example, a scientific theory must include methods that have been supported over and over, as well as being supported with strong amounts of scientific evidence. The results of this current study, which also explored participants’ views of nature of science (NOS), found that over 50% of participants held naïve/transitional views of the nature of scientific theories. Many participants indicated that a scientific theory is ‘just a theory’ rather than a scientific explanation that is supported with abundant evidence collected through a rigorous scientific process. These naïve views could explain why nearly half of the participants (49%) also held low acceptance of the scientific evidence that supports the Theory of Evolution. More discussion on participants’ views of the nature of scientific theories is included in the next section of this chapter.

Conclusion

The results of this current study, which explored participants’ acceptance of the Theory of Evolution, identified that a majority of participants (67.3%) held moderate or high acceptance. Further, findings from this study suggest that participants’ who held conservative religious beliefs and conservative political views were more likely to hold low acceptance of the Theory of Evolution, possibly due to contradictions with their religious beliefs. The results of this current study should be encouraging for college science educators, as it suggests that many students are entering their college-level science classes with a moderate or high acceptance of the Theory of Evolution. However, it is important that science educators are aware that some students, particularly those with conservative religious beliefs and conservative political views, view the Theory of Evolution as a contradiction to the biblical account of creation, resulting in low acceptance.

Discussion Section 2: Views of Nature of Science (NOS)

Participants' Overall Views of NOS

Student understanding of nature of science (NOS) has been identified as an important goal of science education for over 100 years (Central Association of Science and Mathematics Teachers, 1907), and yet, research consistently identifies that many K-12 students, undergraduate students, science educators, and preservice science teachers hold naïve views of NOS (e.g., Akerson & Hanuscin, 2007; Bell et al., 2003; Liu & Lederman, 2007; Miller et al., 2010). In an attempt to enhance student views of NOS, science organizations have advocated for the teaching of NOS in the science curriculum (e.g., AAAS, 1990, 1993). Many research studies have also focused on ways to improve student understanding (e.g., Akerson et al., 2006). Unfortunately, the results of this current study suggest that many undergraduate freshmen continue to enter their introductory science classes holding naïve views of NOS. These findings are consistent with other studies, which also suggest undergraduate students hold naïve views of NOS (Abd-El-Khalick, 2006; Abd-El-Khalick & Lederman, 2000; Karakas, 2008; Liang et al., 2008; Miller et al., 2010; Parker et al., 2008).

This current study explored participants' views of NOS through the use of the *Student Understanding of Science and Scientific Inquiry* instrument (SUSSI) (Liang et al., 2006). The SUSSI assesses six NOS "themes" (Liang et al., 2006, p. 12): *Observations and Inferences, Tentative Nature of Scientific Theories, Scientific Laws and Theories, Social and Cultural Influence on Science, Imagination and Creativity in Scientific Investigations, and Methodology in Scientific Investigations.* Participants' views of each theme are assessed through four Likert items and one constructed-response item, per theme. For the current study, participants' responses to the Likert items were analyzed independently from their constructed-responses. The Likert data suggested participants held the most naïve views of *Scientific Laws and Theories* and the most informed views of *Observations and Inferences*. The constructed-response data suggested participants held the most naïve views of *Scientific Laws and Theories* and *Methodology in Scientific Investigations*, and the most informed views of *Tentative Nature of Scientific Theories.* Additionally, analysis of both the quantitative and qualitative data identified that many participants held common misconceptions of the NOS. Organized by the six NOS themes, the following section will discuss: a) both the Likert and constructed-response results; b) the identified misconceptions; and c) the influence of the misconceptions on student learning of science.

Theme 1: observations and inferences. To hold an informed view of *Observations and Inferences*, participants should be able to identify that observations are descriptive statements about natural phenomena, which are derived from using the human senses or extensions of the senses (Lederman et al., 2002). Inferences, on the other hand, are statements about natural phenomena that are made from man's interpretation of these observations (Lederman et al., 2002). Also, to hold an informed view of observations and inferences, it is important for students to understand that observations and inferences can differ among scientists as they are both guided by past experiences and current knowledge (Abd-El-Khalick, 1998; Karakas, 2008). The majority of participants in this current study held transitional or informed views for *Observations and Inferences*. Participants' responses to the Likert items suggested that 48.9% of participants held the informed view that *observations are not facts and scientists can have different inferences of the same observations due to their past experiences*. Participants' constructed-responses, however, suggested only 23.1% of participants held an informed understanding. Half of the participants (50%) were suggested to hold a transitional view as they agreed that scientists may see the same observation differently, but they could not explain why those differences might occur.

Research identifying undergraduates' views of O*bservations and Inferences* is limited, as many studies which explore views of NOS do not specifically discuss their participants' views of the differences between observations and inferences (e.g., Abd-El-Khalick, 2006; Abd-El-Khalick & Lederman, 2000; Parker et al., 2008). Miller et al. (2010), however, explored undergraduates' views of NOS via the SUSSI (Liang et al., 2006), and similar to this current study, also found the majority of undergraduate students to hold informed views of O*bservations and Inferences*. It is encouraging for college science educators that many undergraduate students appear to hold informed views of O*bservations and Inferences,* since understanding the difference may facilitate students' understanding of the many concepts in science that are based on inferences (e.g., atoms, genes, gravitational forces) (Lederman, et al., 2002).

Theme 2: tentative nature of scientific theories. To hold an informed view of the *Tentative Nature of Science,* students should understand that while a scientific theory is well-established, reliable, and highly validated, a scientific theory could change in light of new evidence (Abd-El-Khalick, 1998; Lederman et al., 2002). The results of this current study identified that a majority of participants held transitional views of the *Tentative Nature of Scientific Theories*. Participants' responses to the Likert items also suggested that most participants agreed that scientific theories are subject to on-going testing and may be changed in light of new evidence or as a result of scientists' reinterpretation of existing observations. However, half of the participants held the view that a scientific theory will not change as long as it is based on accurate experimentation. These findings suggested that half of the participants held the view that a scientific theory may change in light of new evidence, but only if the original experiment was not accurately conducted. When exploring participants' constructed-responses, 44% held an informed view that scientific theories may change in light of new evidence, 8% held a naive view that scientific theories do not change, and 21% of participants held a naive view that scientific theories could easily be changed. Similar to the results of the current study, Abd-El-Khalick (2006) and Miller et al. (2010) explored undergraduates' views of NOS and also found that the majority of students held transitional views of the *Tentative Nature of Scientific Theories*.

Holding informed understandings of the *Tentative Nature of Scientific Theories* is important because students should understand that scientific theories may change but are the most reliable understanding based on the current availability of resources and technology (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). If students hold a naive view that a scientific theory can be easily changed or will not change at all, they may not fully understand how scientists have generated evidence supporting scientific theories, such as the Theory of Evolution (Lombrozo et al., 2008). Further, if students hold the understanding that a scientific theory can be easily changed, they may be more inclined to hold low acceptance of scientific theories (NAS, 1998).

Theme 3: Scientific laws and theories. To hold an informed view of *Scientific Laws and Theories,* students should understand that scientific laws are statements or descriptions of quantitative patterns or relationships that are developed to understand observable natural phenomena (Lederman et al., 2002). Students should also know that scientific theories are well-confirmed, supported, established, and durable sets of general statements that can successfully explain and predict natural phenomena (Lederman et al., 2002). Students should also understand that there is not a hierarchical relationship in which a scientific theory will eventually become a scientific law (Lederman et al., 2002). Interestingly, research consistently suggests many undergraduate students hold naïve views of *Scientific Laws and Theories* (Abd-El-Khalick, 2006; Abd-El-Khalick & Lederman, 2000; Miller et al., 2010; Karakas, 2008; Parker et al., 2008). The findings of this current study were no different, as most participants (85%) were found to hold naïve views of *Scientific Laws and Theories*.

When analyzing participants' Likert answers and constructed-responses for *Scientific Laws and Theories,* two main misconceptions were identified. First, 11.2% of participants indicated that a scientific theory is just an idea, or a guess presented by a scientist, suggesting the misconception that a scientific theory has the same meaning and value as the everyday term "theory". The data suggested that these participants did not recognize the large amount of empirical evidence that must support a theory in order for it to become a scientific theory. Both Lombrozo et al. (2008) and Parker et al. (2008) explored undergraduates' views of NOS and found that a majority of undergraduates hold naïve views of *Scientific Laws and Theories.* The research findings suggest the prevalence of misconceptions concerning scientific theories and laws indicates a need for increased discussion and reflection comparing the meaning of scientific terms with everyday meanings of the words (e.g., "scientific theory" versus "theory"). Lombrozo et al. (2008) suggests that explicit differentiation between "scientific theory" and the everyday usage of "theory" is important for students to recognize the rigorous scientific evidence that must support a scientific theory, leading to higher acceptance of scientific theories. For example, if a student considers a scientific theory to be just an idea presented by a scientist, he/she may see the Theory of Evolution as simply a theory proposed by scientists, which could result in a low acceptance (Lombrozo et al., 2008). Contrary to the suggestions of Lombrozo et al. (2008), this current study found 76% of participants who held low acceptance of the Theory of Evolution and 80% of participants who held high acceptance of the Theory of Evolution also agreed that *scientific laws are theories that have been proven.* This suggests that when compared to participants who held high acceptance of the Theory of Evolution, participants who held low acceptance of the Theory of Evolution were less likely to hold the misconception that scientific theories will eventually become laws when proven enough.

The second misconception identified through participants' responses to the Likert and constructed-responses for *Scientific Laws and Theories* was the misunderstanding of a hierarchical relationship between a scientific theory and law – the idea that a scientific law is absolute or certain, and that a scientific theory will become a scientific law when it is 'proven' correct. This hierarchical relationship is a common misconception as scientific laws state or describe natural occurrences and scientific theories are used to explain patterns of natural occurrences (Lederman et al., 2002). This theory-to-law hierarchical misconception is widely identified in the research literature and held by some K-12 students (e.g., Bell et al., 2003), undergraduate students (Abd-El-Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Miller et al., 2010; Parker et al., 2000), preservice teachers (e.g., Liu & Lederman, 2007; Southerland et al., 2006) and science educators (e.g., Nehm & Schonfeld, 2007). Students who hold this misconception may be more inclined to reject a scientific theory with the understanding that it is "just a theory" because it has not been "proven" enough (Lombrozo et al., 2008). Karakas (2008) found science majors, non-science majors, and a group of participants who did not have a decided major, to all hold naïve understandings of the differences between a scientific law and a scientific theory. Similar to Lombrozo et al. (2008) and Parker et al. (2008), Karakas (2008) suggested the differences between scientific laws and theories is poorly taught in schools and contributes to the need to improve the teaching of NOS in high school and college classrooms.

Theme 4: Social and cultural influence on science. To hold an informed view of *Social and Cultural Influence on Science,* students should understand that while science is universal (e.g., metric system or the periodic table), culture and society play a major role in how, and what, science is conducted (Lederman et al., 2002). Students should also know that science is affected by the culture in which it is embedded (religion, politics, socioeconomics) (Lederman et al., 2002). Similar to Miller et al. (2010), who also explored undergraduates' views of NOS, this current study found that over 60% of participants held transitional views of the *Social and Cultural Influence on Science*. When exploring participants' Likert responses, the majority of participants (over 60%) acknowledged that *scientific research is influenced by society and culture*, and also that *cultural values and expectations determine what science is conducted and accepted*. However, the constructed-response analysis revealed that 69.1% of participants acknowledged that society and culture influence research, but they did not provide examples to support their answer. 30.6% of participants did provide an example of how society and culture influence science, but only one area of research was identified (e.g., the topic being researched, methods used to conduct research). Only 21% held an informed view that society and culture could influence all areas of science. This data suggest that most participants acknowledge that society and culture do influence science, but they do not fully understand how.

One interesting observation identified during data analysis of the open-response item for Theme 4 was that 24 participants referred to the Theory of Evolution as an example of how culture influences research. One participant stated "Society and culture's acceptance of a scientific theory affects whether or not scientific research is pursued to confirm or negate the theory. For example, the Theory of Evolution was frowned upon by society because it was believed to suggest there is no God, in which the religious culture relied upon." Two other examples commonly referenced by participants were stem cell research and global warming. These results suggest many of the participants view evolution, stem cell research, and global warming to be controversial issues that are influenced by the American culture. Since the Theory of Evolution, stem cell research, and global warming are indeed controversial issues in America (Drummond & Fischhoff, 2017), these responses suggest that some undergraduate students are being exposed to the controversial issues of science that exist in America prior to entering their undergraduate career.

Theme 5: Imagination and creativity in scientific investigations. To hold an informed view of *Imagination and Creativity in Scientific Investigations*, students should understand that human creativity and imagination play a major role in all aspects of science (Lederman et al., 2002). Similar to understanding the differences between observations and inferences, understanding how creativity is used in science provides students with a better understanding of many of the entities in science in which inferences and creativity play a major role (e.g., Bohr's model of the atom) (Abd-El-Khalick & Lederman, 2000; Lederman et al., 2002). Understanding the role of creativity also helps explain scientists' interpretation of incomplete evidence (Bell, Lederman, Abd-El-Khalick, 2000). This current study found that over 55% of participants held transitional views of *Imagination and Creativity in Scientific Investigations*. When analyzing participants' Likert responses, 30.9% acknowledged that *scientists used imagination and creativity to collect data* and 42.2% acknowledged that *scientists use imagination and creativity to analyze and interpret data.* These findings suggest more than half of the participants did not agree that imagination and creativity are used in science. The Likert findings were supported by participants' constructed-responses, with 1.9% of participants acknowledging that imagination and creativity could be used in all areas of science. While 26.1% of participants referred to scientists using imagination and creativity to develop experiments, they did not refer to the use of imagination and creativity to analyze and interpret data. Abd-El-Khalick (2006), Abd-El-Khalick and Lederman (2000), Miller et al. (2010) and Parker et al. (2008) also found undergraduate students to hold similar misconceptions to those identified in this current study. Similar to the findings of Miller et al. (2010), 2.7% of participants in this current study viewed the use of imagination and creativity in science as unethical, indicating imagination and creativity should not be used in science and if they were, the results would not be correct. Parker et al. (2008) suggests these misconceptions are developed during student exposure to traditional laboratory designs in some science classes. For example, in some chemistry labs, science experiments are predesigned and are completed without much creativity; students simply follow prescribed steps to complete the laboratory activity. Parker et al. (2008) suggests that from this predesigned method, students develop the misconception that scientists only perform experiments in a controlled laboratory setting and therefore do not use, or need, creativity. Parker et al. (2008) also suggests that because student attitudes towards science can be related to their desire to pursue a career in science, students who do not view science as creative and imaginative in science may be less likely to choose science as a career.

Theme 6: Methodology in scientific investigations. To hold an informed view of *Methodology in Scientific Investigations,* students should know that scientists conduct investigations for a wide variety of reasons and different kinds of items suggest different kinds of scientific investigations (Lederman et al., 2002). They should also be able to acknowledge that there is no single universal step-by-step scientific method that all scientists follow (Liang et al., 2006). When exploring participants' views of *Methodology in Scientific Investigations,* this current study found conflicting results. For the Likert responses, 85.6% of participants indicated that *there is not one universal method to conduct science*. However, when analyzing the constructed-responses, 50% of participants acknowledged that science is conducted in one universal manner, and 29.6% of participants specifically referenced, "The Scientific Method" as the typical method used by scientists to conduct science. These conflicting results suggest that when assessed through the Likert items, many participants agreed that science can be conducted in multiple ways, but when assessed through constructed-responses, many participants indicated that "The Scientific Method" is the preferred way to conduct science. These findings are consistent with the findings of Abd-El-Khalick and Lederman (2000), who found 85% of their participants agreed that scientists follow "The Scientific Method." Miller et al. (2010) also found similar results with 60% of participants referring to the "The Scientific Method" in their constructed-responses. Abd-El-Khalick (2006) and Lederman et al. (2002) suggest the view that science is conducted by "The Scientific Method" is one of the most commonly identified misconceptions when exploring views of NOS. This misconception is an issue for science education because it limits student understanding of how science knowledge is developed. Miller et al. (2010) suggest that because "The Scientific Method" has been strongly incorporated in science curricula across all levels of education, it will most likely take more than simply addressing the issue through classroom activities to overcome. It can be argued that based on the results of Miller et al. (2010), it is imperative that teachers at the early stages of science education (e.g., middle school) enhance student understanding of science by taking careful measures to ensure that students are taught science is not unidirectional.

Demographic Variables

Along with exploring participants' view of NOS, an effort was made in this study to determine if specific demographic variables influence undergraduates' views of NOS. The following participant demographics were explored: STEM major, gender, high school community, religious views, importance of religion, political views, number of science classes taken in high school, exposure to the teachings of evolution and creationism in high school, and in-state/out-of-state tuition status. Of the ten demographic variables explored, the only variables suggested to influence views of NOS were: gender, high school community, the number of science classes taken in high school, and exposure to the teachings of evolution in high school. Specifically, gender was suggested to influence participants' views of the *Tentative Nature of Scientific Theories*; high school community was suggested to influence participants' views of the *Tentative Nature of Scientific Theories* and *Imagination and Creativity in Scientific Investigations*; the number of science classes taken in high school was suggested to influence participants' views of the *Tentative Nature of Scientific Theories, Social and Cultural Influence on Science,* and *Imagination and Creativity in Scientific Investigations*; and the teaching of the Theory of Evolution in high school was suggested to influence participants' views of *Methodology in Scientific Investigations.* However, while these demographic variables were found to significantly influence views of NOS, the effect sizes of the significances were of small practical significance, suggesting none of the participant demographic variables substantially influenced participants' views of NOS. These results are supportive of earlier research studies which also explored student views of NOS, and suggested understandings of NOS are independent of demographic variables such as gender, science content knowledge, science/academic achievement, etc. (e.g., Billeh & Hasan, 1975; Carey & Stauss, 1968, 1970; Wood, 1972). Further, more recent studies also found supportive evidence that participants' NOS views are not related to their gender (Abd-El-Khalick, 2006; Abd-El-Khalick and Lederman, 2000; Dogan & Abd-El-Khalick, 2008), class standing (e.g., freshman, sophomore) (Abd-El-Khalick, 2006; Abd-El-Khalick and Lederman, 2000), or college science credit hours (Abd-El-Khalick, 2006; Abd-El-Khalick and Lederman, 2000).

One demographic variable that has shown, however, to influence views of NOS is college major choice. While this current study, along with Abd-El-Khalick (2006), Karakas (2008), and Miller et al. (2010), found no significant differences between views of NOS among nonscience and science majors, Liu and Tsai (2008) found science majors held more naïve views of the theory-laden and social and cultural influences of NOS when compared to non-science and science education majors. Liu and Tsai suggest their findings were attributed to science majors being subjected to longer periods of time in environments that describe scientific knowledge as objective and universal.

Conclusion

The results of this current study suggest that many students in Oklahoma are entering their college undergraduate science courses holding transitional views of *Observations and Inferences*, *Tentative Nature of Scientific Theories*, *Social and Cultural Influence on Science*, *Imagination and Creativity in Scientific Investigations,* and *Methodology in Scientific Investigation.* The results of this current study also suggest that many students in Oklahoma are entering their undergraduate courses holding naïve views of *Scientific Laws and Theories*. The results of this study did not identify any participant demographic variables that significantly, and substantially, influence views of NOS. Implications for future research concerning these findings are discussed in the last section of this chapter.

Discussion Section 3: Relationship Between
Acceptance of the Theory of Evolution and Views of Nature of Science

This current study did not find a relationship between participants' acceptance of the Theory of Evolution and their views of NOS. This is interesting, as many other studies exploring this relationship have found a relationship to exist. The relationship between acceptance of the Theory of Evolution and views of NOS has been identified among secondary science teachers (Nehm & Schonfeld, 2007), preservice teachers (Allmon, 2011), high school students (Cavallo & McCall, 2008), and undergraduate college students (Carter & Wiles, 2014; Lombrozo et al., 2008). Also, the consistent identification in the research literature supporting the relationship between acceptance of the Theory of Evolution and views of NOS has led researchers and science education organizations to advocate incorporating NOS instruction while teaching the Theory of Evolution (e.g., AAAS, 2006; Lombrozo et al., 2008; NAS, 1998; NSTA, 2013; Scharmann et al., 2005).

Although this study found no relationship between acceptance of the Theory of Evolution and views of NOS, educators should still be encouraged to teach NOS alongside the Theory of Evolution; as advocated by many science education organizations (e.g., AAAS, 2006; NSTA, 2013). NOS describes how scientific knowledge is generated, as well as how science progresses, and student understanding of NOS has shown to decrease student misconceptions that lead to low acceptance of the

Theory of Evolution (Carter & Wiles, 2014; Lombrozo et al., 2008). For example, a common misconception held by many students is that scientists conduct their experiments in an enclosed laboratory, following step-by-step procedures via "The Scientific Method" (Lombrozo et al., 2008). When holding this misconception, students may fail to see other methods of science experimentation as valid (Allmon, 2011). Evidence supporting the Theory of Evolution has been found not only in laboratory experiments, but also from field observations, museum research, the fossil record, and cell biology (Lombrozo et al., 2008). If students hold the view that only experiments conducted in a lab are valid, students may not fully understand the overwhelming amount of scientific evidence supporting the Theory of Evolution, leading to low acceptance (Allmon, 2011). Another NOS misconception that has shown to influence acceptance of the Theory of Evolution is the understanding of a scientific theory (Lombrozo et al., 2008). When students do not understand the amount of scientific evidence that must be present for a theory to be identified as a scientific theory, they may view the Theory of Evolution as having low validity, leading to lower acceptance (Lombrozo et al., 2008).

It is also important to mention that the reliability of the results of the current study, which explored NOS, could be called into question due to reliability concerns of the SUSSI instrument (Liang et al., 2006), which was used to assess participants' views of NOS. Low reliability was reported for NOS themes assessed through the instrument, and one overall NOS score could not be generated, thus requiring the data to undergo many statistical tests. The next section of this chapter includes discussion concerning implications for future research to address the reliability concerns of the findings from the current study.

Discussion Section 4: Implications for Future Research

Implication #1

Originally, the researcher did not intend to explore the influence of participants' religious views on their acceptance of the Theory of Evolution. However, when reviewing research on acceptance of the Theory of Evolution, religious beliefs and religiosity were consistently identified as strong predictors (Baker, 2013; Barone et al., 2014; Coyne, 2012; Mazur, 2004; Nadelson & Hardy, 2015). To compare the validated research to a new population, this current study included religious beliefs and religiosity as demographic variables to explore. However, religious beliefs and religiosity were intentionally explored on a broad level rather than an in-depth level. For example, rather than exploring religious beliefs by church denominations (e.g., Baker, 2014), participants in this current study were asked to simply identify their beliefs as conservative, middle-of-the-road, or liberal. Additionally, instead of exploring religiosity through the attendance of church (e.g., Barone et al., 2014) and/or time dedicated to prayer (e.g., Miller et al., 2006), participants in this current study were asked to rate their religiosity on a 5-option scale from very important to not important at all. Similar to Baker (2013), Barone et al. (2014), Coyne (2012), Mazur (2004), and Nadelson & Hardy (2015), the results of this current study identified that religious views and religiosity significantly influence acceptance of the Theory of Evolution. In fact, out of the ten demographic variables explored in this current study, religious views, religiosity, and political views were the only demographic variables suggested to significantly influence participants' acceptance of the Theory of Evolution (religious views: $F(3,372) = 79.09$, $p < .001$, religiosity: $r_s = .63$, $p < .01$, and political views: $F(2,373) = 62.54$, $p < .001$). Since religious views and religiosity are continuously identified as strong predictors of acceptance of the Theory of Evolution, an implication for future research would be to explore undergraduates' religious views and religiosity at a more in-depth level, such as by their church denomination. By investigating and identifying differences in acceptance of the Theory of Evolution among specific areas within religious beliefs and religiosity, perhaps future studies can provide more beneficial findings for improving student acceptance of the Theory of Evolution. For instance, if a particular church denomination continuously shows to hold lower acceptance, perhaps researchers can explore ways to teach the Theory of Evolution to individuals of that particular denomination.

Implication #2

The results of this current study identified that 30% of participants held conservative religious beliefs/political views. This suggests that some undergraduate freshmen, specifically those attending a university in Oklahoma, are entering their undergraduate science courses holding conservative religious beliefs/political views. Research consistently suggests individuals who hold conservative religious views/political beliefs are more resistant to acceptance of the Theory of Evolution due to contradictions with their religious beliefs (e.g., Rissler et al., 2014). Therefore, it may be beneficial for college science educators to consider students' religious beliefs/political views when teaching about the Theory of Evolution. For instance, if college science educators are aware that some of their students may hold conservative religious views/political beliefs, and potentially low acceptance of the Theory of Evolution, they could incorporate/develop specific teaching techniques to better improve student acceptance of the Theory of Evolution. Further, an implication for future research is to explore teaching techniques that can be used by college science educators to enhance student acceptance of the Theory of Evolution, specifically when teaching students who hold conservative religious beliefs/political views.

Implication #3

Nature of science has been advocated as an important objective in science education, primarily due to its influence for achieving science literacy (AAAS, 1990, 1993; Lederman, 2007). However, research consistently shows that many K-12 students, undergraduate students, and science educators hold naïve views of NOS (e.g. Abd-El-Khalick & Akerson, 2009; Liu & Lederman, 2007; Miller et al., 2010; Urhahne, 2011). Although the majority of participants in this current study were found to hold overall transitional views of NOS, some of the participants held naïve views. The repetitive findings in NOS research that individuals of many populations continue to hold naïve views of NOS led the researcher of this current study to reflect on this consistent cycle of our populace. Where do these naïve views first develop? At what level in the education system can NOS best be addressed to help end this cycle? Miller et al. (2010) explored undergraduates' views of NOS and suggested that student understanding of NOS is dependent upon the content, curriculum, and the teaching practices of science educators at the undergraduate level. Clough (2009) developed a conceptual framework for learning NOS and stated, "Ever present in science content and science teaching are implicit and explicit messages regarding the NOS. The issue is not whether science teachers will teach about the NOS, only what image will be conveyed to students" (p. 464). If student views of NOS are dependent on the views of NOS held by their science teachers (Clough, 2009), perhaps the best place to address NOS is the place where science teachers are taught how to teach science: college and university teacher education programs. It is at this level of education where future science educators can adequately learn about NOS, and also learn how to effectively teach NOS. Will addressing the NOS issues in teacher preparation programs eventually discontinue the cycle of naïve views?

Research exploring the effects of NOS instruction during science methods courses has existed for decades (Akerson et al., 2005). There is also a wide amount of research literature that suggests views of NOS can be enhanced by utilizing inquiry-based instruction, accompanied with an explicit-reflective approach, to teach NOS in science methods courses (Akerson et al., 2005). So perhaps the question is not should NOS be taught in teacher education programs, but rather, how many teacher education programs include a course that specifically addresses NOS? If every preservice science educator were required to take a NOS pedagogy course in which they learned not only about the aspects of NOS, but also how to effectively teach NOS, perhaps NOS misconceptions can be identified and corrected prior to a novice teacher entering the science classroom (Akerson et al., 2005). Therefore, an implication for future research is to explore how many teacher education programs incorporate a NOS course, or NOS instruction in general. Also, is there a difference in views of NOS held by preservice teachers who have completed a teacher education program that includes explicit NOS instruction, compared to those who have completed a teacher education program that does not include NOS instruction? The researcher of this current study hopes to conduct a study in the near future to explore these research questions.

Implication #4

Perhaps the most significant limitation of this study was the use of the SUSSI instrument (Liang et al., 2006) to assess participants' views of NOS. Although the results of this current study suggest there is not a relationship between undergraduates' acceptance of the Theory of Evolution and views of NOS, the researcher recommends a similar study be conducted using a different instrument to assess views of NOS. While the results of this study were statistically analyzed, the reliability of the results could be called into question since the NOS instrument (SUSSI) did not allow for one overall NOS score to be generated. The Student Understanding of Science and Scientific Inquiry (SUSSI) instrument (Liang et al., 2008) was originally viewed as the most appropriate NOS instrument to use for the large sample size, based on its convenient 24 Likert items, accompanied by six constructed-response items. However, due to a low internal consistency, each NOS theme had to be analyzed independently, with the Likert scores being analyzed independently from the constructed-response. This lack of one overall NOS score led to the use of multiple statistical tests on the same data (t-test, ANOVA, correlation), which increased the chance of Type 1 error. To further support the conclusions drawn from this data, the researcher suggests conducting a similar study on the same population but using a NOS assessment that can generate one overall score, such as the Views of Nature of Science-D (VNOS-D; Lederman & Khishfe, 2002). While the VNOS-D (a qualitative, open-ended questionnaire) was not originally chosen for this research study because of the need of a quantitative analysis for the large sample size, there has recently been a scoring index developed for the VNOS-D (Angle, unpublished). This scoring index will allow researchers to convert the open-ended questions of the VNOS-D to one overall NOS score for each participant (Angle, unpublished). To further validate the results of this study, there is a need to conduct a study for the same population, but instead using an instrument that will generate one overall score, such as the VNOS-D, accompanied by the scoring index (Lederman, 2007; Angle, unpublished).

Conclusion

In conclusion, this study explored and addressed the following six research questions:

Research Question #1: *What is the current level of acceptance of the Theory of Evolution held by undergraduate freshmen enrolled at a research university in Oklahoma?* This study found that on a scale of, very low acceptance - low acceptance - moderate acceptance - high acceptance - very high acceptance, the majority of participants (67.3%) held moderate or high acceptance of the Theory of Evolution.

Research Question #2: *Are there differences among specific demographic variables and the acceptance of the Theory of Evolution held by these undergraduate freshmen?* This study found significant differences in acceptance of the Theory of Evolution among participants' varying religious beliefs, religiosity, and political views.

Research Question #3: *What are the current views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?* The majority of participants held transitional views for all six of the NOS themes when analyzed through Likert responses. The majority of participants also held transitional views for all six of the NOS themes when analyzed through constructed-response items, except for *Scientific Laws* *and Theories* and *Methodology in Scientific Investigations,* in which the majority of participants held naïve views.

Research Question #4: *Are there differences among specific demographic variables and the views of NOS held by these undergraduate freshmen?* No substantially significant differences were found to exist among specific demographic variables and views of NOS.

Research Question #5: *Does a relationship exist between acceptance of the Theory of Evolution and views of NOS held by undergraduate freshmen enrolled at a research university in Oklahoma?* No relationship was identified to exist between participants' acceptance of the Theory of Evolution and their views of NOS.

Research Question #6: *If a relationship is found to exist, how do specific demographic variables moderate the relationship between participants' acceptance of the Theory of Evolution and their views of NOS?* This research question was not explored as no relationship was found to exist between participants' acceptance of the Theory of Evolution and their views of NOS.

The findings of this current study contribute to the research literature by providing recent data exploring undergraduates' acceptance of the Theory of Evolution and their views of NOS. Further, this study led to several implications for future research. It is the hope of the researcher that many science educators, particularly those at the college level, will consider the results of this study when developing instruction for teaching the Theory of Evolution. It is also the hopes of the researcher that the results of this current study will lead to enhancement of student acceptance of the Theory of Evolution, as well as their views of NOS, by informing educators of the importance of inclusion of both Theory of Evolution and NOS in their instruction.

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APPENDICES

Appendix A

Recruitment Email

Hello There!

Welcome to Oklahoma State University! One of the many great things about our university is that we are a research institution. This means that as a student, you will be able to partake in research studies that are being conducted to contribute to the betterment of the world! Support in such studies is highly encouraged as your participation will be greatly appreciated to the researchers/students conducting these studies.

I am currently a Ph.D. student here at Oklahoma State University and I am conducting a study for my dissertation (which is my final step in graduating). Sample size is important for my study, so I am in need of your help. My research explores the acceptance of evolution and understandings of Nature of Science held by undergraduate freshman students (that would be you!). Attached, you will find a link to a survey that will allow me to collect data for this topic. If you are willing to complete the survey, you will be able to enter in a drawing for a $100 dollar gift card to Starbucks (trust me, you're going to need all the coffee you can get the next four years). The survey should take no more than thirty minutes and your answers will be completely anonymous. In fact, you will only be asked for your name and email address when you are directed to another link to enter for the drawing, after the survey is completed. Your contact information will not be shared with anyone (don't worry, no spam mail!) and I will contact the winner of the drawing, personally. Your participation in this study will be greatly, greatly appreciated. Simply click on the link below to get started! Thank you for your time!

Brenna Heaton

Appendix B

Consent Form

PROJECT: Exploring the Relationship of Evolution and Nature of Science

INVESTIGATORS:

Leigh Brenna Heaton, doctoral student in Professional Studies: Science Education

Oklahoma State University

PURPOSE:

The purpose of this study is to: 1) explore the current acceptance of evolution held by undergraduate freshman at a Midwest research institution; 2) explore the current understandings of nature of science held by undergraduate freshman at a Midwest research institution; 3) explore the relationship between students' understanding of nature of science and acceptance of evolution; and 4) identify predictor variables that may predict a students' acceptance of evolution and understandings of nature of science.

PROCEDURES

A survey will be conducted in three sections and will be completed using the Qualtrics online program. The first section will ask you to complete a short demographic survey that should take no more than five minutes to complete. After that, you will be directed to the next section which will explore your acceptance of evolution and understanding of nature of science using questions, randomly administered, from two instruments: the Measurement of the Acceptance of Evolution (MATE) and the Student Understanding of Science and Scientific Inquiry (SUSSI). Both instruments ask that you read several statements and respond to them based on the extent to which the statements reflect agreement or disagreement with your opinions. This part of the study is designed to last approximately 25 minutes. The entire survey should take no more than 30 minutes to complete. Once you complete the survey, you will be given the opportunity to enter your first name and email in order to enter a drawing for a $100 gift-card to Amazon.com. Your personal identification will be excluded from data analysis and will not be associated with your answers given in the survey. Your personal identification will only be used to contact you if you are the chosen winner for the gift card.

RISKS OF PARTICIPATION:

There are no risks associated with this project, including stress, psychological, social, physical, or legal risk which are greater, considering probability and magnitude, than those ordinarily encountered in daily life. If, however, you begin to experience discomfort or stress in this project, you may end your participation at any time.

BENEFITS OF PARTICIPATION:

The findings of this research study will help educators hold better understandings of the current acceptance of evolution and understandings of nature of science held by undergraduate freshman at a Midwest state research institution. Additionally, the findings of this research study will help science educators of all levels to better teach the theory of evolution and nature of science.

CONFIDENTIALITY:

The records of this study will be kept private. Research records will be stored on a password protected computer in a locked office and only the researcher and individuals responsible for research oversight will have access to the records.

COMPENSATION:

None

CONTACTS:

If you have questions about the research study, you may contact:

Brenna Heaton, brenna.heaton@okstate.edu, 580-748-2537 or

Dr. Julie Angle, Ph.D., 227 Willard Hall, School of Teaching and Curriculum Leadership, Oklahoma State University, Stillwater, OK 74078, (405) 744-8147.

If you have questions about your rights as a research volunteer, you may contact the Oklahoma State University Institutional Review Board (IRB) Chair, Dr. Hugh Crethar at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

PARTICIPANT RIGHTS:

I understand that my participation is voluntary; that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. By clicking yes, I sign it freely and voluntarily. A copy of this form will be given to me upon request. I hereby give permission for my participation in this study.

Appendix C

The Measurement of the Acceptance of Evolution (MATE)

For the following items, please indicate your agreement/dis-agreement with the given statements using the following scale:

A	B	C	D	E
strongly Agree	Agree	undecided	disagree	strongly disagree

1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.

2. The theory of evolution is incapable of being scientifically tested.

3. Modern humans are the product of evolutionary processes that have occurred over millions of years.

4. The theory of evolution is based on speculation and not valid scientific observation and testing.

5. Most scientists accept evolutionary theory to be a scientifically valid theory.

6. The available data are ambiguous (unclear) as to whether evolution actually occurs.

7. The age of the earth is less than 20,000 years.

8. There is a significant body of data that supports evolutionary theory.

9. Organisms exist today in essentially the same form in which they always have.

10. Evolution in not a scientifically valid theory.

11. The age of the earth is at least 4 billion years.

12. Current evolutionary theory is the result of sound scientific research and methodology.

13. Evolutionary theory generates testable predictions with respect to the characteristics of life.
14. The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.
15. Humans exist today in essentially the same form in which they always have.
16. Evolutionary theory is supported by factual historical and laboratory data.
17. Much of the scientific community doubts if evolution occurs.
18. The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms.
19. With few exceptions, organisms on earth came into existence at about the same time.
20. Evolution is a scientifically valid theory.

Appendix D

Student Understanding of Science and Scientific Inquiry Questionnaire (SUSSI)

Please read EACH statement carefully, and then indicate the degree to which you agree or disagree with EACH statement by circling the appropriate letters to the right of each statement (SD= Strongly Disagree; D = Disagree More Than Agree; U = Uncertain or Not Sure; A = Agree More Than Disagree; SA = Strongly Agree).

1. Observations and Inferences

A. Scientists observations of the same event may be different because the scientists prior knowledge may affect their observations.

SD D U A SA

B. Scientists observations of the same event will be the same because scientists are objective.

SD D U A SA

C. Scientists observations of the same event will be the same because observations are facts.

SD D U A SA

D. Scientists may make different interpretations based on the same observations.

SD D U A SA

With examples, explain why you think scientists observations and interpretations are the same OR different.

____

2. Change of Scientific Theories

A. Scientific theories are subject to on-going testing and revision.

SD D U A SA

B. Scientific theories may be completely replaced by new theories in light of new evidence.

SD D U A SA

C. Scientific theories may be changed because scientists reinterpret existing observations.

SD D U A SA

D. Scientific theories based on accurate experimentation will not be changed.

SD D U A SA

With examples, explain why you think scientific theories do not change OR how (in what ways) scientific theories may be changed.

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3. Scientific Laws vs. Theories

A. Scientific theories exist in the natural world and are uncovered through scientific investigations.

SD D U A SA

B. Unlike theories, scientific laws are not subject to change.

SD D U A SA

C. Scientific laws are theories that have been proven.

SD D U A SA

D. Scientific theories explain scientific laws.

SD D U A SA

With examples, explain the nature of and difference between scientific theories and scientific laws

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4. Social and Cultural Influence on Science

A. Scientific research is not influenced by society and culture because scientists are trained to conduct pure, unbiased studies.

SD D U A SA

B. Cultural values and expectations determine what science is conducted and accepted.

SD D U A SA

C. Cultural values and expectations determine how science is conducted and accepted.

SD D U A SA

D. All cultures conduct scientific research the same way because science is universal and independent of society and culture.

SD D U A SA

With examples, explain how society and culture affect OR do not affect scientific research.

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5. Imagination and Creativity in Scientific Investigations

A. Scientists use their imagination and creativity when they collect data.

SD D U A SA

B. Scientists use their imagination and creativity when they analyze and interpret data.

SD D U A SA

C. Scientists do **not** use their imagination and creativity because these conflict with their logical reasoning.

SD D U A SA

D. Scientists do **not** use their imagination and creativity because these can interfere with objectivity.

SD D U A SA

With examples, explain how and when scientists use imagination and creativity **OR** do not use imagination and creativity.

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6. Methodology of Scientific Investigation

A. Scientists use different types of methods to conduct scientific investigations.

SD D U A SA

B. Scientists follow the same step-by-step scientific method.

SD D U A SA

C. When scientists use the scientific method correctly, their results are true and accurate.

SD D U A SA

D. Experiments are not the only means used in the development of scientific knowledge

SD D U A SA

With examples, explain whether scientists follow a single, universal scientific method OR use different types of methods.

VITA

LEIGH BRENNA HEATON

Candidate for the Degree of

Doctor of Philosophy

Dissertation: EXPLORING FRESHMEN UNDERGRADUATES' ACCEPTANCE OF THE THEORY OF EVOLUTION AND VIEWS OF NATURE OF SCIENCE

Major Field: Science Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Science Education at Oklahoma State University, Stillwater, Oklahoma in May, 2019.

Completed the requirements for the Master of Education at Northwestern Oklahoma State University, Alva, Oklahoma in 2013.

Completed the requirements for the Bachelor of Science in Biology at Northwestern Oklahoma State University, Alva, Oklahoma in 2011.

Experience:

8th Grade Science Teacher, Alva, OK: August 2018 - Current

Adjunct Instructor for the Department of Natural Sciences, Northwestern Oklahoma State University, Alva, OK: Summer 2016 - Current

Graduate Research Assistant for the College of Education, Oklahoma State University, Stillwater, OK: Fall 2014

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