CONCEPTUAL KNOWLEDGE OF EVOLUTION AND NATURAL SELECTION: HOW CULTURE AFFECTS KNOWLEDGE ACQUISITION

A Dissertation

by

MARÍA DEL REFUGIO GUTIÉRREZ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2009

Major Subject: Rangeland Ecology and Management

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Approved by:

Co-Chairs of Committee,	Cruz C. Torres
	Ben X. Wu
Committee Members,	C. Wayne Hanselka
	Roel R. Lopez
Head of Department,	Steve G. Whisenant

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ABSTRACT

Conceptual Knowledge of Evolution and Natural Selection:

How Culture Affects Knowledge Acquisition. (December 2009)

María del Refugio Gutiérrez, B.A., Southwest Texas State University;

B.A., Southwest Texas State University;

M.A.G., Southwest Texas State University

Co-Chairs of Advisory Committee: Dr. Cruz C. Torres
Dr. Ben X. Wu

This study examined what effects, if any, cultural factors have on conceptual knowledge of evolutionary theory through natural selection. In particular, the study determines if Latino and non-Latino students differ in their misconceptions of natural selection and, if so, could cultural factors be the reason for the differences. A total of 1179 college students attending eight Hispanic-Serving Institutions in Texas participated in the study. The results revealed that students encountered difficulties in causes of phenotypic variation, i.e., mutations are intentional, and selective survival based on heritable traits. And even though the top four natural selections misconceptions were similar between the Latino and non-Latino students, no statistical significant differences were found between groups.

DEDICATION

This dissertation is dedicated to every individual who has ever assisted me in my life; in particularly to my soul mate and husband, Darnell Douglas Michel, who has been extremely patient, supportive, understanding, and has never once complained during my educational journey. In addition, I dedicate this manuscript to my beloved friends who anticipated the completion of this manuscript and looked forward to my graduation, but who were unfortunately called to the Lord's Kingdom within the last year. My beloved and spiritual friends—Den, Sandi, and Betty, I thank you for loving me unconditionally and for the many *oraciones* you prayed on my behalf. And finally, I dedicate this manuscript to my wonderful and wise paternal grandfather. Refugio Gutiérrez Gutiérrez was the first individual who taught me to love, respect, and to be a steward of Mother Nature. We (humans) are still not capable of reproducing the essential resources to sustain life without Mother Nature. Hence, I now truly understand and conceptualize my grandfather's infamous quote. "*¡Si los científicos se creen tan chingones, porque no siembran el frijol y el maíz, pa' no [quebrarme el lomo en] sembrarlo; pues claro, todavía no son tan chingones como se creen—al fin de todo, son incapaces de duplicar lo qué la naturaleza nos regala****, POR ESO TENEMOS QUE CUIDARLA****!*"

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CHAPTER I

INTRODUCTION

Charles Robert Darwin investigated the evolution of species and, in 1838, formed his theory of natural selection (Wilson 2007). Darwin's evolutionary theory involves biological processes that cause genetic variation and as a result, variants are either common or rare in a population (Geraedts and Boersma 2006). For example, at the cellular level, sexual recombination and mutations account for genetic variation that account for phenotypic differences within a population. These phenotypic differences are manifested in differential survival and reproduction rates of each *individual organism* causing *population* changes over time (Geraedts and Boersma 2006). Evolution emerges through the biological process of natural selection as organisms with favorable genetic traits or adaptations increase in a population (Stallings 1996, Anderson 2003, Kutschera and Niklas 2004, Sadler 2005, Geraedts and Boersma 2006, Balgopal 2007). For this reason, natural selection is not only the primary mechanism of evolution but also forms the conceptual framework for modern biology (Dobzhansky 1973, Demastes, Good, and Peebles 1995a, Demastes, Settlage, and Good, 1995b, National Research Council 1996, Anderson, Fisher, and Norman 2002).

This dissertation follows the style of the Journal of BioScience.

The theory of evolution through natural selection serves as the cornerstone for the life sciences (Sadler 2005, Balgopal 2007). The literature clearly indicates that, by having a comprehensive and thorough understanding of evolutionary theory, students gain the conceptual knowledge to synthesize and integrate diverse biological concepts and processes (Bishop and Anderson 1986, Demastes et al. 1995a, b). In addition, students are more likely to understand the progression of population change over time (Bishop and Anderson 1986, Demastes et al. 1995a, b, Geraedts and Boersma 2006). Evolution, by means of natural selection provides the theoretical framework for modern biology (Bishop and Anderson 1986) as the origin of new phenotypic variants or population diversity increases through the natural selection process (Stallings 1996, Anderson 2003, Kutschera and Niklas 2004).

Unfortunately, many students (science and non-science majors) do not understand the concept of natural selection or believe in evolution altogether, even after instruction (Brumby 1984, Demastes et al. 1995a, b, Anderson et al. 2002, Geraedts and Boersma 2006). Many students hold misconceptions or incorrect preconceived notions about the mechanisms of evolution and natural selection (Geraedts and Boersma 2006). These misconceptions hinder students' conceptual learning and are difficult to change even after instruction (Clement, Brown, and Zietman 1989, Anderson 2003). Is the resistance to change due to the complexity of the theory, as even biology majors and medical students struggle to conceptualize this biological theory (Mayr 1982, Brumby 1984, Anderson 2003, Geraedts and Boersma 2006, Balgopal 2007, Nehm and Reilly 2007)? Or is it because cultural factors, e.g., ethnicity, linguistics, beliefs, attitudes, religion, religiosity, etc., affect the student's cognition? If neither of these two rationalizations provides a possible explanation, then perhaps traditional pedagogical instruction fails to impart to students adequate knowledge and give sufficient time to conceptualize evolutionary theory. Unfortunately, traditional pedagogical methods have been known to cause students to become disinterested in science courses, and the subject matter is sometimes content deficient (Brown 2006). Diversified instructional strategies, on the other hand, have been proven to be superior teaching methods, and thus more likely to dismantle misconceptions through conceptual change (Scharmann 1990). However, these high-caliber teaching methods require more preparation time, different teaching tools/supplies, and challenge instructors to be creative in order to engage students. Regardless of the reason(s), the outcome is disheartening as many students encounter difficulties in conceptualizing evolutionary theory even after instruction (Mayr 1982, Brumby 1984, Anderson 2003, Geraedts and Boersma 2006, Balgopal 2007, Nehm and Reilly 2007.

Statement of the Problem

The earth's biological processes are driven by a series of chemical reactions that are in constant states of flux (Demastes, et al. 1995a, b, National Research Council 1996, Stallings 1996, Anderson 2003). Hence students must develop sound scientific skills and knowledge to understand these biological processes. After all, science education is not only about making and measuring observations but also about providing students with the conceptual knowledge, critical thinking skills, and aptitude to discover universal truths (Jensen 2005). However, the relevant literature informs us that many members of society do not understand evolutionary theory (Brumby 1984, Clough and Wood-Robinson 1985, Bishop and Anderson 1990, Lederman 1992, Demastes et al. 1995a, b, 1996, Abd-El-Khalick and Lederman 2000, Anderson et al. 2002, Dagher and BouJaoude 2005, Nehm and Reilly 2007) and as a result, this lack of knowledge significantly impacts how world situations are interpreted, addressed, and ultimately resolved (Alters and Nelson 2002, Blackwell, Powell, and Dukes 2003).

When Charles Darwin proposed “descent with modification” or “natural selection” as the basic mechanism for the origin of new phenotypic variants, he also implied that non-random processes contribute to evolution as well (Kutschera and Niklas 2004). Hence, as genomic variations are eliminated, the affected species’ offspring are unable to adapt to its environment and therefore do not survive (Kutschera and Niklas 2004). Indeed, the concept of adaptation is one of the most complex ideas of evolutionary theory, and students struggle to conceptualize this aspect of evolutionary theory (Mayr 1982, Anderson 2003). For example, Anderson’s (2003) study documented that students continue to struggle with this concept as she discovered that students had difficulty conceptualizing: 1) *causes of phenotypic variation*, 2) *how new species originate*, and 3) *change in the distribution of individuals with certain heritable traits.*

Researchers have systematically documented students’ struggle to comprehend evolution by means of natural selection (Bishop and Anderson 1990, Demastes et at. 1995a, b, Southerland, Abrams, Cummins, and Anzelmo 2001, Anderson et al. 2002, Balgopal 2007). Regrettably, the teaching of evolution, at least in the U.S., has and continues to be controversial and opposed by many sectors of the general public, in particular by religious groups (Stallings 1996, Balgopal 2007). However, despite concerns and apprehension of children's faith decreasing as a result of evolution education, Francis and Greer (2001) discovered that both Catholic and Protestant teenage students living in Northern Ireland did not experience a decrease in their attitudes about Christianity as they increased their understanding of the nature of science. Even though research indicates that the acceptance or conceptual understanding of evolutionary theory does not displace religious beliefs, the teaching of evolutionary theory continues to be challenged and is difficult to teach.

In addition, scholars have discovered that students are not the only individuals who do not understand evolutionary theory, as some biology teachers still do not understand or even accept evolution as the foundation for population diversity (Eve and Dunn 1990, Brem, Ranney, and Schindel 2003, Alberts and Labov 2004, Miller,Scott, and Okamoto 2006, Balgopal 2007). As a result, some teachers find it emotionally difficult to teach and deal with this subject matter (McCormack 1982, Nelkin 1982, Elgin 1983, Johnson 1985, Nelson 1986), and thus evade teaching evolution all together (McCormack 1982, Nelkin 1982, Johnson 1985, Nelson 1986, Scharmann 1990, Stallings 1996, Elgin 1983).

In the quest to further assist biology educators, the National Science Foundation in 1992 sponsored a national conference on *evolution education* (Stallings 1996). Shortly after the conference the proceedings were published along with the proposed evolution education agenda for all grade levels (including higher education) (Good, Trowbridge, Demastes, Wandersee, Hafner, and Cummins 1992, Stallings 1996). Unfortunately, this educational publication did not recommend to the teaching community specific or precise teaching strategies nor identify best teaching practices to produce conceptual changes. Consequently, the teaching of evolutionary theory continues to be restricted to non-threatening instructional styles, even though these pedagogical teaching methods are known to be inadequate or of poor content (Stallings 1996, Brown 2006). Regardless, these teaching methods continue to be used by the teaching community which explains why students continue struggling to conceptualize evolutionary theory.

Evolution by means of natural selection is a paradox in which the advancement of humanity is directly threatened by our overall lack of knowledge (Brem et al. 2003). It is well established that students tend to hold misconceptions about the nature of science and evolution. In addition, many misconceptions are resistant to instruction and reluctant to change (Gibson 1996, Blackwell et al. 2003, Sundberg 2003, Abd-El-khalick and Akerson 2004). Furthermore, science is regarded differently by all cultures (Aikenhead 1997, Alters and Nelson 2002, Blackwell et al. 2003, Brown 2006); therefore, cultural differences could be one reason that some students struggle to conceptualize evolutionary theory (Aikenhead and Jegede 1999). It is, therefore, critical that the educational community be provided with additional knowledge of how cultural factors impact students' cognition of scientific learning. After all, science is not only about teaching the scientific method or making and assessing observations, but it is also about providing students with the conceptual knowledge and critical thinking skills to arrive at sound scientific conclusions (Jensen 2005).

Furthermore, many scholars have documented science misconceptions and have discovered that incorrect alternative conceptions are common phenomena and are not exclusive to evolutionary theory (Lederman1992, Abd-El-Khalick and Lederman 2000, McComas 2002, Brem et al. 2003). For example, Mestre (1989) discovered that misconceptions exist in mathematics and are also resistant to conceptual change. Fifteen years later, Tirosh (2000) discovered that school teachers were having difficulty explaining basic mathematical procedures such as division of fractions (an essential mathematics application). The students' ability to solve analytical problems was hindered as a result of their misconceptions (Tirosh 2000). Unfortunately, misconceptions are not unique to mathematics and evolutionary theory as they are common in other fields, e.g., astronomy, physics, engineering, etc. (Helm and Novak 1983, Skam 1994, Jordan, Cardenas, and O'Neal 2005). However, since the subject matter of these disciplines is not considered controversial, they lend themselves to increased research and funding opportunities and as a result, these disciplines have made greater strives in dismantling misconceptions (Mestre 1991, Tirosh 2000).

Purpose and Significance of Study

Many scholars have documented misconceptions of evolutionary theory. However, limited research has been conducted regarding misconceptions about natural selection by intended biology majors as they progress through their advanced biology coursework (Nehm and Reilly 2007). Furthermore, few research projects have been conducted on teacher-student interactions and students' perceptions and attitudes toward science (Fisher and Waldrip 1999). Moreover, any correlations between evolutionary theory, cognition, and cultural factors e.g., ethnicity, religion, religiosity, linguistics, etc. are limited in the literature, even though cultural background and cultural factors are known to affect student cognition (Brown 2006). Furthermore, cultural factors have been known to impact how science is regarded and such regard differs from culture to culture (Aikenhead 1997).

As stated above, in the literature it is documented that students lack evolutionary conceptual knowledge. In addition, lack of evolutionary understanding significantly impacts how students observed and addressed scientific issues. Furthermore, different cultures regard science differently (Aikenhead 1997, Alters and Nelson 2002, Blackwell et al. 2003, Brown 2006). So the question then becomes, why cultural factors not been studied as variables of evolutionary theory cognition? Is it because the learning of science is considered an *acculturation process* and believed to be *value free* (Fisher and Waldrip 1999, Brown 2006)? Or is it because cultural differences sometimes cause students to unconsciously prohibit or inhibit themselves from acquiring scientific knowledge, especially if their culture does not regard science highly (Aikenhead and Jegede 1999)?

Unfortunately, scholars have documented that some members of the teaching community do not understand or even believe that cultural conflicts exist in students, particularly among minority students; however, cultural conflicts impact student cognition (Delgado-Gaiten and Trueba 1991, Fisher and Waldrip 1997, Brown 2006). Unfortunately, the lack of awareness, poor understanding, or even the belief that science is *value free* affects minority students' ability to conceptualize theories, ideas, concepts, etc. (Delgado-Gaiten and Trueba 1991, Fisher and Waldrip 1997, Brown 2006). In addition, students' attitudes towards education are also affected when cultural conflicts are present (Delgado-Gaiten and Trueba 1991, Fisher and Waldrip 1997, Brown 2006).

Misconceptions of natural selection are prevalent and scholars have revealed that many students under study hold incorrect preconceived notions or misconceptions about evolutionary theory. Furthermore, these misconceptions tend to hinder students' ability to acquire new knowledge (Delgado-Gaiten and Trueba 1991, Fisher and Waldrip 1997, Brown 2006). And, despite the many efforts including those made in 1907 by the Central Association of Science and Mathematics Teachers to teach scientific methods and processes (Lederman 1992), minimal gains (at best) have been made as the majority of students still believe that evolution results as a process of environmental conditions, thus associating changes in traits as a result of a need basis rather than random mutations (Brumby 1984, Bishop and Anderson 1990, Anderson et al. 2002). Therefore, in order to make greater strides in this century and to ensure that "no child is left behind," educators (in particular science teachers) need to take many factors into consideration, i.e., student's culture, culture and cognition, demographics trends, and teaching best practices, etc.

Furthermore, the teaching community needs to evaluate how culture affects science learning, but more specifically, how cultural factors impact the conceptual understanding of evolutionary theory by natural selection. Hence, in order to contribute to literature and address this critical research need, the present study was designed to determine whether Latino and non-Latino students differ in their conceptual understanding of natural selection. In addition, this project evaluates Latino and non-Latino misconception differences and attempts to determine which cultural factors contribute to these misconceptions.

Demographic Trends

It is essential for the teaching community to establish a more comprehensive understanding of how cultural factors impact teaching and learning because misconceptions are difficult to change (Mestre 1989, Aikenhead 1997, Brown 2006). As the demographics in the U.S. continue to change, educational institutions, regardless of whether they are private or public, will continue to see increases in student enrollment from ethnically-diverse populations (Laden 2001). Thus, it is imperative to evaluate how cultural factors affect conceptual cognition of evolutionary theory.

The literature is abundant with regards to misconceptions of evolution and natural selection; however, it is extremely limited regarding misconceptions among minority populations with regards to conceptual understanding and misconceptions of evolution and natural selection. Thus, inferences will have to be made from other studies regarding Latino students in higher education. Furthermore, it is indispensable to ascertain conceptual knowledge of evolutionary theory of the Latino student population. After all, the Latino population increased from 22.4 to 35.3 million between 1990 and

2000 respectively and an additional 5 million four years later (U.S. Census Bureau Press Release n.d.). The U.S. Census Bureau projects that, by the year 2050, one in three U.S. residents or thirty percent will be of Latino decent (U.S. Census Bureau News n.d.). In addition, by the year 2039, the total U.S. population is projected to reach 400 million (U.S. Census Bureau News n.d.). This demographic growth was driven as a result of an influx of immigrants who arrived in this county during the 1970s thus, "…the first generation—foreign born—has become more numerous than the second or third generations—those born in the United States of U.S.-born parents" (Suro and Passel 2003, p. 2). Now almost four decades later, scholars still have not evaluated Latino student knowledge of evolutionary theory despite the fact that evolutionary principles relate to and are necessary to understanding human affairs (Wilson 2007); hence significantly impacting how world situations are addressed and resolved.

Commensurate with the demographics given above, Latino representation in higher education is also changing. For example, between 2000 and 2004, the number of Latino undergraduate students increased almost 25% as compared to 9% for whites (NCES, Digest of Education Statistics Table 2005). Total Latino enrollment currently accounts for about 11% of the total student enrollment in higher education (NCES, Digest of Education Table 205 2005). Hence, Latino students are more likely to attend colleges and universities at higher rates than most other ethnic minorities (Rooney, Hussar, Planty, Choy, Hampden-Thompson, Provasnik, and Fox 2006, National Center for Education Statistics, Retrieved 11 May 2007). Furthermore, the majority of these Latino students attend Hispanic-Serving Institutions (Laden 2001).

Hispanic-Serving Institutions (HSIs) are either public or private 2 and 4-year colleges and universities that have a total Latino enrollment of twenty-five percent or greater full-time equivalent students (Laden 2001). These institutions of higher education play a vital role in providing educational opportunities for Latino students. They account for nearly six percent of all postsecondary institutions, enroll over a million Latino students annually, and educate nearly fifty percent of the Latino student population. In addition, they educate approximately twenty percent of all college students (Laden 2001).

Research Hypotheses

The research hypotheses for this study are as follows:

H_0: Latino and non-Latino students do not differ in their conceptual understanding of natural selection and evolutionary theory.

H_1: Latino and non-Latino students differ in their conceptual understanding of natural selection and evolutionary theory.

H_0: Cultural factors do not affect students' preconceived notions of natural selection and evolutionary theory.

H_1: Cultural factors do affect students' preconceived notions of natural selection and evolutionary theory.

These hypotheses will be tested by using a modified version of the Conceptual Inventory of Natural Selection (CINS) instrument developed and validated by Anderson et al. (2002). A comprehensive survey description can be found in the methodology chapter (Chapter III) of this dissertation.

Research Questions

1. What differences exist between Latino and non-Latino college students?
2. What misconceptions of natural selection are more prevalent within the Latino college student population?
3. What misconceptions of natural selection are more prevalent among college students' with a religious affiliation?

Theoretical Framework for the Study

The purpose of this study as stated above was to examine what affects, if any, cultural factors have on the conceptual understanding of evolutionary theory. More specifically the focus of this study is to determine if Latino and non-Latino students differ in their misconceptions of natural selection and, if so, could cultural factors contribute to the differences in these misconceptions? In addition, an attempt is made to identify the cultural factors associated with misconceptions of evolutionary theory. Drawing from Jean Piaget's (1964) work, cognitive disequilibrium or dissonance is the state in which a student realizes or acknowledges that his/her conception or notion is not only flawed but also lacks explanatory power (Piaget 1964, 1968). Constructivism is currently the governing learning theory, and it explains how students acquire and construct knowledge structures (Anderson 2003). Constructivism suggested that individuals give meaning to newly acquired information; however, the meaning or level of understanding differs from person to person due to prior knowledge, experience, or belief system (Anderson 2003).

Therefore, in order for conceptual change to take place, the learner must first accommodate new concepts or ideas and then integrate them into new knowledge structures or mental frameworks (Anderson 2003, Balgopal 2007). This is important because students do not take in and learn information exactly as it was instructed, presented, or taught due to the fact that students actively perceive/process information, then use the newly acquired information to build more complex and intricate knowledge structures (Novak and Growin 1984, Anderson 2003). Unfortunately, the literature suggests that not everyone is able, capable, or willing to undergo conceptual change (Anderson 2003, Balgopal 2007). However, individuals who go through conceptual change are able to so because they develop and use meaningful learning strategies to assist them in resolving conceptual conflicts (Martin, Mintzes, and Clavijo 2000, Mintzes, Wandersee, and Novak 2000, Anderson 2003, Balgopal 2007).

Limitations

The limitations for the current study are as follow:

1. This study focuses on public 4-year higher education Hispanic-Serving Institutions in Texas and thus, the results cannot be generalized to be representative of all higher education or all Hispanic-Serving Institutions.
2. Instrument wording may result in a potential response bias.
3. The modified CINS instrument surveys students only once for knowledge of natural selection and evolution.

CHAPTER II

LITERATURE REVIEW

Scholars mutually understand that in order to make significant and meaningful contributions to the body of science, new research endeavors need to take into consideration the findings and recommendations of other scholars. By doing so, studies are not only fine-tuned and improved, but pitfalls are also minimized or avoided altogether. It has also been observed that many disciplines tend to evade participating in research outside their *domain* for a multitude of reasons. However, collaborating efforts should be considered as oftentimes these multidisciplinary studies are highly sought out by funders, yield fruitful opportunities, and make meaningful scholarly contributions. Multidisciplinary studies are considered more encompassing, are highly regarded and valued by various disciplines, and provide *breadth* and *depth* knowledge of real-world situations. These types of studies often facilitate new research opportunities as they test and measure variables once considered irrelevant or insignificant in a particular discipline or domain.

In order to explore the notion of cultural factors and how they may influence students' conceptual knowledge of natural selection, this research project attempts to identify which cultural factors, if any, have the greatest impact on students' misconceptions of natural selection. This chapter begins by providing a Overview of Students' Failure to Conceptualize Evolutionary Theory; then it addresses: 1) Evolution and Natural Selection Research Timeline; 2) The influence of Culture on Knowledge

Acquisition and Evolutionary Theory; 3) Theoretical Framework of Knowledge Acquisition; 4) Conceptual Change Theory; 5) Levels of Reasoning; 6) Learning and Teaching; 7) Cultural Theory; 8) Socio-cultural Theory and Learning; and ends with 9) Cultural Factors and Knowledge Acquisition.

Overview of Students' Failure to Conceptualize Evolutionary Theory

Darwin's theory of natural selection transformed the biological sciences by identifying natural selection as the driving mechanism of evolution (Stallings 1996, Anderson 2003, Kutschera and Niklas 2004, Sadler 2005, Balgopal 2007). In addition, the theory of evolution serves as the nucleus for all the life sciences (Sadler 2005). Since environmental changes are constant, natural selection continuously influences genetic characteristics of populations (Pidwirny 2006). For this reason, natural selection accounts for the origin of new phenotypic variants or for the diversification of life over time as the process of natural selection increases the frequency of alleles or genetic traits (Stallings 1996, Anderson 2003, Kutschera and Niklas 2004). Therefore, it is imperative that students understand the biological processes that occur in nature. By doing so, they are more apt to conceptualize diverse biological concepts (Bishop and Anderson 1986, Demastes et al. 1995a, b, Anderson 2003). And as a result, students are more likely to conceptualize how random mutations and natural selection change over time (Bishop and Anderson 1986, Demastes et al. 1995a, b).

Because evolutionary theory is the nucleus for the life sciences (Anderson et al. 2002, Sadler 2005, Balgopal 2007), the biology teaching community has been directed by the National Academy of Science and the National Research Council to make evolutionary theory the center theme of biology courses (Anderson 2003). By providing students with the theoretical framework to achieve conceptual knowledge, they are more apt to synthesize and integrate diverse biological concepts and as a result, address complex issues (Bishop and Anderson 1986, Demastes et al.1995a, b, Anderson 2003). Unfortunately, many science and nonscience majors still do not thoroughly understand nor do they accept the concept of natural selection or the different evolutionary processes, even after instruction (Brumby 1984, Demastes et al. 1995a, b, Anderson et al. 2002, Nehm and Schonfeld 2007). Furthermore, misconceptions continue to be resistant and difficult to change (Clement, Brown, and Zietman 1989, Otero 2000). Additionally, researchers have not been able to reach a consensus as to how evolutionary misconceptions originate nor why they continue to be difficult to change, even after instruction (Clement et al. 1989, Otero 2000, 2001).

The relevant literature informs us that evolutionary theory is misunderstood and negated (Brumby 1984, Clough and Wood-Robinson 1985, Bishop and Anderson 1990, Lederman 1992, Demastes et al. 1995a, b, 1996, Abd-El-Khalick and Lederman 2000, Anderson et al. 2002, Dagher and BouJaoude 2005, Nehm and Reilly 2007), and that evolutionary theory continues to provoke public controversy despite the scientific community's acceptance and support of its being taught in public schools (Balgopal 2007, NSTA 1998, 2000, 2003). In fact, most of the controversy regarding this theory has been centered in the public school system; as a result, some school districts are prohibited from teaching evolution altogether (Stallings 1996, Anderson 2003, Balgopal

2007). Nonetheless, evolutionary theory is taught in biology and ecology courses at institutions of higher education, e.g., community colleges, junior colleges, technical colleges, and universities (Stallings 1996).

Evolution and Natural Selection Research Timeline

On the grand scale of scientific research, the relevant literature demonstrates that limited studies have been conducted on students' attitudes, beliefs, conceptual knowledge, conceptual understanding of evolution and natural selection in comparison to other areas of science. However, research publications increased after the publication of the *Proceedings of the 1992 Evolution Education Research* (Stallings 1996). Nonetheless, scholars have documented students' failure to conceptualize evolutionary principles.

For example, Anderson's (2003) study revealed that many nonbiology majors were unable to comprehend the concept of evolution. Her results are not unique; other researchers document similar findings. In 1984, Brumby examined medical students' reasoning patterns related to natural selection and discovered that they had a poor understanding of natural selection and thereby believed that evolutionary changes transpire due to *need* within a population (Brumby 1984, Stallings 1996, Anderson et al. 2002, Anderson 2003). Clough and Wood-Robinson (1985) tested young students (ages 12-16) on biological adaptation and discovered that many students had difficulty explaining biological adaptation. In addition, the majority of the students in this study used teleological and anthropomorphic explanations with regards to evolutionary changes (Clough and Wood-Robinson 1985, Stallings 1996, Anderson et al. 2002).

Other studies, like Bishop and Anderson (1990) evaluated students' knowledge of evolutionary theory after one week of instruction in a 10-week course. To their dismay, these authors discover that many of the students had difficulty conceptualizing 1) origin and survival of new traits, 2) the role of variation in a population, and 3) evolution as a changing proportion of alleles (Bishop and Anderson 1990). Also in 1990, Scharmann published the results of diversified instructional methods as they were incorporated to assess and evaluate the effectiveness of teaching college students evolutionary concepts. Scharmann's study revealed diversified instructional strategies to be superior to traditional pedagogical teaching methods (Scharmann 1990). In 1994, Settlage evaluated evolutionary theory and documented a decrease in teleological or Lamarckian explanations of evolutionary theory; thus he recommended evolutionary theory to be taught year-round instead of limiting it to a single-block of time, unit, or textbook section.

In the quest to dismantle evolutionary misconceptions, Demastes, Settlage and Good (1995b) closely duplicated the Bishop and Anderson (1990) study by using the same conceptual-change teaching module in two separate studies on college nonbiology majors and high school students respectively. The results of the college student study demonstrated that neither the amount of prior instruction nor students' beliefs of evolution increase the use of scientific concepts (Demastes et al. 1995b). However, the results were contradictory when it came to the high school students as the amount of prior instruction and students' beliefs significantly impacted the use of scientific concepts (Demastes et al. 1995b). In an effort to define theory limits, Demastes, Good and Pebbles (1996) investigated patterns of students' conceptual restructuring of biologic evolution based on conceptual change theory. These researchers discovered that conceptual change in one sphere requires change in many others and thus, reported conceptual change to be: (a) *cascade*, (b) *wholesale*, (c) *incremental*, and (d) *dual constructions* (Demastes et al.1996).

In 1996, Jensen and Finley reported their findings after assessing students' learning of evolution by natural selection in four sections of an introductory biology course by using different combinations of educational materials (traditional or historically rich materials) and instruction (paired problem solving or traditional lecture). Unfortunately, the results were disheartening as evolutionary misconceptions proved once again resistant to change even after incorporating different educational teaching combinations (Jensen and Finley 1995, 1996). On the other hand, in 2001 Reiser, Tabak, Sandoval, Smith, Steinmuller, and Leone reported middle school students' ability to use and construct an excellent understanding of natural selection when provided sufficient time and a cognitively-rich learning environment. Nonetheless, students continue to face challenges as Balgopal's (2007) study revealed that many of the students who participated in her study were unable to conceptualize the theory of natural selection as they fail to recognize or identify *variation changes or genetic variation*, which results in differential survival and reproduction rates of organisms.

Indeed, the overall results paint a gloomy picture and must be demoralizing to educators. However, students may not be the sole perpetrators of this educational calamity as teachers' beliefs and personal conceptual understanding of evolutionary theory may have some influence on student's poor knowledge of evolutionary theory. It appears that even after a 14-week evolution course, more than 50% of secondary biology teachers preferred students be taught some creationism in school (Nehm and Schonfeld 2007). Furthermore, "9% of the biology teachers preferred that students believe creationism exclusively,…[while] 48% of the biology teachers preferred that students believe both evolution and creationism" (Nehm and Schonfeld 2007, p. 712). Moreover, some biology teachers still do not accept evolution as the foundation for the diversification of life (Eve and Dunn 1990, Brem et al. 2003, Alberts and Labov 2004, Miller et al. 2006, Balgopal 2007). In addition, some educators find the subject matter emotionally difficult and thus evade teaching evolution altogether (McCormack 1982, Nelkin 1982, Elgin 1983, Johnson 1985, Nelson 1986, Scharmann 1990, Stallings 1996), perhaps explaining why students continue to arrive at institutions of higher education confused and with evolutionary misconceptions.

The Influence of Culture on Knowledge Acquisition and Evolutionary Theory

Evolutionary Misconceptions

Misconceptions about evolutionary theory continue to persist. The relevant literature illustrates that scientific terminology lacks clarity as some evolutionary terms are poorly defined thereby confusing students on evolutionary theory (Anderson 2003, Balgopal 2007). It appears that evolutionary definitions cause students to misunderstand or misinterpret evolutionary concepts as they often fail to identify and address both the mechanical processes and the meaning of scientific terminology (Anderson 2003). Unfortunately, scientific theories use general terminology/vocabulary, yet these terms differ in meaning from common use definitions (Anderson 2003, Balgopal 2007). Interestingly, this problem is not unique to U.S. students as similar problems have been documented worldwide (Balgopal 2007).

For example, Balgopal (2007) reported that in 1994, Bizzo discovered that Brazilian high school students accepted to enter higher education institutions had difficulty recognizing the differences between biological *competition* and *fighting* (Balgopal 2007). Evolutionary terms that tend to confuse students are words like *adaptation, biological evolution, competition, fitness*, etc. A perfect example is the word *fitness*, which is often referred to or defined as physical strength rather than an organism's ability to survive and reproduce (Anderson et al. 2002, Balgopal 2007). Unfortunately, colloquial definitions that differ from scientific definitions cause students to misunderstand evolutionary concepts (Bishop and Anderson 1990, Demastes et al. 1996, Anderson et al. 2002, Rowe 2004, Balgopal 2007).

Furthermore, semantics impact how words are interpreted and understood (Anderson et al. 2002, Balgopal 2007). Different languages have different semantic features that are above lexical semantics (Swoyer 2003). Hence, students from diverse populations, for example, Latino students, often bring with them a different language to the learning experience, possibly causing them to comprise, interpret, or conceptualize scientific words differently.

Consequently, students may arrive at institutions of higher education with misconceptions based on different learning experiences or language usage (Demastes et at. 1996, Anderson 2003, Balgapol 2007). Students may also have colloquial term definitions or explanations that are at odds with scientific meaning (Demastes et at. 1996, Anderson 2003, Balgapol 2007). As a result, students may fail to conceptualize, comprehend, and understand the various processes of natural selection e.g., *mutations, variation, adaptation*, etc., which are the driving forces behind evolution (Demastes et at. 1996, Anderson 2003, Balgapol 2007).

The scientific research community began studying metacognition, the study of "learning-relevant properties of information or data" (Flavell 1976, p 232), teaching tools, and learning strategies that encourage conceptual change (Balgopal 2007). Tao and Gunstone (1999) suggest that the study of metacognition is essential in teaching for conceptual change. After all, identifying what prompts conceptual change would enable the teaching community to integrate intervention mechanisms to increase students' conceptual knowledge (Balgopal 2007).

Theoretical Framework of Knowledge Acquisition

The acquisition of knowledge or academic learning is directly influenced by time and relation of prior knowledge to new information. In other words, knowledge is acquired when students spend the adequate amount of time on age-appropriate academic tasks and also when new information is structured in such a manner that relates it to student's prior knowledge (Gess-Newsome and Lederman 1999). Hence, conceptual knowledge and/or conceptual understanding (interchangeable words) establishes the framework for knowledge and its organizational strategies vary between novice and expert learners, as the storage and use of information to formulate knowledge requires different cognition applications (Gerace 2001). In other words, conceptual understanding requires contextual learning in order to make or establish inferences, correlations, and relationships from observed phenomenon (Pfannkuch and Wild 2004).

Conceptual Knowledge/Conceptual Understanding

The acquisition of conceptual knowledge or conceptual understanding requires the learner to generate different mental processes or apply higher-order thinking to analyze correlations and relationships between knowledge structures and qualitative reasoning (Gerace 2001). Conceptual knowledge or conceptual understanding characterizes b*readth* and *depth* knowledge acquisition and application that is derived from contextualizing scientific principals, theories, and concept relationships of scientific domains (Alao and Guthrie1999).

The acquisition of *breadth* and *depth* will facilitate conceptual knowledge differences as the novice and expert learner will differ in how they acquire, store, and ultimately utilize the acquired knowledge structures/information (Alao and Guthrie 1999). Thus, the acquisition of critical or strategic knowledge skills allows the novice learner to transition to an expert learner by increasing his/her thinking skills (thinking capability) to evaluate, assess, and solve complex, concept-based problems (Aloa and Guthrie 1999, Gerace 2001). Thinking skill is referred to as the cognitive process that facilitates the use of information to create meaning and/or to understand (Shinn, Briers, Christiansen, Harlin, Lindner, Murphy, Edwards, Parr, and Lawver 2004). On the other hand, strategic knowledge skills are defined as elements or *schema*s that enable an "expert to devise forward looking, concept-based problem solving methods" (Gerace 2001, p. 3).

Why is concept problem solving important? It is because it denotes students' acquisition of b*readth* and *depth* conceptual understanding of concepts or abstract thinking (Alao and Guthrie 1999, Gerace 2001). Furthermore, conceptual understanding, procedural knowledge (knowledge encoded in functions or actions) and declarative knowledge (factual knowledge) enable students to apply informational knowledge to evaluate situations (Gerace 2001, Shinn et al. 2004) and thus resort to higher-order thinking to resolve issues or problems (Alao and Guthrie 1999, Shinn et al. (2004). After all, the capacity to conceptualize and address complex problems requires the utilization of specialized skills to analytically assess the issue(s) at hand (Gerace 2001). Unfortunately, not all instructors and/or teachers facilitate this process for a variety of reasons, e.g., due to lack of training, lack of knowledge, lack of adequate training materials, or insufficient training materials, as well as having a classroom environment not conducive to active or engaged learning. Regardless of the reason(s), the end result is demoralizing as it has a profound impact on conceptual understanding and ultimately, on conceptual change (Alao and Guthrie 1999, Gerace 2001, Shinn et al. 2004).

For many years, scholars like Brown, Bransford, Ferrera, and Campione (1983); Entwistle and Ramsden (1983), Graesser, Golding, and Long (1991); Shinn et al. (2004); and Brown (2006) have demonstrated that higher-level learning and higher-order thinking facilitate conceptual learning (i.e., conceptualization of concepts, theories, and abstract ideas) as students are able to decipher convoluted schemes as well as establish correlations and relationships. Furthermore, higher-level learning and higher-order thinking facilitate high academic performances as students are taught to identify and solve complex problems (Alao and Guthrie 1999), instead of memorizing concepts and theories.

So the question then becomes "how do students acquire higher-level learning and higher-order thinking?" The literature demonstrates that it is a result of active classroom engagement or *active learning* as well as adequate amount of time invested in age-appropriate academic tasks and academic activities (Alao and Guthrie 1999, Gerace 2001). Active learning has been known to promote students' acquisition of conceptual understanding, procedural knowledge, and declarative knowledge by engaging students and facilitating conceptual learning and conceptual understanding (Alao and Guthrie 1999, Gerace 2001). And as a result, students do not resort to the memorization of concepts, figures, relationships or specific details. Instead, students are assisted and encouraged to solve problems by working out solutions that are derived from assessing knowledge structures and applying sound reasoning (Alao and Guthrie 1999, Gerace

2001). "For example, a student who tries to figure out how information…[is connected regarding the various] ecological concepts [that are involved] (e.g., community, food chain, energy pyramid)…is more likely to understand that the size of a population in a community will depend on how much energy is available to that population (the community-energy pyramid relationship) than a student who simpl[y] memorizes the different ecological concepts" (Alao and Guthrie 1999, p. 9).

Content Knowledge/Context Knowledge (procedural and declarative knowledge)

For the purpose of this research project, content knowledge and/or context knowledge are used interchangeably and define the parameters of declarative and procedural knowledge. While procedural knowledge refers to the skills necessary and used to achieve a particular goal or outcome, declarative knowledge refers to the knowledge about knowing things (Shinn et al. 2004), in other words, it is knowledge on or how to perform/conduct or do something. Regardless, content or context knowledge is subject-domain knowledge denoting the transformation of contextual understanding which rest on b*readth* and *depth* as well as the capacity to formulate powerful representations and reflections of the acquired knowledge (Gess-Newsome and Lederman 1999)

Declarative knowledge serves as the foundation and the building blocks for higher-level learning and higher-level thinking, as it facilitates the development of the various skills necessary to synthesize ideas and evaluate concepts (Shinn et al. 2004). Students acquire declarative knowledge when they are able to understand, remember, retrieve, and apply information (Shinn et al. 2004). Students are also required to integrate new knowledge into existing schema(s) by decoding, constructing consequential meanings, organizing, storing, and internalizing information into a manner that makes sense to them and have it readily available when needed (Shinn et al. 2004). In other words, declarative knowledge must first be acquired through a "compilation process in terms of adaptability of the human cognitive system…[and] then converted or compiled [in]to procedural knowledge" (Ng and Hallinger n.d., p. 3).

Procedural knowledge on the other hand refers to procedural representations of knowledge (Basjes 2002) or as knowledge manifested in doing something. Hence, it is knowledge or information on "how to do something" or simply stated, "knowing stuff" (Marzano, Pickering, Arredondo, Blackburn, Brandt, and Moffett 1992, Basjes 2002). The acquisition of procedural knowledge facilitates the process of determining *when*, *how*, and *why* to do a specific task, as it requires an individual to use information to make sound decisions by evaluating knowledge structures (Basjes 2002, Marzano et al. 1992). As stated above, conceptual change cannot be taught without first assessing and evaluating the theoretical framework of knowledge acquisition. In addition, conceptual change cannot take place if teachers/instructors are not teaching to promote conceptual understanding and are not using content (contextual) knowledge when teaching.

Conceptual Change Theory

Concept learning requires metacognitive and self-reflective capabilities (Balgopal 2007). Conceptual change refers to an individual's ability to observe and evaluate relationships between concepts, thus allowing individuals to formulate knowledge structures that can be used to explain situations, address problems, or make educated predictions (Ausubel 1968, Novak and Growin 1984, Anderson 2003). Conceptual change modifies or transforms an existing conception e.g., belief, idea, or way of thinking (Orey 2001). Teaching for conceptual change requires an understanding of learning theories, specifically how knowledge is acquired, organized, and conceptualized. In addition, it requires diversified teaching methods rarely found in traditional pedagogical instruction (Ausubel 1968, Novak and Growin 1984, Orey 2001, Anderson 2003, Balgopal 2007).

Teaching for conceptual change calls for the uncovering of student's preconceptions about either a topic or phenomenon and requires the use of various teaching techniques/methods to assist the learner in changing his/her conceptual framework (Davis 2001). It is believed that conceptual change takes place when a learner shifts his/her understanding of reasoning and restructures existing knowledge, beliefs, or conceptions into new foundations of knowledge to solve problems or explain situations (Orey 2001). Furthermore, "A student's current understanding and all existing knowledge is referred to as his/her conceptual ecology and encompasses (a) prior knowledge, (b) relationships between concepts, (c) new knowledge about alternative conceptions, and (d) epistemological beliefs" (Balgopal 2007, p. 42).

However, according to the literature, not all students are able and capable of undergoing conceptual change as some students are not prepared to or know how to either resolve cognitive conflict or learn the meaningful strategies and processes needed to resolve conceptual dilemmas (Hewson and Hewson 1983, Novak and Gowin 1984, Mason 1998, Martin et al. 2000, Mintzes et al. 2000, Balgopal 2007).

Extrapolating from Anderson's (2003) work, it is important to reemphasize the roles that constructivism and Schema Theory play in conceptual change. The philosophy behind constructivism is based on the notion that students actively perceive and process information to formulate complicated knowledge structures based on what the student already knows and understands (Anderson 2003). Therefore, individual learners must *actively* build knowledge and skills by either adjusting or modifying mental frameworks/representations to accommodate, adapt to, or accept new experiences (Orey 2001, Huitt 2003).

Constructivism in itself is multifaceted and brings to light the importance of identifying and understanding what is possible for students to learn (Vygotsky 1978, Anderson 2003). Vygotsky's (1978) original zone of proximal development (ZPD) exemplifies differences between what a learner is able to do "with" or "without" assistance. This pedagogical framework reinforces the concept that students can only build new knowledge or mental frameworks by adding or modifying existing ones (Anderson 2003).

Schema Theory provides the theoretical framework for understanding the cognitive process and proposes the notion that a learner first structure new obtained knowledge into understandable formats by organizing the information into manageable categories (Rumelhart and Ortony 1977). However, the most important concept of Schema Theory is the role *prior knowledge* plays during the processing stages of learning (Windmayer 2007). Furthermore, schema plays a significant function in how information is interpreted and decoded (Halliday and Hasan 1989, Driscoll 1994). Thus, the format in which learners learn is similar to Piaget's model where a learner can respond differently to new knowledge by *accommodating*, *tuning*, and *restructuring* the new information (Windmayer 2007).

Furthermore, how knowledge is presented strongly correlates to how it is interpreted, coded, categorized, organized, and eventually used (Vosniadou and Brewer 1987, Windmayer 2007). Moreover, knowledge structuring is neither global nor domain specific (to some degree explaining the reason that apprentice learners tend to hold different knowledge views which are difficult to modify or change (Vosniadou and Brewer 1987)). As a result, Schema Theory has been expanded and modified since it was first introduced by Piaget in 1952. Hence, to better understand cognitive learning and conceptual change, different measuring tools have been developed to improve teaching effectiveness (Stallings 1996, Anderson 2003).

Levels of Reasoning

The cognitive learning literature strongly suggests that a student's ability to understand complex concepts is directly attributed and correlated to his or her level of reasoning, and thus measures of formal operational reasoning are *highly related to a* *student's academic achievement* in biology, mathematics, English, and social studies (Lawson 1985, Stallings 1996). Scientific reasoning is defined as "the ability to logically solve problems through the application of the science method which includes problem identification/observation; inductive and deductive reasoning; hypothesis generation; experimentation; interpretation of results; making logical conclusions and critical evaluations…[by] mak[ing] observations and identify a problem, classif[ing] and interpret[ing] data, develop[ing] a hypothesis, design[ing] experiments/ collect[ing] data, [and] critically evaluat[ing] experimental outcomes" (Limbaugh 2005, p.3).

Hence, many studies have looked at how students' reasoning levels correlate to scientific reasoning, biological misconceptions, and scientific beliefs (Lawson and Thompson 1988). For example, a study of seventh grade students looked at formal reasoning levels on genetics, natural selection, and student misconceptions. The results of this study demonstrated that the only variable strongly associated with students' misconceptions was their level of formal reasoning (Lawson and Thompson 1988).

Lawson and Weser (1990) reported that nonbiology majors who were less skilled reasoners were not only less likely to change their perceived conceptions/ideas but were also less likely to commit to scientific beliefs or forms of reasoning. Two years later Lawson and Worsnop (1992) reported reflective reasoning to be positively correlated to scientific beliefs; yet they did not find any correlation between reflective reasoning skills and changes in religious beliefs, even after evolutionary theory instruction. Hence, as stated in the previous chapter, conceptual understanding of evolutionary theory does not appear to displace religious beliefs or practices.

Learning and Teaching

It only takes a glimpse into the literature to quickly discover and conclude that: (1) conceptual understanding or the construct of knowledge about a subject differs slightly from student to student; (2) students' minds are not blank slates; hence education in not a "pour-in" process as each student possesses distinct sets of alternative views and as a result influences students' learning capabilities; (3) all individuals, regardless of ethnicity, gender, age, or any other cultural background are capable of learning, conceptualizing, and conducting scientific research; (4) students' construction of knowledge results from concrete experiences and abstract reasoning via creation, modification, improvement, restructuring; and (5) acceptance, rejections, and/or newly-constructed knowledge structures result from a student's diverse sets of experiences, explorations, inventions, and discoveries (Anderson 2003, Bulunuz 2007). Many educators believe that the best way for students to learn a concept or idea is by having the learner construct his or her own knowledge structure rather than by having someone else construct it for him/her (Nondestructive Testing, n.d.).

Conceptual change in the sciences has been a pedagogical goal among science educators since the 1970s and even though strong arguments have been made against traditional teaching methods and techniques (e.g., lecturing, reading, observation of scientific principles, or limited hands-on activities), little has been done to mandate the use of diversified instructional methods (Watson and Konicek 1990). Furthermore, the pedagogical literature indicates that as early as the 1920s, the philosophy of science was recommended to be taught as an investigation to generate higher-level thinking (Watson and Konicek 1990). However, the texts and curricula of the 1950s tell a different story (Watson and Konicek 1990). Even today, many science texts do not contain an array of thorough/detailed experiments that promote hands-on activities, active learning, etc.; instead these manuscripts are nothing more than reading books containing predigested demonstrations of various facts asking students questions like, "Does air have weight?", thereby encouraging students to memorize responses as opposed to assisting them to conceptualize concepts and ideas (Watson and Konicek 1990).

Therefore, in an effort to measure conceptual knowledge and conceptual change, many scholars are still developing and evaluating different methods that assess quantitative and qualitative research techniques in order to determine better students' performance, conceptual knowledge, and understanding of evolutionary theory (Balgopal 2007). Instruments range from written analysis discourse, to conceptual mapping, diagnostic short answer tests, diagnostic multiple-choice surveys, student interviews, classroom observations, and laboratory reports and summaries (Balgopal 2007). Even though written reports or reflections provide a glimpse into conceptual knowledge and conceptual change, this method is daunting and time-consuming. Similarly, student interviews are time-consuming, difficult to schedule, and sometimes intimidating to students (Anderson 2003, Balgopal 2007).

Cultural Theory

"Human beings are inherently complex. We have history, background, [values, beliefs,] experiences, emotions, knowledge, and goals. We make assumptions, recognize traditions, make sense of information, invoke beliefs, and take action. In some cases we recognize and can articulate the basis for our actions, in others we cannot, seeming to act on instinct. To make sense of the teaching process and to understand the influence of teachers' knowledge on instruction, it is necessary to reduce the conceptual and contextual complexity of teaching…[perhaps terms such as] knowledge, beliefs, attitudes, and values, as well as a myriad of constructs are now used to help reduce, yet still communicate, this complexity….[However, scholars sometimes use these and other similar terms] unclear[ly and] inconsistently" (Gess-Newsome and Lederman 1991, p. 3).

In the quest to diminish this complexity, many scholars have developed or enhanced conceptual tools to identify and disprove old, outdated interferences, representations, correlations, and relationships of hypothesized culture constructs and/or cultural variables (Gess-Newsome and Lederman 1991). In addition, cultural factors, like religion or religiosity have not always been considered worthy of research by some disciplines; perhaps due to a lack or limited knowledge or understanding of the relationships between an individual's personal religious belief system and its effects on cognition/knowledge acquisition. The lack of consideration denotes negligence in scholarly work as "…individualism first took primacy in the religious sphere of the Reformation. It then spread to the secular sphere through the philosophers of the Social

Contract,…and later to the liberal economic theorists and into the cultural realm of Romanticism" (Roland 2003, p. 5). Thus culture resides and is deeply imbedded in both the conscious and unconscious of self (Hoare 2003).

So what is *culture*? Unfortunately culture is as difficult to define as it is complex, multifaceted, and diversified. Nonetheless, there are as many definitions of culture as there are cultures. Additionally, culture cannot be considered or regarded as a monolithic block because it differentiates into subcultures (Smith 2006). Nevertheless, scholars have put forth the effort to define it in terms of the "human dimension." For example, one scholar defines culture as "set[s] of perceptions, technologies, and survival systems used by members of a group to ensure the acquisition and perpetuation of what they consider to be a high quality of life" (Taylor 2001, p. 3). While another references it as "the systems of meaning and values that shape human behavior…it can be expressed in a variety of contexts including ecological setting (rural, urban, suburban), philosophical or religious values, nationality, type of family organization, social class, occupation, and migratory patterns" (Baker 2001, p. 9). Hence, "culture may be understood as a collection of values, ideas, beliefs and social guidance formed by memory, identity and future vision, which are supported by one or more national languages, embodied within traditions, habits and manners…" (Terezinha da Silva Bello Flores et al. 2008, p. 98). Thus, culture is not only arbitrary but also subjective and ever changing. In addition, cultural variables, i.e., perceptions, values, attitudes, beliefs, etc. are sometimes manifested negatively as cultural assumptions, stereotypes, biases, etc. (Taylor 2001).

Culture is learned and therefore, cultural assumptions are also learned and reside at the conscience and subconscious level of an individual (Taylor 2001). Furthermore, cultural assumptions tend to cause poor cross-cultural communications that can be expressed verbally (language or dialect spoken by and individual) and nonverbally (eye contact, body movement, touch, perception of time, etc) (Shiori, Someya, Helmeste, and Tang 1999, Taylor 2001). Regrettably, cultural differences sometimes distort communication, lead to misunderstandings and misinterpretations, and ultimately can become unintentional social insults (Shiori et al. 1999). This is why scholars who study linguistics recommend that language be used in the context of how it functions (Saville-Troike 1982, 1986). In other words, terminology should only be used interchangeably when it conveys “exact” meaning and/or expression; otherwise the possibility exists for incorrect inferences or interpretations (Hoare 2003). For example, consider the terms *culture* and *society*; oftentimes these words are used interchangeably when referencing aspects of culture (Hoare 2003). However, both of these words communicate and express very distinct concepts; i.e., *culture* describes ethnicity, customary mores, traditions, values, and beliefs; while *society* refers to the common “attitudes, feelings, and interests” of people (Hoare 2003). The same is true about scientific terminology. It should be defined and expressed in the context of its function, concept and application; as the learner’s advancement is impeded when he/she fails to comprehend the precise and distinct meaning/process/function/method of the word (Smith 2006).

Socio-cultural Theory and Learning

Socio-cultural theory draws on Vygotsky's work as well as on that of other theoreticians such as Tharp and Gallimore (1989) who provide a socio-cultural perspective with profound implications for teaching, schooling, and education (Valenzuela n.d.). Within the socio-cultural context of learning, social and cultural experiences play an important role in the acquisition and conceptualization of knowledge, as well as in the organization, application, and use of the information (Tharp and Gallimore 1989, Velenzuela n.d.). Hence, culture is an essential element in the human psyche development and also characterizes human biology (i.e., origin, history, life processes, habits, etc.) (Vygotsky 1978, Gauvain 2000). "In other words, biology and culture co-evolved, with the connection…[of the] social-cognitive processes…[providing] the ability to understand the self and others, to understand and use the accumulated knowledge of the group, to transmit this knowledge to subsequent generations" (Gauvain 2000, p. 11). Vygotsky (1978) claimed that mental functioning is derived from the social interactions. Thus in order to understand the individual, his/her-social context also needs to be studied (Valenzuela n.d., Terezinha da Silva Bello Flores, Dufresne, and Lévesque, 2008). Hence, social interactions are fundamentally cultural and thereby cultural knowledge is expressed and it is meaningful within the realm of an individual's culture (Valenzuela n.d.).

The key concept of socio-cultural theory is constructed on the basis of ongoing human dimensions and interactions (Mason 1998, Balgopal 2007). Therefore, students' conceptual knowledge is strongly influenced by others; thus "when teachers and the media use teleological and anthropomorphic language when discussing biological evolution, students learn to do the same" (Balgopal 2007, pgs. 22-23). Moreover, social interactions direct "step-by-step" processes related to cognitive development, conceptual knowledge/changes, and behavior due to the diffusion of cultural variables, i.e., attitudes, beliefs, actions, activities, conduct, governing factors, etc. (Nisbett and Norenzayan 2002) . Furthermore, these cultural markers are either acquired or adapted and vary extensively from culture to culture as cultural practices and cognition constitutes one another (Nisbett and Norenzayan 2002). In addition, social capabilities (the ability to engage in reciprocal exchanges and social behaviors) facilitate access to the thinking of other people and thereby, enables individuals to participate in social arrangements in which the valued knowledge of the group is made available and supported in rudimentary and advanced forms (Bronfenbrenner 1979). A socio-cultural approach is consistent with the ecological perspective in that both concentrate on the reciprocal nature of maturation and experience in human psychological growth (Bronfenbrenner 1979).

Cultural Factors and Knowledge Acquisition

"Many theories of learning emphasize that various social and cultural factors should be taken into account when trying to explain and develop learning. [Therefore] learning is not just a cognitive issue but also a matter of participating in cultural practices. On one hand, according to Bruner [3], knowledge is treated as the objective truth that can be transmitted from one person to another and a medium, such as a teacher is needed to transport the knowledge. The common assumption is that learning is something that individuals do. On the other hand, the alternative assumptions of social-constructivism and social learning theory [4], state that there is no objective truth and knowledge is constructed in social-interactions between people" (Leiba and Nachmias 2006, p. 500).

As noted, cultural factors are complex, diversified and encompass more than sets of beliefs, moral values, traditions/customs, language, and laws (Rose 2001). In addition, they also determine characteristics such as home language, religious observances and practices, acceptable gender roles and occupations, dietary preferences and practices, educational and intellectual practices, and many other aspects of human behavior (Kett and Trollope-Kumar 2008). Furthermore, the relevant literature demonstrates that cultural differences exist not only between distinct cultural groups but also within similar ones (Terezinha da Silva Bello Flores et al. 2008). Thus, "culture as being reflecting of different perceptions of the world…[gives rise and allows] people [to] have different ways to analyze and interpret the facts according to the culture they are inserted in, therefore, depending on the type of culture people are from, the individuals have distinct viewpoints upon a specific fact, and the interpretation of this fact depends on the cultural rules of the group they belong to" (Terezinha da Silva Bello Flores et al. 2008, p. 98).

Even though studies demonstrate how culture plays a role in cognition and knowledge acquisition, neither a single study nor a collection of studies, for that matter, have been able to reform the K-16 educational arena (K-12, community colleges, and universities). However, it is important to note and acknowledge that many scholarly contributions have improved education environments. Nonetheless, progress has not yet reached the level of systematic changes across the educational spectrum despite profound discoveries. Perhaps the lack of influence is because culture overall has been characterized as an open question by some, while others regard it as an inescapable fact or as an underlying assumption (Smith 2006). Regardless, cultural orientations exist and the acquisition of knowledge has a “social element which is often ignored” (Smith 2007, p. 229). Furthermore, as stated in the previous chapter, different cultures regard science differently (Aikenhead 1997, Alters and Nelson 2002, Blackwell et al. 2003, Brown 2006) and as a result, cultural differences sometimes cause students to unconsciously prohibit themselves from acquiring or conceptualizing scientific knowledge (Aikenhead and Jegede 1999). Hence, science learning is not *value free* (Gutiérrez, Torres, and Lopez 2009). Therefore, depending on the student’s culture, he/she will have distinctive perspectives of scientific facts, theories, concepts, etc. and as a result, will interpret them according to his/her cultural rules (Terezinha da Silva Bello Flores et al. 2008).

Educational institutions that reflect culturally insensitive views through their policies, practices, and procedures consequently refuse to acknowledge that individuals view the world through different lenses and many also conceptualize knowledge in one learning mode more easily than in another (Smith 2006). Thus, the *one learning mode fits all* teaching mentality will continue to dominate the pedagogical community.

So the question then becomes, what cultural factors have been found to promote knowledge acquisition, conceptual understanding, and conceptual change among diverse student populations? Unfortunately, it is beyond the scope of this research project to collectively identify, describe, evaluate, etc. all of the cultural factors that affect teaching and learning. However, the research will identify and describe the relevant cultural variables, cultural markers, and cultural factors found pertinent to this study in the data analysis chapter.

CHAPTER III

METHODOLOGY

The purpose of this study was to investigate and determine whether Latino and non-Latino college students differ in their preconceived notions and/or misconceptions of the theory of evolution and natural selection. And if a difference is detected, what impact if any, could cultural factors have in the formation of these preconceived notions or misconceptions. Specifically, this project was designed to identify which natural selection misconceptions, if any, are more prevalent among the Latino college student population attending 4-year Hispanic-Serving Institutions (HSIs) in Texas. Furthermore, this research project sought to determine and identify which cultural variables, if any, mark natural selection misconceptions and what conceptual knowledge differences exist, if any, between Latino and non-Latino students.

This chapter describes the method and procedures used in conducting the current study. In addition, the measurement instrument is discussed and explained.

Instrument Design

Modern survey methods are based on random-sampling techniques which were developed to sample large human populations (Kuechler 1998). Surveys based on these techniques have become powerful functional tools used to analyze human behavior and explore human characteristics, attitudes and thoughts (Groves, Couper, Lepkowski, Singer, and Tourangeau 2004). A survey is “a systematic method for gathering information from ([or] a sample of) entities for the purposes of constructing quantitative descriptors of the attributes of the larger population of which the entities are members.” (Groves et al. 2004, p. 2).

One of the main reasons that surveys are used is because they facilitate the collection of large data sets that are representative of a targeted population or group of people (Groves et al. 2004). In addition, survey questionnaires are cost effective and usually are not very time consuming. Furthermore, participants are generally able to complete a survey without any assistance or support on behalf of the researcher and/or the person administering the survey (Salkind 1994, Levine 1997). The random survey method, when applied correctly, not only provides a mirror image of the population–at-large, but it is also democratic (i.e., it offers everyone the same opportunity to be selected into the sample pool). Furthermore, participants are not pressured to respond in a certain way and responses count exactly the same when they are not weighted (Kuechler 1998). Quantitative survey tools advantageously facilitate the opportunity to gather and analyze data from small groups of people or specific sectors of a population (i.e., a sample) and draw inferences about larger groups of individuals or populations that would otherwise be prohibitively expensive and time consuming to study (Holton and Burnett 1997).

The paper-and-pencil Scantron survey that was utilized for the current research project was a modified version of the Conceptual Inventory of Natural Selection (CINS) survey that was developed, field-tested, and validated by Anderson, Fisher, and Norman (2002). Many researchers have used the CINS survey to assess student knowledge and understanding of natural selection (Demastes et al. 1996, Alters and Nelson 2002, Rowe 2004, Crawford, Higham, Renvoize, Patel, Dale, Suriya, and Tetley 2005, Sutherland, Armstrong-Brown, Armsworth, Brereton, Brickland, Campbell, Chamberlain, Cooke, Dulvy, Dusic, Filton, Freclketon, Godfray, Grout, Harvey, Hedley, Hopkins, Kift, Kirby, Kunin, MacDonald, Marker, Naura, Neale, Oliver, Osborn, Pullin, Shardlow, Showler, Smith, Smithers, Solandt, Spencer, Spray, Thomas, Thompson, Webb, Yalden, and Waltkins, 2006, Balgopal 2007, Nehm and Reilly 2007). The Modified Survey of Natural Selection (MSNS) used in the current study was developed after requesting and receiving permission from Dr. Dianne L. Anderson (via telephone conversation, June 2007). In order to keep the questionnaire short, concise and succinct, closed-ended questions were asked and the total number of pages limited to five. A shorter format avoids the pitfalls identified by Borg and Gall (1983) who found that "… on average, each page added to the total questionnaire reduced the number of responses by about [0].5 percent." (Borg and Gall 1983, p. 422). A copy of the Modified Survey of Natural Selection (MSNS) instruments is found in the appendix of this dissertation.

Section one of the survey-questionnaire used in this study contained 10 multiple–choice questions that examined the students' conceptual understanding of natural selection. Each question tested students' knowledge on evolutionary theory through natural selection. Only one scenario (Galapagos Finches) was used to assess the theory of natural selection; therefore, questions nine (9) and ten (10) were modified by replacing the word "guppies" with the word "finches." By incorporating this change, students were tested on the seven (7) natural selection concepts (1) *carrying capacity*,

(2) *competition*, (3) *great reproductive potential*, (4) *change in population with certain traits*, (5) *limited survival based on heritable traits*, (6) *inherited phenotypic variation*, (7) *causes of phenotypic variation.*

The second section of the survey contained a series of demographic, sociopolitical, and socio-cultural questions. The demographic variables included: (1) *ethnicity*, (2) *gender,* (3) *age,* (4) *religious preference,* (5) *religiosity*, (6) *student's work status*, (7) *student's income and parents' combined income,* (8) *hometown location,* and (9) *father's and mother's education level*.

Ethnicity which often refers to social groups who share cultural roots, a sense of identity, history, and geography was measured as Mexican (born in Mexico); Mexican-American (born in the United States); Anglo-American; other. *Gender* on the other hand is a term that is socially-constructed and refers to the "appropriate" characteristics or qualities that are expected to accompany each biological sex was measured male or female. *Age* is referred to as age in years, it is self-reported, and is a classification used by the U.S. Census Bureau to categorize individuals; thus, it was measured as a continuous variable.

Conversely, *Religious preference* refers to an individual's religion affiliation. Religion is often referred to as a set of beliefs or a belief system that includes faith, prayers, spirituality, values, attitudes, opinions etc., regarding the existence, nature, and worship of a supernatural agency, e.g., God(s), a Supreme Being, or Supernatural Force and was measured as Catholic, Protestant, non-Christian, or other (Wikipedia on Religion, Retrieved on August 18, 2009). However, *Religiosity* refers to the various aspects, condition, or practices of religious activities regardless of religion affiliation or religion organization and was measured as attendance of religious services as never, ≤once a year, 1-2 year, several times/year, once a month, 2-3 times a month, nearly every week, every week, several times a week, service attendance other than weddings or funerals.

Many studies have documented that s*tudent's work status* tend to predict the accessibility and completion of higher education degrees. As working students, in particular students who work full-time, tend to experience adverse consequences in higher education attainment e.g., they are more likely to abandon college studies or take longer in completing degrees as compared to non-working or part-time working students because work limits and interferes with class schedules, limits library access, hinders study time, etc.. This study measured a student's work status as "does work" or "does not work" rather than percentage of employment, e.g., part-time or full-time. The current study wanted to measure the percentage of working students as compared to nonworking students since the number of students who work either part-time or full-time has increased since the mid 1980s (Orszag, Orszag, and Whitmore 2001). *Student's income* was asked in order to determine student's total earned yearly income and was measured using the same measurements as parents' combined income. *Parents' combined income* was asked in order to determine if parent's combined yearly income correlated to student's misconceptions. Hence, yearly income was measured as <$1,000; $1,000-2,999; $3,000-3,999; $4,000-4,999; $5,000-5,999; $6,000-6,999; $7,000-7,999; $8,000-9,999; $10,000-14,999; $15,000-19,999; $20,000-24,999; $25,000-34,999;

$35,000-39,000; $40,000-49,000; $50,000-59,999; $60,000-74,999; $75,000-89,999; $90,000-109,999; >110,000.

H*ometown location* was asked to determine the number of students who affiliated their "roots" to metropolitan or non-metropolitan areas and therefore measured as an open variable. For the purpose of this study, a metropolitan area is defined as an area with a population of a million or greater (U.S. Census Bureau n.d.). A f*ather's* and m*other's education level* was asked in order to determine which students were first generation college students. In addition there was a desire to measure the percent of parents with college or professional degrees. Father's and mother's education level was measured as <high school, high school (with a diploma or equivalent), technical school or some college (with or without a high school diploma or equivalent), college degree (undergraduate degree, graduate degree, or professional degree).

The sociopolitical variables included in the current study were: (1) *environmental association,* (2) *political affiliation*, (3) *voting practices,* and (4) *political position regarding environmental issues*. *Environmental association* was asked in order to determine whether "*Latino environmental identity*" was present among the Latino students since traditionally, Latinos are known to place environmental values on "practices that are interpreted, sustained, and refined through culture identification, beliefs, and behaviors" (Westra and Lawson 2001, p. 168). Thus, environmental association was measured as active, sympathetic, neutral, unsympathetic, or don't know. *Political affiliation* and *voting* practices are use to evaluate political differences of cultural groups. Hence, political affiliation was measured as Republican, Democrat, Independent, or Other. Voting practices were measured as yes or no regarding whether they had voted during the last national election. The current study wanted to measure the number of politically active voters. *Political position regarding environmental issues* was posed as a question regarding the candidate's position on environmental issues and whether it influenced the way they voted. Political position regarding environmental issues was measured as very important, somewhat important, and not very important.

Researchers use different socio-cultural variables to assess population cultural orientation. In this research project, the variables that were used focused on *ethnicity, ethnic orientation,* and *acculturation* with, (1) *Generation* and (2) *Acculturation* being the two socio-cultural variables used. The model for "*Generation* of *Acculturation*…assess the various dimensions of acculturation by measuring two or more cultures independent of each other…it assumes that one's adaptation to the new culture does not negate the possibility of retaining all or part of one's culture of origin" (Bernal, Trimble, Burlew, and Leong 2003, p. 211). Thus, *generation* was measured by assessing the number of parents and grandparents born in the U.S. *Acculturation* was evaluated using the Acculturation Rating Scale for Mexican Americans-II (ARMSM-II) which assesses multidimensional acculturative types and measures cultural orientation toward Mexican-American and Anglo-American culture independently (Cuéllar, Arnold, and Maldonado 1995, Lopez 2005). *Acculturation* was thus measured using five acculturation levels: Level I-very Mexican oriented; Level II, Mexican oriented to approximately balanced bicultural; Level III, slightly Anglo oriented, bicultural; Level IV, strong Anglo oriented; and Level V, very assimilated, Anglicized (Cuéllar, et al.

1995, Cuéllar, Roberts, Nyberg, and Maldonado 1997). Before, the MSNS was submitted to the Office of Research Compliance for Institutional Review Board (IRB) at Texas A&M University, it was first reviewed by Dr. Cruz C. Torres for accuracy. The rationale for not revalidating the MSNS instrument was based on the fact that Anderson et al. (2002) had already established the validity of the CINS and thus, it was possible to assess students' knowledge and understanding of the theory of natural selection without going through the revalidating process. As stated previously, the CINS has been widely accepted and used in similar research studies. Furthermore, the CINS questionnaire was used to conduct a pilot study in two (2) sessions of RENR 205: Fundamentals of Ecology at Texas A&M University during the fall semester of 2006.

In the pilot study, the CINS survey was administered as an electronic questionnaire. Students who completed the survey earned extra-credit points (one point for each correct answer) based on the number of correct answers. The results from the pilot study were inconclusive due to the low number of Latino student participants. However, it was discovered that, in order to test the hypotheses, demographic information needed to be obtained and thus, the second part of the questionnaire was developed by using and modifying sections of Lopez's (2005) survey. Even though the demographic questions employed in this study's survey instrument are standard questions commonly utilized by the U.S. Census Bureau (and are not copyrighted), a courtesy call was placed to Lopez in June 2007 to inform her that the demographic section of her validated survey was being used.

In addition to submitting the IRB application to the Office of Research Compliance at Texas A&M University, a list of Hispanic-Serving Institutions (HSIs) was compiled by using the World-Wide Web and conducting a search on Google and Yahoo for "Texas' Hispanic-Serving Institutions". The information was then verified by logging onto the Hispanic Association of Colleges and Universities (HACU) homepage and also by calling the San Antonio office of this association located at 8415 Datapoint Drive, Suite 400. This additional step was taken to ensure that all qualifying 4-year public institutions were included in the survey, since Websites are not always updated on a regular basis. HACU's list proved to be both up-to-date and accurate.

The Office of Research Compliance at Texas A&M University approved the project under protocol number 2007-0447. Because the research project involved multiple academic institutions, Collegial IRB's were required from all of the participating HSIs; therefore, the IRB process was repeated at each institution. At the same time, the MSNS word document was converted to a Scantron format by the Measurement and Research Services Office at Texas A&M University. This step was taken to facilitate the data gathering process as university students are more familiar with this questionnaire format. Once Collegial IRB approval was granted by each of the participating universities, a list of introductory biology or ecology courses was compiled for each university.

Each individual university's Website was searched in order to identify the science and/or biology departments and to obtain contact information. When the Website contact information was not up-to-date, the university operator was contacted.

Unfortunately, in several instances, the researcher's findings were similar to Levine's (1997); inconsistencies existed due to the lack of correct or up-to-date contact information. Nonetheless, a comprehensive list was compiled after each department was contacted via telephone. Specific instructions and/or protocols were obtained from each department for making initial contact with faculty members. In addition, names and electronic addresses were obtained for all faculty members who were scheduled to teach an introductory biology or ecology course during the 2007 fall semester. Some department heads preferred approaching faculty members themselves about participating, while other department heads and administrative assistants only requested to be kept in the communication loop by copying them on all electronic correspondence; yet other departments preferred that faculty be directly contacted via electronic mail or telephone. It is important to note, that before contact was initiated with any faculty member, Collegial IRB approval was first requested and consequently all IRB Chairs at each respective university were maintained in the communication loop until the faculty member or course instructor either granted or denied permission to administer the surveys.

Because all faculty members were initially contacted via electronic mail, the electronic cover letter contained pertinent information regarding the project, i.e., purpose of the study, estimated survey time, no expense to the department or to the individual faculty member, etc. In addition, the initial correspondence requested permission to administer the MSNS in the prospective classroom the first day of classes. A copy of the electronic email is included in the appendix along with the complete IRB application.

While most professors/instructors responded via electronic mail, some faculty members failed to respond and were contacted via telephone, which proved to be a worthwhile effort, as several faculty members did not check electronic mail on a regular basis during the summer. However, once initial contact was made, all correspondence thereafter was via electronic mail.

Sample Selection

Universities

The following criteria were used to identify potential participating universities. Each institution chosen:

1. be a Texas public 4-year university;
2. be a HSI;
3. have a biology, science, or ecology department that offered undergraduate science degrees; and
4. was required to offer an introductory or first semester biology or ecology course on campus the semester that the data was to be collected.

Even though 2-year HSIs play a critical role in higher education, they were not included in this study in that many do not teach introductory biology or ecology courses. This is unfortunate because in 1999, 68 percent of the HSIs were community colleges, institutions that serve as the gateway to higher education for many minority groups (Laden 2004). Nonetheless, HSIs were selected because at least 25 percent of total undergraduate full-time equivalents are Hispanic (Laden 2001). It is important to note that these accredited, degree-granting public or private non-profit institutions were not established to serve a particular ethnic student population but are classified strictly by current student enrollment ratios (Santiago 2006).

In addition, more often than not, HSIs are located in areas with high Latino populations and thus, attract Latinos who seek community with other Latinos, employment opportunities, and low-cost higher education institutions (Laden 2004, Lopez 2005). This project targeted HSIs because the focus of this study was on students of Latino descent, in particular Mexican-American college students.

Ten (10) public institutions met the above criterion. Sul Ross State University, Texas A&M International University, Texas A&M University-Corpus Christi, Texas A&M Kingsville, The University of Texas at Brownsville, The University of Texas at El Paso, The University of Texas at San Antonio, The University of Texas of the Permian Basin, The University of Texas-Pan American, and the University of Houston-Downtown. All but two of the identified universities participated in this study. The two (2) universities who did not participate were The University of Texas at El Paso and the University of Houston-Downtown. The Office of Research and Sponsored Projects at The University of Texas at El Paso required that the participating faculty member meet the training requirements in human subject research and research ethics as mandated by the Department of Health and Human Service (DHHS) under the provisions of 45 CFR 46. Unfortunately, the only faculty member willing to participate at this university lacked the required training; and though willing to complete the training, was unable to do so in time for the study. Time constraints prevented the other two faculty members who taught the introductory biology course from participating in the study. Such was not the case at the University of Houston Downtown as declined participation stemmed from professional preference at the faculty level. The only professor who taught all of the first semester biology courses did not allow anyone to survey his students at anytime or for any reason during the semester and thus, upon contact, refused to grant permission to administer the surveys in any of his classes. Hence, this university was immediately eliminated from the list.

Participants

Latino students enrolled in 4-year public HSIs were the primary target population for this research project. In this way, it was anticipated that the secondary target population, Latino students born in the U.S., would be sampled. Groves et al. (2004) refers to a “target population” as a group of elements for which the investigative tool is used to make inferences using the sample statistics (Groves et al. 2004). Thus, target populations are delineated by time, place and any other characteristic(s) that identifies the group of elements or unit of study (Alexander and Winne 2006). A critical aspect of the current study was to determine whether conceptual understanding differences between Latinos and non-Latinos exist in students’ responses concerning evolutionary theory.

Furthermore, participants selected needed to be enrolled in a first-semester introductory biology or ecology course, since the College Board and the Advanced

Placement Program's (AP) guiding principles for introductory biology courses require that 25 percent of the course time be spend on evolutionary theory (2007 CollegeBoard 2008-2009). As indicated earlier, understanding the key elements of evolutionary theory is essential in learning introductory biology. These elements contribute to the framework students need to conceptualize ideas/concepts and obtain knowledge and skills necessary to assimilate course materials into a conceptual and expandable body of knowledge (2007 CollegeBoard 2008-2009). Hence in order to facilitate conceptual change, biology educators need to first identify students' preexisting misconceptions, evaluate them, and then strategize and develop a plan to implement a diverse set of instructional techniques that will result in students' conceptual change. Furthermore, teaching abstract concepts in a relevant context can improve students' attitudes towards academic work (Kirshner and Whitson 1997).

It was originally anticipated that more than one introductory ecology course would be taught the semester the data were collected in this study. However, only the A&M-Corpus Christi campus offered an introductory ecology course. Thus, most of the participants in the study were students who were enrolled in introductory biology courses at the various participating HSIs.

The MSNS questionnaire was administered to 1264 students during the 2007 fall semester. Because the total number of students surveyed surpassed the forecasted number set at 800 surveys, an IRB amendment was filed to comply with university requirements/codes. The surveys were administered during normal course hours on the first day of class. The number of students per class ranged from 22 to 150. Students were given a project information sheet in addition to being informed about the project the day the surveys were administered. Furthermore, students were asked to read the project information sheet before completing the survey. Also, students were informed that participation was on a voluntary basis and anonymous. To ensure anonymity, they were asked not to write their names anywhere on the survey. Students were not monetarily compensated nor did they earn any bonus points towards their course grade for participation.

Of the total number of questionnaires completed during the fall of 2007, 1179 questionnaires were found suitable for analysis for this study. Conceptual knowledge and/or conceptual understanding was evaluated by comparing student responses using the Statistical Package for the Social Sciences (SPSS) produced by SPSS Inc. Hence, various SPSS applications are used, i.e., ANOVA, partial correlation, multiple regression, Natural Selection Performance Quotient (NSQP) scores and Discriminability p-values were calculated, analyzed and evaluated in order to answer all of the research questions. For example, forty-seven percent of the participants were of Latino descent (with 43.4 percent identifying themselves as Mexican-Americans) compared to almost thirty-seven percent (36.6 %) who were Anglo-Americans. Sixty-two percent of the participants were females and thirty-eight percent were males. Eight-nine percent were Christians of which 54.4% were Catholic and eleven percent were non-Christians.

Data Collection Method and Procedures

Once permission was granted to proceed with this study, a schedule was developed. Initially, this researcher intended to personally administer all of the surveys; however, as date, time, and location conflicts arose, several of the professors at the participating institutions agreed to administer the surveys themselves. They were provided with all necessary materials, e.g., student consent forms, sharpened pencils, and pre-paid return labels and boxes for the surveys to be mailed to Texas A&M after completion. However, for some HSIs, the Office of Research Compliance's IRB approval required that the researcher personally administer the surveys. Thus, scheduling priorities were given to these institutions.

Faculty members had the option to choose the time the survey was administered as long as it was before any lectures on evolution and the theory of natural selection were conducted. However, the first day of class was suggested in order to minimize disruption/interruption to the course lectures and to the overall course agenda. In addition, by administering the surveys the first day of class, students were allotted ample time to complete the surveys. Most professors seldom lecture on the course topic the first day of class and it is customary to use this class period only to review the course syllabus, class rules, and regulations. All the surveys were administered the first day of classes at each university.

When all surveys were collected, each survey was processed and given an identification number for each institution. In addition, each survey was numbered in chronological order to facilitate data entry and verification. If more than one class was surveyed at a given university, then the date the survey was administered was added to a column along with the faculty's initials. This was completed in order to keep the class surveys organized and together by participating class for data entry purposes. The bubbled responses were scanned by the Measurement and Research Services Office. The data were transferred into a spreadsheet. The written responses were entered into the spreadsheet after coding them by number. Once all of the data were entered, entries were verified for accuracy on two separate occasions. Initially, with the assistance of the researcher's spouse and the second time with the assistance of a trustworthy friend responses were called out loud as the researcher verified and corrected any incorrect entries. Before transferring the data to SPSS for analysis, incomplete surveys were deleted from the list. For the purpose of this study, an incomplete survey was classified as a questionnaire that lacked three (3) or more responses in part one (1) and/or did not contain the necessary demographic information e.g., ethnicity, gender, etc. to properly assess and evaluate the variables under study in part two (2) of the questionnaire. Once these records were deleted, the data were verified a third time following the same prescribed methodology described above. The data was then transferred it into SPSS for analysis.

Data Analysis Overview

SPSS 17.0 statistical analysis software was used to analyze the data. Various statistical analyses were conducted. However, before performing correlation analysis, a scatterplot was generated to check for violations of assumptions of linearity and homoscedasticity. In addition, scatterplots also provide an overview of the relationship between the variables (Pallant 2007). Once the data were checked for outliers, distribution of data points, and the direction of the variable relationships, correlation analyses were performed.

Hence, frequency analysis was conducted on all of the variables to detect data entry errors. The descriptive results were derived from the output data obtained through descriptive statistical analysis of frequencies and cross-tabulations. The results of the USA geographical hometown locations were transferred to a USA metro/non-metro county map obtained from an ERS-USDA government Website. The inferential statistical results were obtained by running a variety of statistical analysis, i.e., comparison of means, independent-sample testing, one-way ANOVA, univariate linear analysis, and linear regression for each question. Chapter IV and V contain additional details of the various analyses conducted.

CHAPTER IV

RESULTS

The present study was conducted to examine what effects, if any, cultural factors have on conceptual knowledge of evolutionary theory through natural selection. In particular, the study determines if Latino and non-Latino 4-year college students differ in their misconceptions of natural selection and, if so, could cultural factors be the reason why such differences exist? Hence, by evaluating students' conceptual knowledge of scientific concepts, the present study establishes the complexity that exists between teaching and learning. In addition, this study ascertains the need to evaluate culture and its impact on conceptual learning of other scientific theories.

Part I Demographic and Cultural Characteristics of the Participants

A total number of 1264 college students participated in the study; however, only 1179 MSNS questionnaires were usable. The remaining eighty-five unsuitable surveys failed to provide the participants’ gender, ethnicity and in addition three (3) or more natural selection questions were omitted. In addition, only eight questions were analyzed (questions three (3) and eight (8) were omitted); as the remaining questions encompass the seven concepts of natural selection listed on page 40 of this manuscript. It is important to note that two questions six (6) and nine (9) comprised one of the seven natural selection concepts.

Of the 1179 students 47.8% of the respondents identified themselves as Latinos which included *Mexican-Americans* (43.4%), *Hispanic Americans* (2.5%), or *Multiracial Latinos* (1.7%) (Table1). About thirty-seven percent (36.6%) of the students were *White.* The *Other* ethnicity category was collapsed into a dichotomous group representing US born non-Latino non-Whites or multiracial non-Latinos. For the purpose of this study, students were categorized Multiracial if they listed two or more distinctive ethnicities, i.e., Mexican-Anglo American, African-Chinese American, Asian-Indian American, etc. Hence, the dichotomous group identified for this study was comprised of *African Americans* (4.7%), *Asian Americans/Pacific Islanders* (1.9%), *Native Americans* (0.4%), m*ultiracial non-Latino Americans* (0.2%), and *other nonlisted Americans (0.8%).* The international students accounted for 7.6% of all the study participants. Furthermore, the age of the students ranged from 16 to 59 and the average age was 19.76 with a standard deviation of 3.81 years. A larger percentage of the student participants were female (62.4%).

Almost sixty-seven percent (66.9%) of the students attended one of the three Texas A&M universities: TAMU at Corpus Christi (50.2%), TAMU at Kingsville, (10.9%), and A&M International University (5.8%). Approximately a third (28.3%) were from the University of Texas System: UT at San Antonio (14.6%), UT Brownsville (5.8%), UT Permian Basin (5.7%), and UT Pan-American (2.2%). The remaining participants were from Sul Ross State University (4.8%).

Table 1. Ethnic composition of the students.		
Ethnicity category and sub-groups	Number	Percent
Latinos	*563*	*47.8%*
Mexican-Americans	512	43.4%
Hispanic Americans	30	2.5.%
Multiracial Latinos	21	1.7%
White	*432*	*36.6%*
Other	*94*	*8.0%*
International	*90*	*7.6%*

About 62.7% of the students were in science related majors. Biology (16.8%), pre-nursing/nursing (15.4%), and bio-medical sciences (11.0%) were the most popular majors and together accounted for 43.2% of the students who specified their majors (Table 2). The majority of the students were lower level undergraduate students. Among the students, 57.3% were *freshmen*, 26.0% *sophomores*, 11.2% *juniors*, and 4.5% *seniors*. The remaining one percent was comprised of postgraduates or students seeking second bachelor's degrees.

Eighty-nine percent the participants identified themselves as Christian as opposed to six percent non-Christian and five percent either agnostic or atheist (Table 3). In the Christian categories, fifty-four percent of the participants identified the denomination of Catholic as compared to eleven percent Baptist, eight percent Christian (as an actual denomination), and five percent Protestant. Close to ninety percent (87.5%) indicated that they attended religious services at least once a year; however, close to a third (28.3%) practiced religiosity weekly to several times per week.

Table 2. Number and percentage of students in specified majors.

Major	Number	Percent
Accounting	13	1.1
Art	6	0.5
Biochemistry	7	0.6
Biology	198	16.8
Bio-Medical Science	130	11.0
Business	55	4.7
Chemistry	21	1.8
Child & Family Studies	7	0.6
Communications	20	1.7
Computer Science	7	0.6
Criminal Justice	29	2.5
Education	62	5.3
Engineering	12	1.0
Environmental Sciences	18	1.5
Fine Arts	4	0.3
Food and Nutrition Science	4	0.3
History	5	0.4
Kinesiology	83	7.0
Language Arts	10	0.8
Marine Biology	51	4.3
Mathematics	8	0.7
Multidisciplinary Studies	8	0.7
Physical Therapy	12	1.0
Political Science	9	0.8
Pre-Dentistry/Dentistry	5	0.4
Pre-Medical/Medical	41	3.5
Pre-Nursing/Nursing	182	15.4
Pre-Pharmacy/Pharmacy	29	2.4
Pre-Veterinary/Veterinary	4	0.3
Psychology	50	4.2
Rangeland/Wildlife Management	32	2.7
Undecided	44	3.7

Table 3. Number of students by religious affiliations.

Christian & non-Christian Religions	Latino (n=533)	White (n=405)	Other (n=83)	Intl. (n=84)	Total (n=1105)
Agnostic	3	19	1	1	24
Atheist	4	24	2	3	33
Bahia	-	-	1	-	1
Baptist	21	75	17	4	117
Buddhist	-	1	-	2	3
Catholic	415	109	25	47	596
Christian	36	32	11	4	83
Church of Christ	1	9	-	1	11
Episcopalian	-	4	-	-	4
Hindu	-	-	7	4	11
Jehovah Witness	1	-	-	1	2
Jewish	-	2	-	-	2
Lutheran	2	23	-	-	25
Methodist	4	24	1	1	30
Muslim	-	1	1	5	7
non-Denominational	13	31	3	2	49
Pagan	-	-	1	-	1
Pentecostal	10	3	2	1	16
Presbyterian	-	7	-	1	8
Protestant	23	40	10	7	80
Wiccan	0	1	1	-	2
Total	533	405	83	84	1105

The participants' position on environmental causes was favorable since 56.1% of the participants considered themselves 'sympathetic to environmental causes' and/or 'active environmentalist'. In addition, 90.8% of the students indicated that they considered a political candidate's environmental position to be 'somewhat to very important'.

The participants' sociopolitical affiliation was as follows: Democrats 35.3%, Republicans 32.4% and 32.2% were Independents (Table 4). Twenty percent of the respondents reported voting in the last national election. It is important to note, however, that fifty percent of the students were 18 years old at the time the survey was conducted.

Table 4. Number and percentage of students by political party affiliation.

Political Party Affiliation	Democratic		Republican		Independent	
	Number	%	Number	%	Number	%
Latinos	248	21.8	128	11.2	165	14.5
non-Latino	121	10.6	231	20.3	159	14.0
International	33	2.9	10	.9	43	3.8
Total	402	35.3	369	32.4	367	32.2

Close to 19% of the parents of the Latino students had college or professional degrees (College), while over 33% of the parents of White, Other, and International students held degrees (Figure 1). At the other extreme, 20% of the parents of the Latino and International students had less than high school education (<high school), while less than 10% of the parents of White and 'Other' students did. Across all ethnicity groups,

more fathers than mothers had high school diplomas or equivalent but more mothers had some college or technical schooling than fathers. Interestingly, parents of the international students had the highest percentage among the groups for both extremes of education levels (College and < high school).

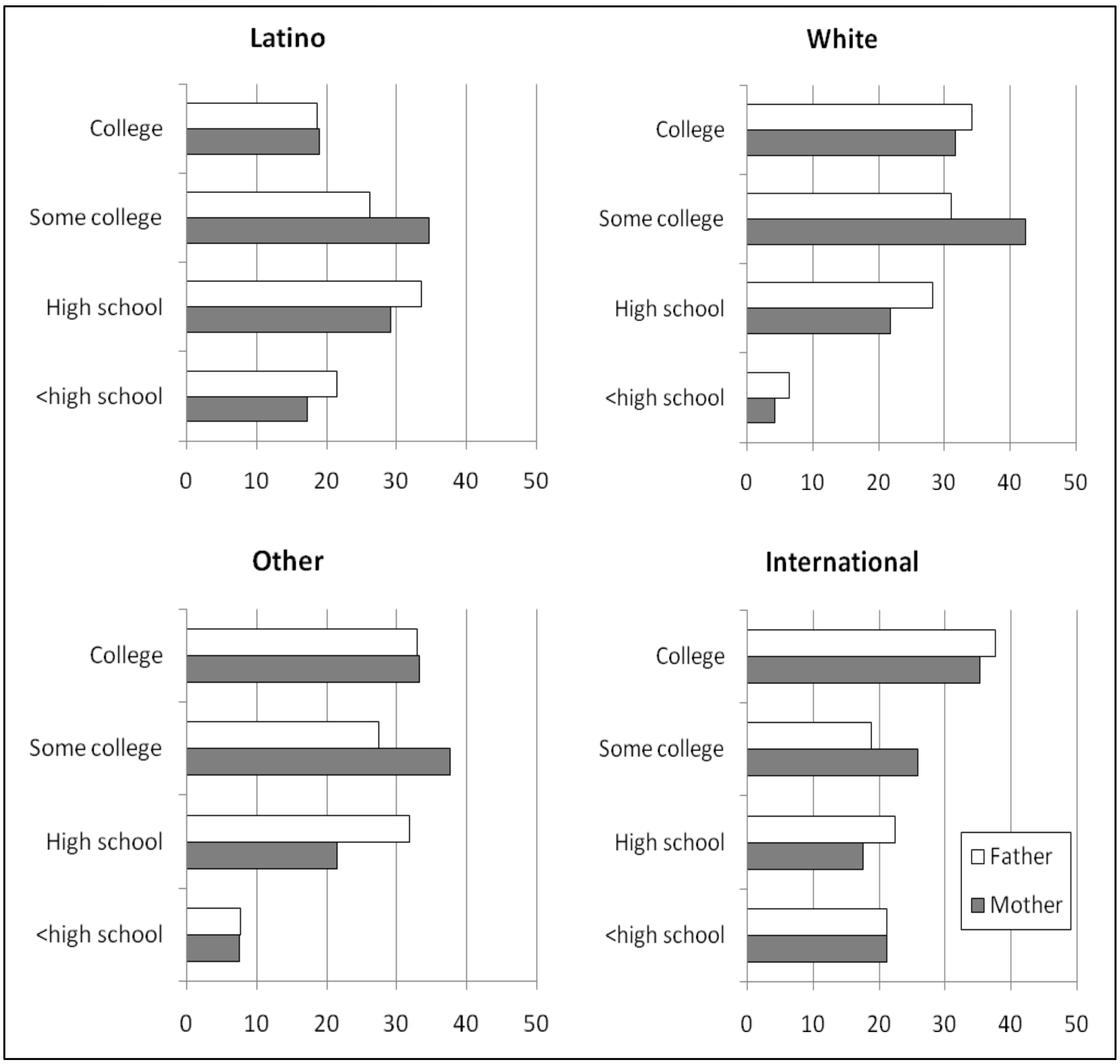

Figure 1. Percent of parents with different educational levels. College: college or professional degrees; Some college: some college or technical schooling; High school: high school diplomas or equivalent; and <high school: less than high school education.

Almost half (45.5%) of the parents of Latino students had less than $25,000/year combined income-of which 13.2% earned less than $10,000/year and only about 17.3% of them earned more than $50,000/year. In contrast, only 14.3% of parents of White students had less than $25,000/year combined income and close to half (48.3%) of them earned more than $50,000/year. The pattern of parental income for other and International students was more similar to that for Latinos than for Whites (Figure 2). However, these two groups of parents had higher household incomes than the Latino parents.

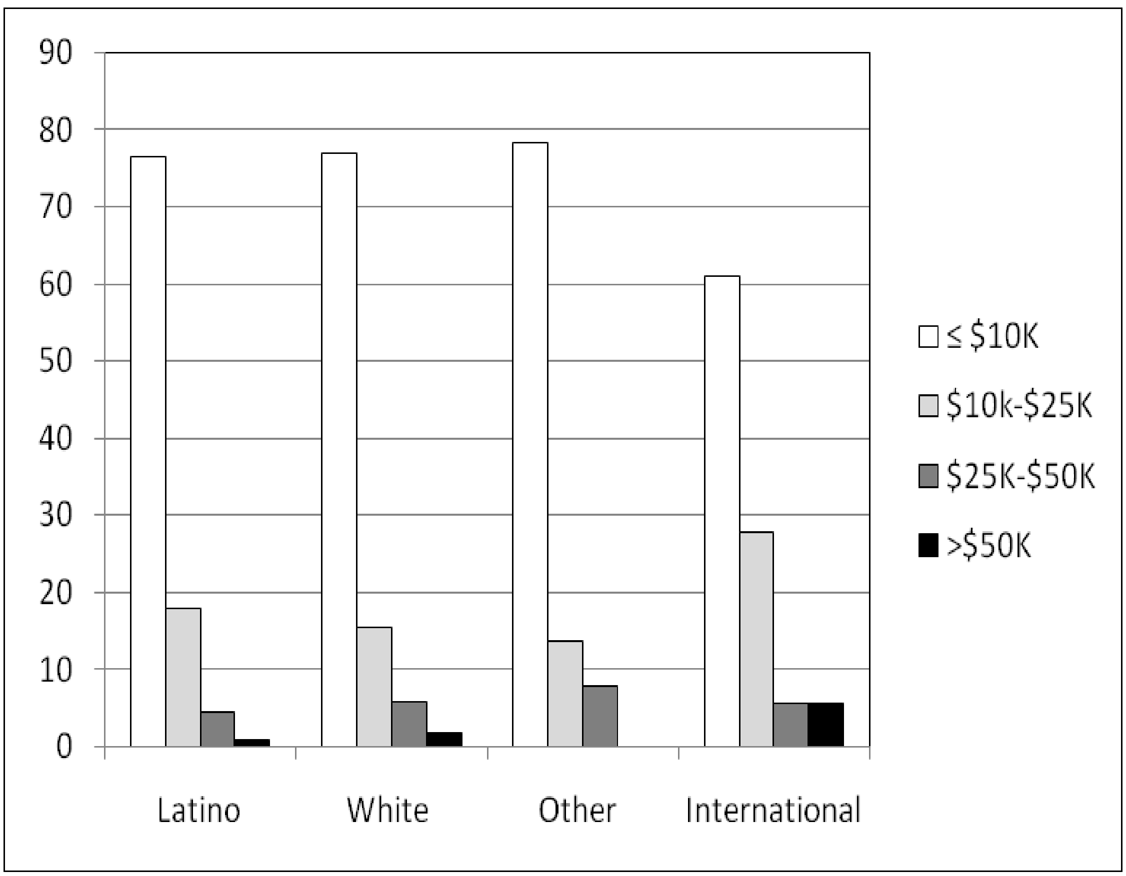

Figure 2. Percent of students with parents' combined annual income.

About 62.8% of the US born students were employed at the time the survey was conducted. Of this group, 51.5% were freshmen, 27.0% were sophomores, 14.3% were juniors, 5.7% were seniors, and the remaining 1.5% were post graduates or students seeking second bachelor degrees. Over 93.5% of them earned less than $25,000/year and 76.9% earned less than $10,000/year. The pattern of income for the International students was similar to those for US born students (Figure 3).

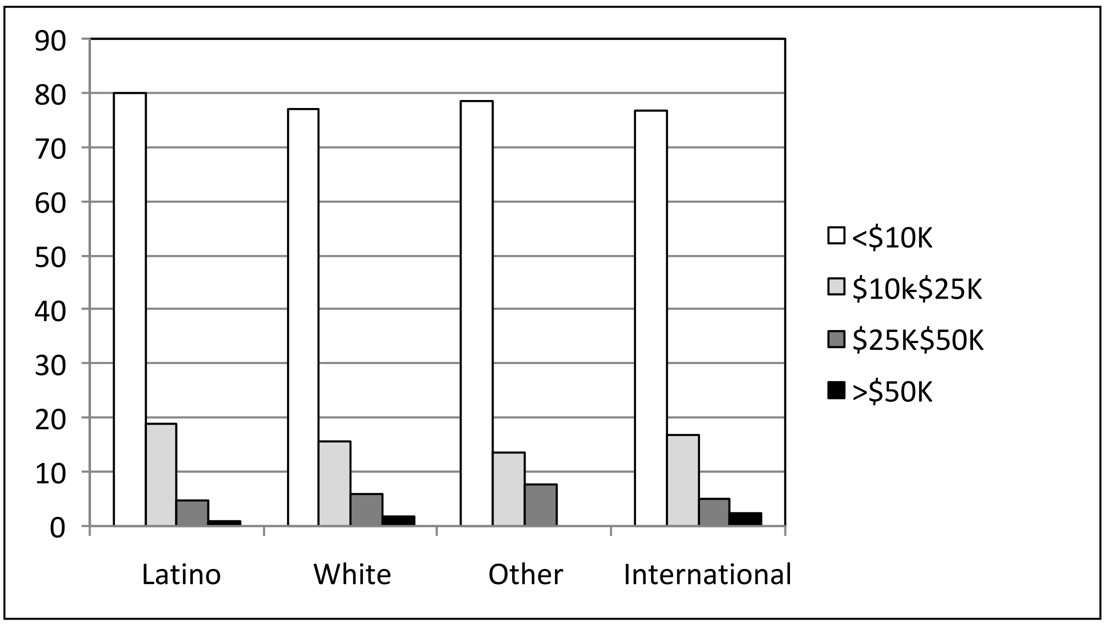

Figure 3. Percent of working students and yearly earned income.

The participants' hometowns (including international students' hometown) were found to be geographically located in many non-metro counties across the US. Figure 4, illustrates the geographical location of the students' hometowns by county, except for international locations. The majority of students' hometowns in Texas were border, coastal bend, and panhandle counties.

The students' generation level was assessed by the number of parents and grandparents born in the U.S. Figure 5, illustrates the percent of US born generations. Over a third (32.7%) of the Latinos were first generation US born. And approximately half (51.9%) of the Latinos while almost ninety-five percent (95.8%) of the Whites were third generation US born.

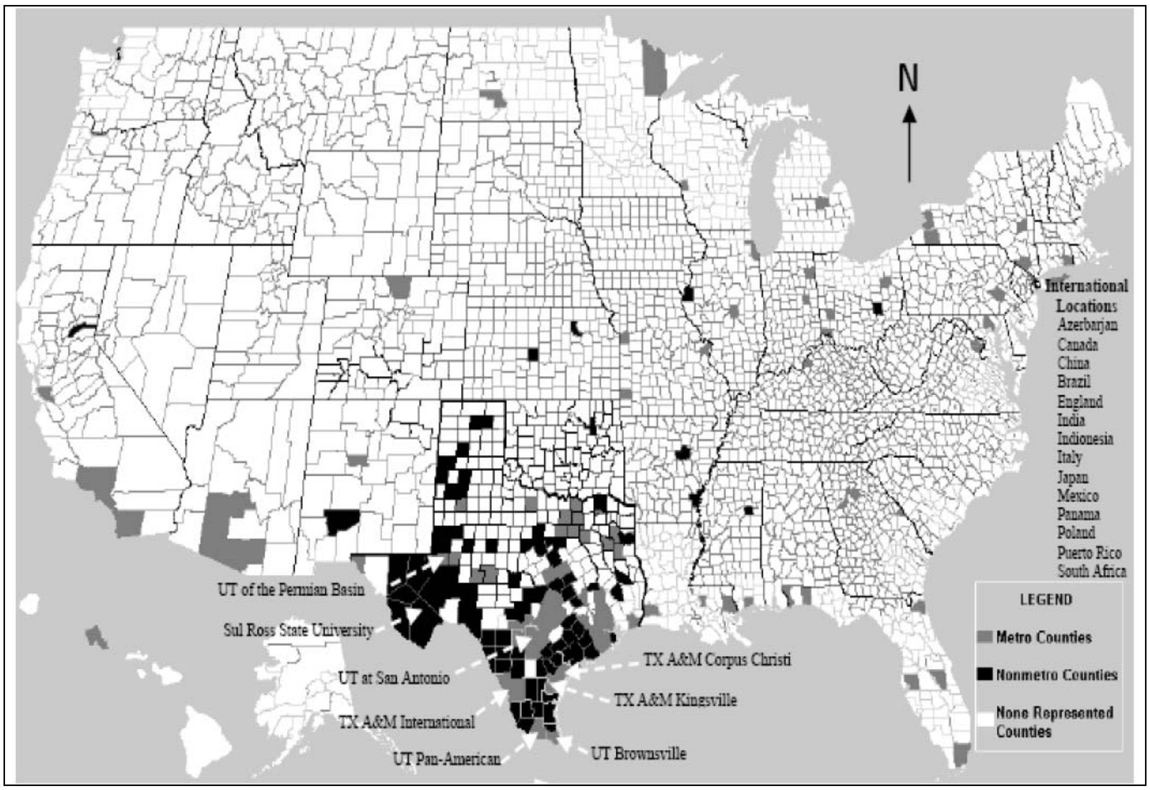

Figure 4. Students' hometown geographical locations by county for the 50 United States Only. International locations are listed by country rather than by county.

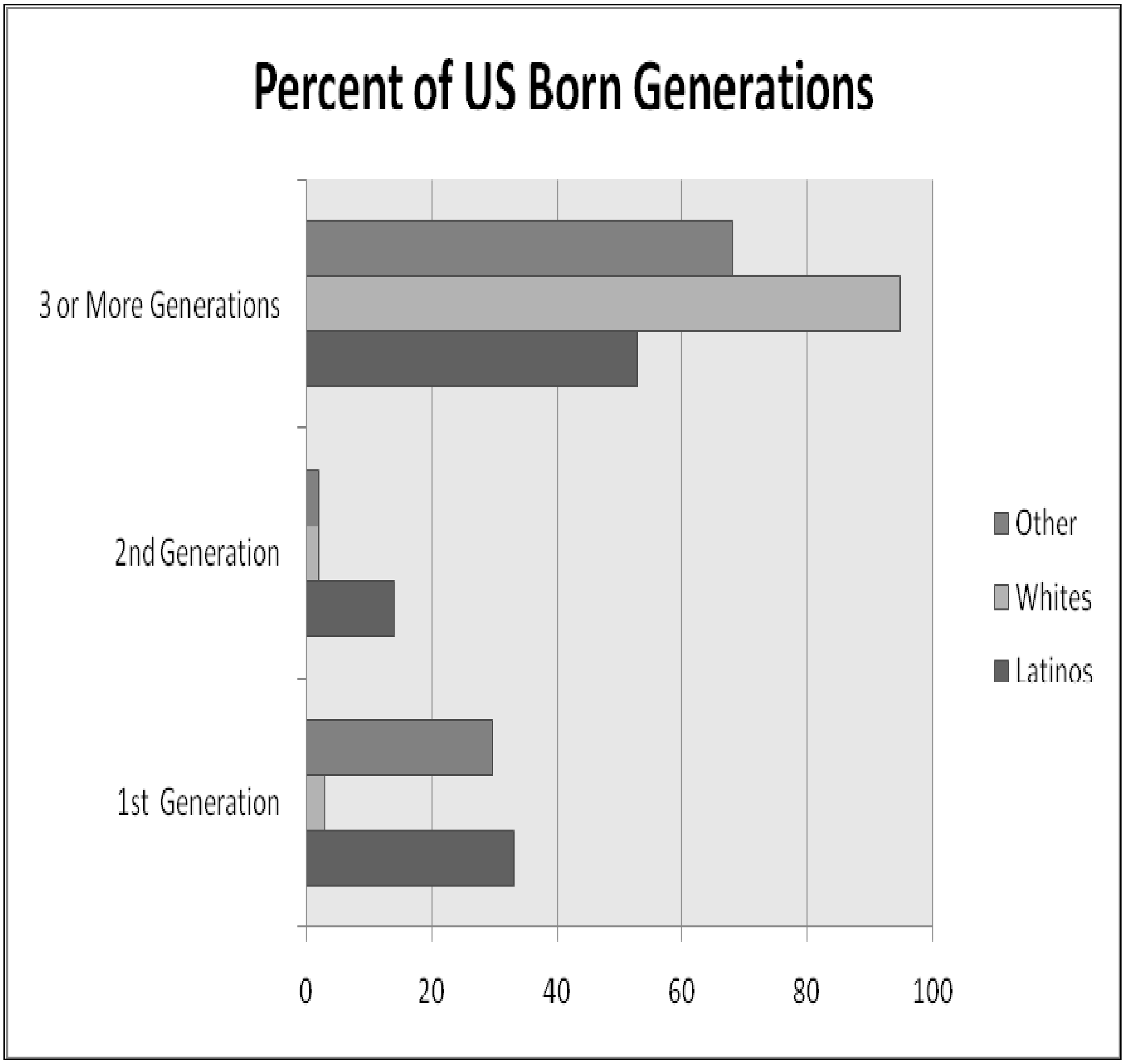

Figure 5. Percent number of USA born Latino and non-Latino Students.

Acculturation was evaluated by assessing the multi-dimensions of Mexican-American and Anglo-American cultural domains by using the five acculturation levels developed and refined by Cuellar et al. (1995, 1997). Table 5, illustrates the differences between the Latino and non-Latino participants. Twenty-nine percent of all US born Latinos are considered to be well assimilated in the Anglo culture as compared to thirty-three percent with strong Mexican orientation but biculturally balanced.

Table 5. Absolute percentage of Student Acculturation Levels.				
Acculturation Levels	Latinos (n=563)	Whites (n=432)	Other (n=94)	Intl. (n=90)
Level I-Extremely Mexican Oriented (Foreign Born)	-	-	-	1.3*
Level II-Strongly Mexican Oriented and Biculturally Balanced (First U.S. Born Generations)	33.2	-	-	-
Level III-Slightly Anglo Oriented and Bicultural (Second U.S. Born Generations)	14.0	2.1	2.1	-
Level IV-Strongly Anglo Orientated (Third U.S. Born Generations)	24.0	7.6	2.1	-
Level V-Well Assimilated and/or Anglicized (Four or more U.S. Born Generations)	28.8	87.3	66.0	-

*Percent Reported is for Mexican nationals only.

PART II Conceptual Knowledge of Evolutionary Theory and the Influence of Cultural Factors

The results provided in this section are organized and presented by the standard demographic variables reported in the literature to impact student cognition. These variables include: ethnicity, gender, acculturation, parent's education and parents' combined income. Religion was also analyzed since science is regarded differently by all cultures (Aikenhead 1997, Alters and Nelson 2002, Blackwell et al. 2003, Brown 2006) and because religious belief systems are known to influence how science is regarded and it is at the core of the evolution teaching controversy. The assessments of these demographic variables also address the research questions original set forth by this investigation.

In order to gain a better understanding of students' conceptual knowledge of evolutionary theory and how culture or cultural background might potentially influence the students' conceptual understanding of natural selection, a series of statistical analyses were conducted and each demographic variable was analyzed independently. Aside from calculating absolute percent and raw mean scores of correct responses and misconceptions, discriminability p-values and NSPQ were also calculated. All of these analyses were conducted incorporating the seven key concepts of natural selection identified and described by Nehm and Reilly (2007 p. 266) as: "(1) the causes of phenotypic variation (e.g., mutation, recombination, sexual reproduction), (2) the heritability of phenotypic variation, (3) the great reproductive potential of individuals, (4) limited resources or carrying capacity, (5) competition or limited survival potential, (6) selective survival based on heritable traits, and (7) a change in the distribution of individuals with certain heritable traits."

To precisely and accurately illustrate the findings, the evolutionary theory through natural selection complexity levels was charted and is illustrated in Figure 6. These three distinctive yet related evolutionary theory concepts are referred to ecological, evolutionary, and genetics. The literature reports that out of the three evolutionary concepts, the theories dealing with genetics are considered the most difficult evolutionary theory ideas to comprehend and have been reported to be the most problematic to students in general (Anderson et al 2002).

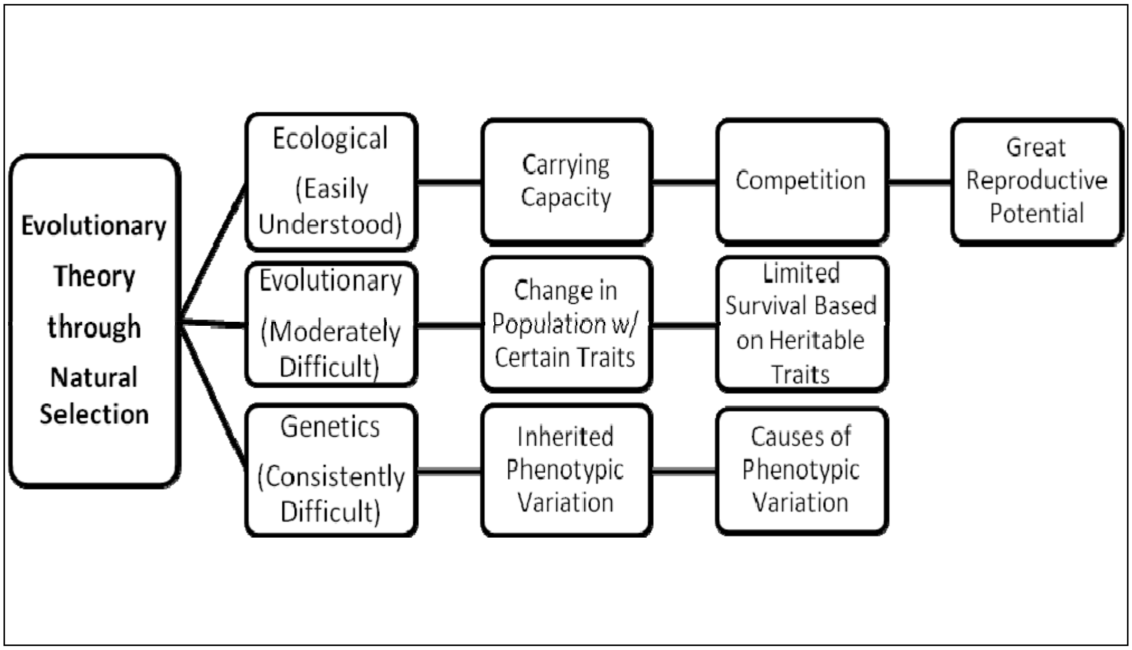

Figure 6. Complexity levels of evolutionary theory. The ecological concepts are considered straightforward and easily understood by the majority of students. On the other hand, concepts dealing with genetics are consistently more difficult and a result many students struggle to conceptualize these concepts.

The Influence of Ethnicity

To assess the influence of ethnicity, absolute percents and raw mean scores were calculated for correct responses and misconceptions. Table 6 show the percent of correct responses and misconceptions while Table 7 shows the number of correct natural selection concepts. Figure 7 shows the percent of correct responses grouped by the three evolutionary concepts. Contradictory to the literature, the students in this study performed better in the *genetics* concepts than in the *evolutionary* concepts, this was true across the ethnic groups. The raw mean comparison is showed in Figure 8. As can be seen throughout these figures and tables, no significant differences were found between the Latino and Whites.

***Table 6. Absolute percentage of correct responses and misconceptions. Correct responses are bolded and underlined; misconceptions are italicized*.**

Evolutionary Theory Concepts and Misconceptions		Latino (n=563)	White (n=432)	Other (n=94)	Intl. (n=90)
Carrying Capacity	**All species have great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully**	**61.1**	**72.5**	**59.6**	**74.4**
	Organisms only replace themselves	*3.2*	*1.4*	*1.1*	*2.2*
	Population level off	*35.7*	*26.2*	*39.3*	*13.3*
Competition	**Natural resources are limited; nutrients, water, oxygen, etc. necessary for living organisms are limited in supply at any given time**	**57.7**	**71.5**	**70.2**	**55.6**
	Organisms can always obtain what they need to survive	*42.3*	*28.5*	*29.8*	*24.4*
Change in a Pop. w/ Certain Traits	**The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations**	**16.5**	**11.8**	**15.1**	**15.6**
	Changes in a population occur through a gradual change in all members of a population	*25.6*	*19.7*	*18.3*	*21.1*
	Learned behaviors are inherited	*19.0*	*23.4*	*28.0*	*22.2*
	Mutations occur to meet the needs of the population	*38.9*	*45.1*	*38.7*	*41.1*
Great Reproductive Potential	**Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction surviving each generation**	**52.7**	**67.3**	**51.1**	**54.4**
	Organisms work together (cooperate) and do not compete	*38.8*	*24.8*	*38.3*	*33.3*
	There is often physical fighting among one species (or among different species) and the strongest ones win	*8.5*	*7.9*	*10.6*	*12.2*

Table 6. Continued.					
Evolutionary Theory Concepts and Misconceptions		Latino (n=563)	White (n=432)	Other (n=94)	Intl. (n=90)
Causes of Phenotypic Variation	**Random mutations and sexual reproduction produce variations; while many are harmful or of no consequence, a few are beneficial in some environments.**	**46.4**	**48.1**	**46.8**	**46.7**
	Individuals of a population vary extensively in their characteristics	**7.1**	**13.5**	**10.6**	**6.7**
	Mutations are intentional: an organism tries, needs, or wants to change genetically	*72.3*	*72.4*	*70.2*	*68.8*
	Mutations are adaptive responses to specific environmental agents	*20.6*	*14.2*	*19.1*	*24.4*
	All members of a population are nearly identical	*12.5*	*7.9*	*9.6*	*6.7*
	Variations only affect outward appearance; do not influence survival	*41.1*	*44.0*	*43.6*	*46.7*
Heritability of Phenotypic Variation	**Much variation is heritable**	**40.2**	**55.6**	**46.8**	**40.0**
	Traits acquired during an organism's lifetime will be inherited by offspring	*11.4*	*10.6*	*11.7*	*11.1*
	Traits that are positively influenced by the environment will be inherited by offspring	*33.0*	*22.7*	*24.5*	*34.4*
	When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	*15.2*	*11.1*	*17.0*	*14.4*
Selective Survival Based on Heritable Traits	**Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals**	**38.7**	**49.0**	**44.7**	**38.9**
	Organisms with many mates are biologically fit	*6.4*	*3.9*	*2.1*	*6.7*
	Fitness is equated with strength, speed, intelligence or longevity	*54.9*	*47.1*	*53.2*	*54.4*

Table 7. Absolute percentage and total number of natural selection concepts by ethnicity.				
Number of Correct Concepts	Latinos (n=563)	White (n=432)	Other (n=94)	Intl. (n=90)
0	1.8	0.2	-	-
1	10.3	4.6	7.4	12.2
2	21.5	14.6	16.0	20.0
3	23.4	19.9	24.5	25.6
4	23.6	26.6	34.0	17.8
5	14.0	20.1	11.7	18.9
6	5.3	13.0	6.4	5.5
7	-	0.9	-	-

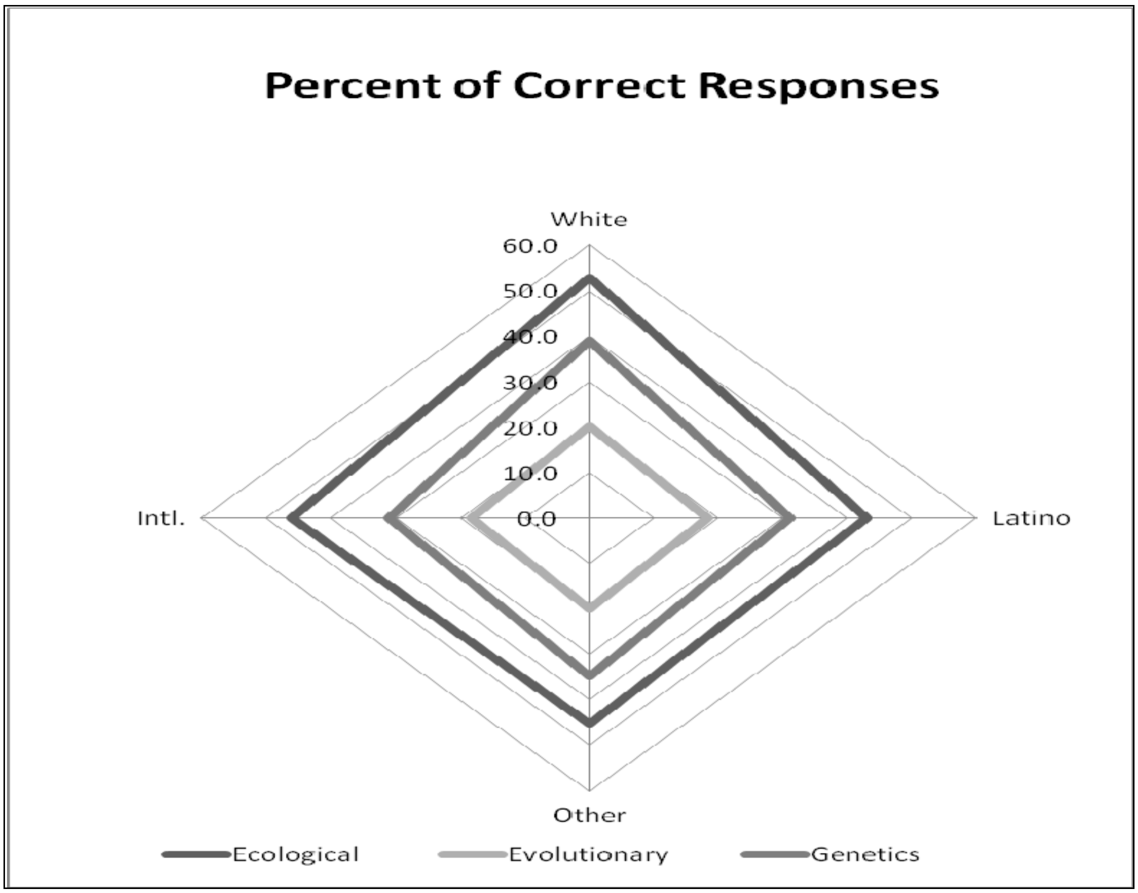

Figure 7. Absolute percentage of correct responses grouped by ecological, evolutionary, and genetics concepts.

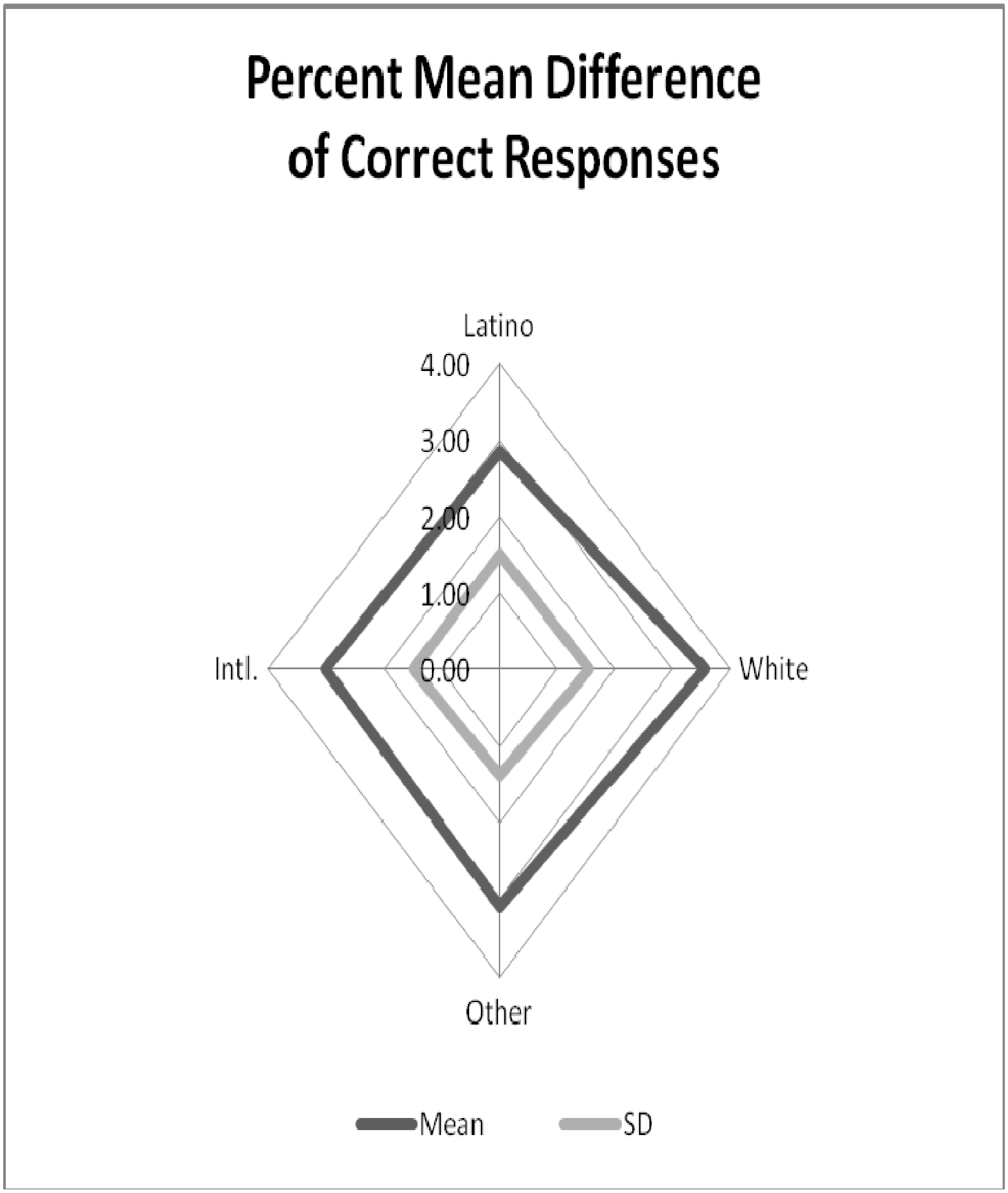

Figure 8. Raw mean and standard deviation of correct response by ethnicity.

To further assess the influence of ethnicity on conceptual understanding of the seven key concepts of natural selection, the discriminability p-values were calculated and evaluated. Discriminability p-values provide the proportion of students who selected the correct response thereby serving as a proxy for item/concept difficulty. Figure 9 illustrates the discriminability p-value results. Even though there is a 16.8% cumulative difference between the Latinos (42.9%) and White (59.7%) students who correctly answered four or more natural selection concepts, no statistical differences were found between the two groups when the raw mean comparison was evaluated.

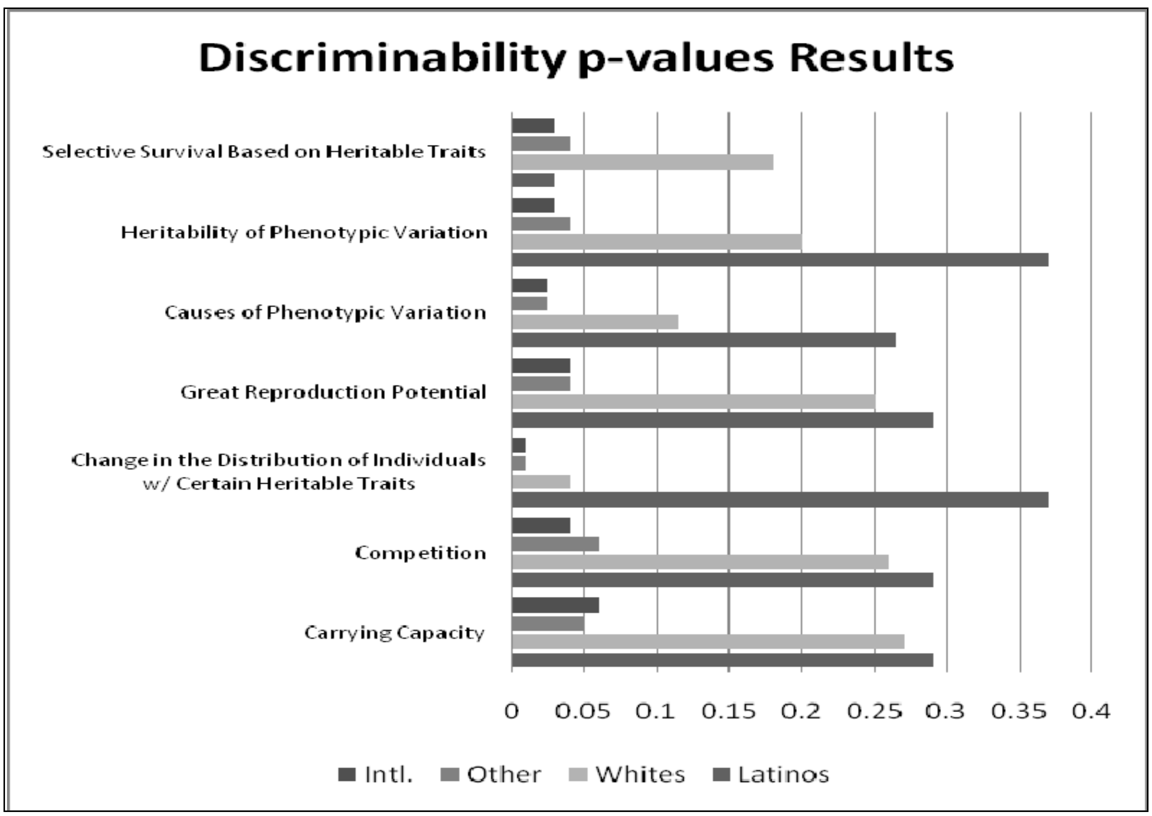

Figure 9. *Discriminability p-values for evolutionary theoryby natural selection concepts. Low values indicate difficulty concepts.*

Table 8 demonstrates the NSPQ scores which measure and quantify the diversity of key concepts and misconceptions by taking into account the proportion of the students' correct answers to how the correct proportion compares to the most complete possible response. The NSPQ scores were calculated and calibrated in accordance to Nehm and Reilly (2009) measurement description thereby quantifying student understanding of evolutionary theory and "…distinguishes clearly between students who have problems with their understanding of natural selection, despite displaying significant knowledge, and [from] those students with no misconceptions who displayed differing levels of knowledge" (Nehm and Reilly 2007, p 266). Raw percent mean differences are graphed in Figure 10.

Table 8. Absolute percentage of NSPQ scores by ethnicity.

Actual Score	**Latinos** (n=563)	**White** (n=432)	**Other** (n=94)	**Intl.** (n=90)
0.00	1.8	0.2	-	-
0.25	10.3	4.6	7.4	12.2
0.42	-	-	-	-
0.54	21.1	14.4	16.0	20.0
0.57	0.4	0.2	-	-
0.65	23.4	19.4	25.4	25.6
0.69	-	0.5	-	-
0.75	23.3	26.6	34.0	17.8
0.80	0.4	-	-	-
0.84	14.0	20.1	11.7	18.9
0.93	5.3	13.0	6.4	5.6
1.00	-	0.9	-	-

Score index: 0.0 = 0 correct responses and 8 misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

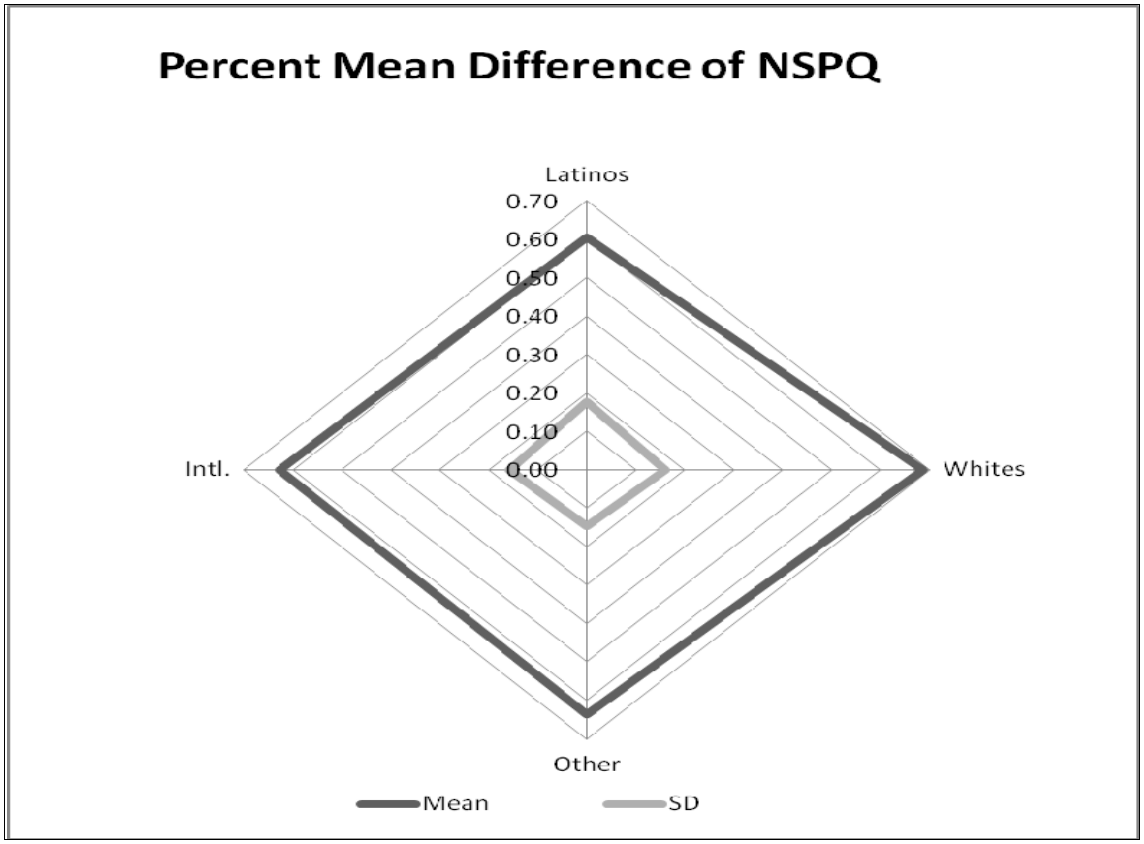

Figure 10. Raw mean difference and standard deviation of the NSPQ.

The top misconception for all of the student groups was the same; as the majority of the students believed that *mutations are intentional: an organism tries, needs, or wants to change genetically (genetics).* However, the second most common misconception differed between the groups as the Latinos believed that *organisms can always obtain what they need to survive (ecological)* as compared to the Whites students who believed that *mutations occur to meet the needs of the population (evolutionary);* while the other student group *believed that variations only affect outward appearance; do not influence survival (genetics).* Nonetheless, there were no statistical significant differences between the student groups.

The Influence of Gender

The influences of gender as well as the remaining demographic variables were assessed similarly to ethnicity; hence, the absolute percent of correct responses and misconceptions are illustrated in Table 9. Table 10 and Figures 11 and 12 show the percent of correct responses grouped by the evolutionary concept levels and the raw mean comparison. Note that in general, the International males had higher correct genetics concept; however, the Latino females outperformed the International females by almost 10 percent. On the other hand, the discriminability p-values illustrated in Figure 13 show similar difficulty patterns.

Table 9. Absolute percentage of correct responses and misconceptions by gender. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions		Latino (n=563)		White (n=432)		Other (n=94)		Intl. (n=90)	
		M	F	M	F	M	F	M	F
Carrying Capacity	**<u>All species have great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully</u>**	**<u>66.5</u>**	**<u>58.3</u>**	**<u>76.3</u>**	**<u>69.9</u>**	**<u>62.5</u>**	**<u>58.1</u>**	**<u>81.8</u>**	**<u>67.4</u>**
	Organisms only replace themselves	*4.6*	*2.4*	*1.2*	*1.5*	*3.1*	*-*	*2.3*	*2.2*
	Population level off	*28.9*	*39.3*	*22.5*	*28.6*	*34.4*	*41.9*	*15.9*	*30.4*
Competition	**<u>Natural resources are limited; nutrients, water, oxygen, etc. necessary for living organisms are limited in supply at any given time</u>**	**<u>58.2</u>**	**<u>57.5</u>**	**<u>71.1</u>**	**<u>71.8</u>**	**<u>71.9</u>**	**<u>69.4</u>**	**<u>54.5</u>**	**<u>56.5</u>**
	Organisms can always obtain what they need to survive	*41.8*	*42.5*	*28.9*	*28.2*	*28.1*	*30.6*	*45.5*	*43.5*
Change in a Pop. w/ Certain Traits	**<u>The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations</u>**	**<u>15.5</u>**	**<u>17.1</u>**	**<u>12.5</u>**	**<u>16.4</u>**	**<u>12.5</u>**	**<u>16.4</u>**	**<u>11.4</u>**	**<u>19.6</u>**
	Changes in a population occur through a gradual change in all members of a population	*27.8*	*24.4*	*12.5*	*21.3*	*12.5*	*21.3*	*25.0*	*17.4*
	Learned behaviors are inherited	*20.1*	*18.4*	*34.4*	*24.6*	*34.4*	*24.6*	*25.0*	*19.6*
	Mutations occur to meet the needs of the population	*36.6*	*40.1*	*40.6*	*37.7*	*40.6*	*37.7*	*38.6*	*43.5*
Great Reproductive Potential	**<u>Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction surviving each generation</u>**	**<u>51.0</u>**	**<u>53.5</u>**	**<u>64.2</u>**	**<u>69.4</u>**	**<u>50.0</u>**	**<u>51.6</u>**	**<u>59.1</u>**	**<u>50.0</u>**
	Organisms work together (cooperate) and do not compete	*39.2*	*38.6*	*28.3*	*22.5*	*40.6*	*37.1*	*29.6*	*37.0*
	There is often physical fighting among one species (or among different species) and the strongest ones win	*9.8*	*7.9*	*7.5*	*8.1*	*9.4*	*11.3*	*11.4*	*13.0*

Table 9. Continued.

Evolutionary Theory Concepts and Misconceptions		Latino (n=563)		White (n=432)		Other (n=94)		Intl. (n=90)	
		M	F	M	F	M	F	M	F
Causes of Phenotypic Variation	**Random mutations and sexual reproduction produce variations; while many are harmful or of no consequence, a few are beneficial in some environments**	**9.8**	**5.7**	**17.9**	**10.5**	**12.5**	**9.7**	**6.8**	**6.5**
	Individuals of a population vary extensively in their characteristics	**37.3**	**51.2**	**49.1**	**47.5**	**40.6**	**50.0**	**63.6**	**30.4**
	Mutations are intentional: an organism tries, needs, or wants to change genetically	*70.6*	*73.2*	*61.8*	*79.5*	*62.5*	*74.2*	*68.2*	*69.6*
	Mutations are adaptive responses to specific environmental agents	*19.6*	*21.1*	*20.2*	*10.1*	*25.0*	*16.1*	*25.0*	*23.9*
	All members of a population are nearly identical	*11.9*	*12.7*	*5.8*	*9.3*	*12.5*	*8.1*	*4.5*	*8.7*
	Variations only affect outward appearance; do not influence survival	*50.8*	*36.0*	*45.1*	*43.2*	*46.9*	*41.9*	*31.8*	*60.9*
Heritability of Phenotypic Variation	**Much variation is heritable**	**39.8**	**40.7**	**61.8**	**51.4**	**56.3**	**41.9**	**47.7**	**32.6**
	Traits acquired during an organism's lifetime will be inherited by offspring	*8.9*	*12.7*	*6.9*	*13.1*	*9.4*	*12.9*	*9.1*	*13.0*
	Traits that are positively influenced by the environment will be inherited by offspring	*33.0*	*33.1*	*20.8*	*23.9*	*25.0*	*24.2*	*27.3*	*41.3*
	When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	*18.3*	*13.6*	*10.4*	*11.6*	*9.4*	*21.0*	*15.9*	*13.0*
	Organisms with many mates are biologically fit	*8.2*	*5.4*	*2.9*	*4.7*	*-*	*3.2*	*6.8*	*6.5*
Selective Survival Based on Heritable Traits	**Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals**	**35.6**	**40.4**	**47.4**	**50.0**	**50.0**	**41.9**	**40.9**	**37.0**
	Organisms with many mates are biologically fit	*8.2*	*5.4*	*2.9*	*4.7*	*-*	*3.2*	*6.8*	*6.5*
	Fitness is equated with strength, speed, intelligence or longevity	*56.2*	*54.2*	*49.7*	*45.3*	*50.0*	*54.8*	*52.2*	*56.5*

Even though differences in absolute percentages exist, no significant differences were found among the groups and/or between the male and female students. Once again, the number one misconception was in the genetics concepts (*mutations are intentional: an organism tries, needs, or wants to change genetically)*. However, the second most common misconception was similar between the genders with the exception of the International males, as they believed *variations only affect outward appearance; and do not influence survivals* as compared to *fitness equating to strength, speed, intelligence, or longevity (evolutionary).*

Table 10. Absolute percent and total number of natural selection concepts by gender.

Number of Correct Concepts	Latinos (n=563)		White (n=432)		Other (n=94)		Intl. (n=90)	
	M	F	M	F	M	F	M	F
0	1.5	1.9	.6	0.0	-	-	-	-
1	20.6	18.7	5.8	10.8	9.4	14.5	15.9	17.4
2	22.2	24.7	18.5	17.4	28.1	21.0	20.5	28.3
3	26.8	25.2	25.4	27.8	18.8	33.9	27.3	30.4
4	12.9	8.9	12.7	14.3	25.0	16.1	2.3	6.5
5	10.8	15.4	20.8	20.1	9.4	9.7	27.3	15.2
6	5.2	5.1	14.5	6.8	9.4	4.8	6.8	2.2
7	-	-	1.7	2.7	-	-	-	-

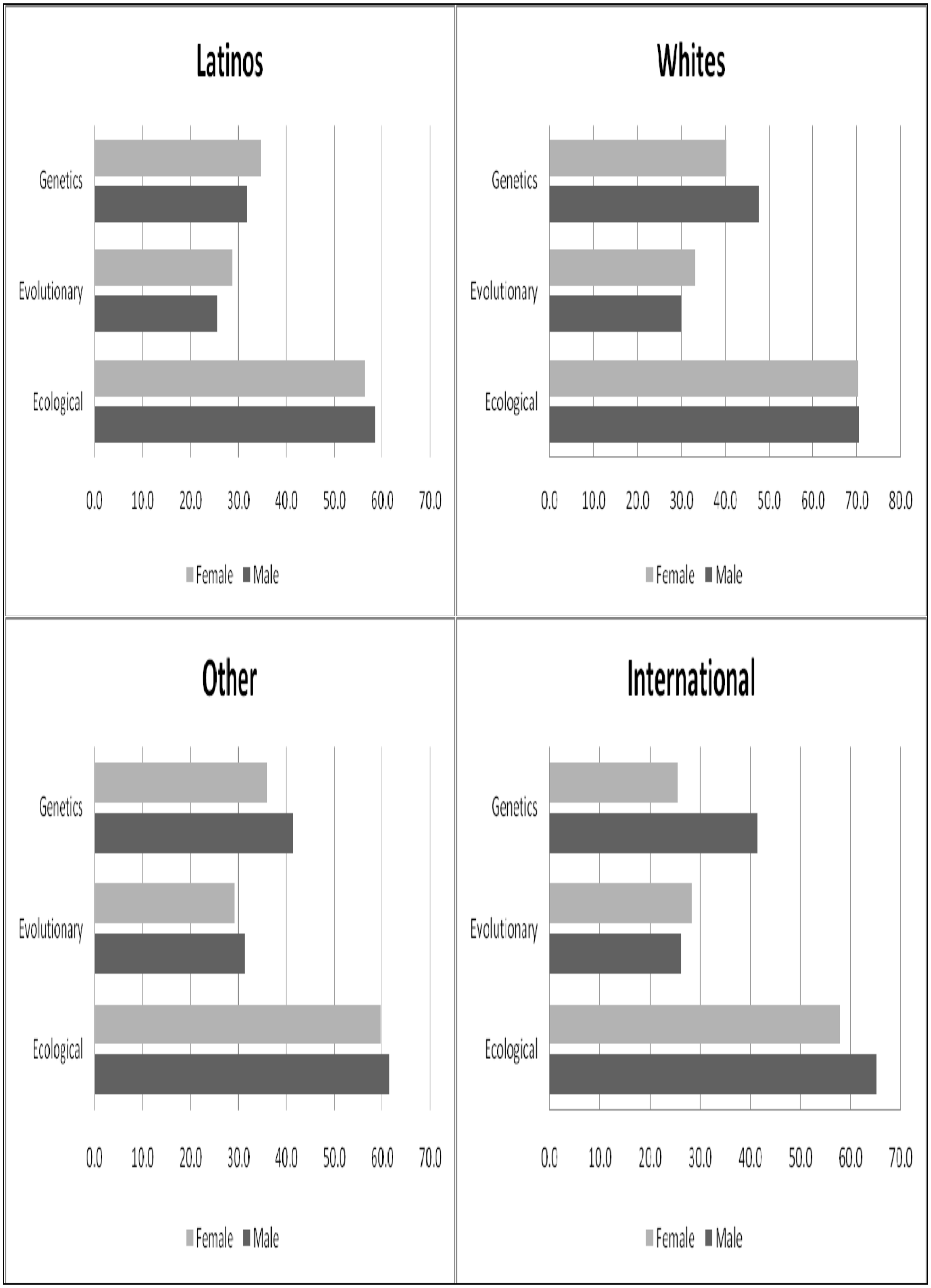

Figure 11. *Absolute percentage of correct responses by gender and evolutionary concepts.*

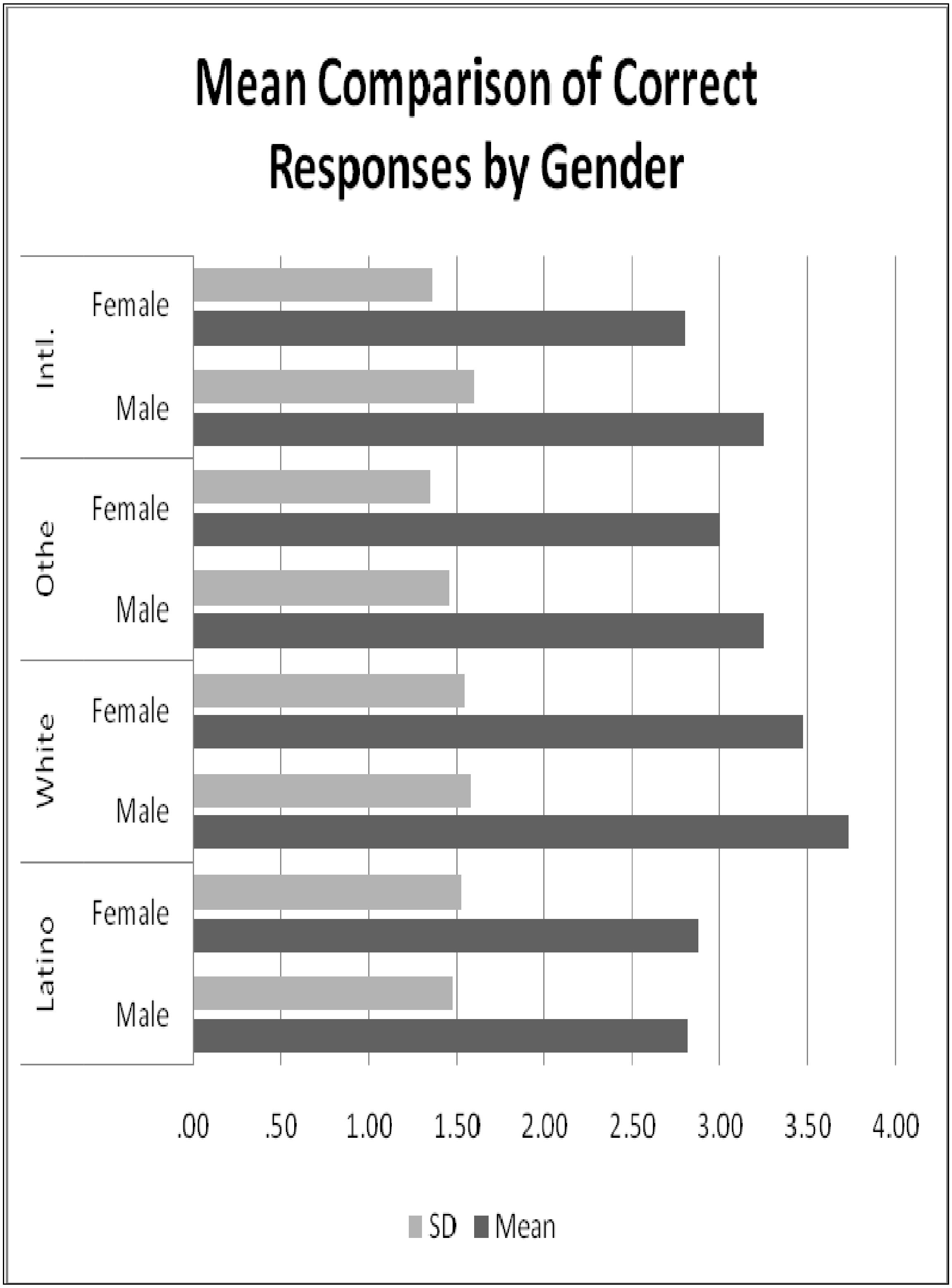

Figure 12. *Raw mean comparison by gender and ethnicity.*

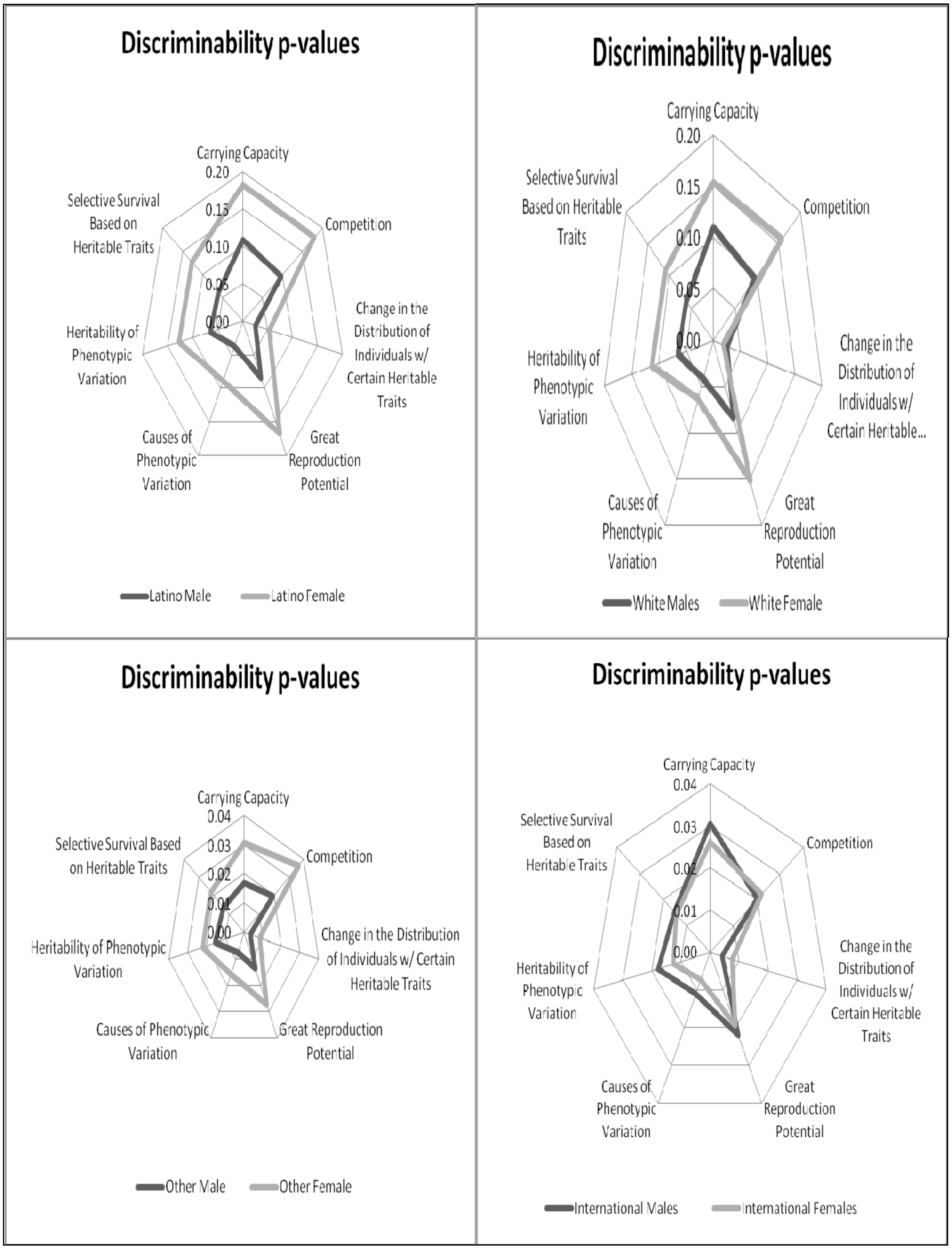

Figure 13. Discriminability p-values by gender. Low p-values indicate difficutlt concepts since these values take into account the percentage of students choosing the correct response.

The NSPQ scores are illustrated in Table11 and reveal differences amongst the groups; however, the differences are not statitstically signficantl. Note that the White student group was the only group to score a perfect 1.0 indicating that these students correctly answered the seven key concept question. While no White females failed to anwer all questions incorrectly, one of the White males did and thus accounts for the 0.6 percent.

Table 11. Absolute percentage of NSPQ scores by gender and ethnicity.

Actual Score	**Latino** (n=563)		**White** (n=432)		**Other** (n=94)		**Intl.** (n=90)	
	M	F	M	F	M	F	M	F
0.00	1.5	1.9	0.6	-	-	-	-	-
0.25	20.6	18.7	5.8	10.8	9.4	14.5	15.9	17.4
0.42	-	-	-	-	-	-	-	-
0.54	22.2	24.7	18.5	17.4	28.1	21.0	20.5	28.3
0.65	26.8	25.2	25.4	27.8	18.8	33.9	27.3	30.4
0.75	12.9	8.9	12.7	62.7	25.0	16.1	2.3	6.5
0.84	10.8	15.4	20.8	20.1	9.4	9.7	27.3	15.2
0.93	5.2	5.1	14.5	6.9	9.4	4.8	6.8	2.2
1.00	-	-	1.7	2.7	-	-	-	-

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

The Influence of Acculturation

As stated in chapter three, acculturation assesses the various acculturation dimensions of two cultures and portrays cultural orientation towards the cultures. In this particular study, the assessment is between the Mexican-American and Anglo-American cultures. Table 12 illustrates the absolute percent responses categorized by number of U.S. born generations and cultural orientation levels. Level-1 is not reported because it is associated with foreign born. Level-2 on the other hand refers to the first U.S. born generation; while level-3 is second U.S. born and Levels4-5 referring to three or more generations born in the U.S. While Table 13 reports the percent of the total correct concepts by levels of acculturation.

Table 12. Absolute percentage of correct responses and misconceptions by ethnicity and students' acculturation levels. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	**Latino (n=563)**				**White (n=432)**				**Other (n=94)**			
	1st	**2nd**	**3 or more**		**1st**	**2nd**	**3 or more**		**1st**	**2nd**	**3 or more**	
	L-2	**L-3**	**L-4**	**L-5**	**L-2**	**L-3**	**L-4**	**L-5**	**L-2**	**L-3**	**L-4**	**L-5**
CARRYIG CAPACITY:												
All species have great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully	**58.3**	**60.8**	**57.0**	**67.9**	**61.5***	**77.8**	**60.6**	**73.7**	**53.6**	**100**	**50.0**	**61.3**
Organisms only replace themselves	3.7	5.0	*3.0*	*1.9*	-	-	-	*1.6*	-	-	-	*1.6*
Population level of	38.0	34.2	*40.0*	*30.2*	38.5*	*22.2*	*39.4*	*24.7*	46.4	-	*50.0*	*37.1*
COMPETITION:												
Natural resources are limited; nutrients, water, oxygen, etc. necessary for living organisms are limited in supply at any given time	**54.5**	**63.3**	**57.0**	**59.3**	**53.8***	**56.6**	**66.7**	**72.9**	**85.7**	**50.0**	**100**	**62.9**
Organisms can always obtain what they need to survive	45.5	36.7	43.0	40.7	46.2*	44.4	33.3	27.1	14.3	*50.0*	-	37.1
CHANGE IN A POP. W/ CERTAIN TRAITS:												
The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations	**19.8**	**19.0**	**12.6**	**14.6**	**7.7***	**33.4**	**12.1**	**11.4**	**17.9**	**50.0**	***13.1***	***13.1***
Changes in a population occur through a gradual change in all members of a population	21.9	20.3	29.6	29.7	7.7*	11.1	24.3	19.9	17.9	-	*19.7*	*19.7*
Learned behaviors are inherited	18.2	17.7	16.3	22.6	46.1*	11.1	21.2	23.1	21.3	-	*31.1*	*31.1*
Mutations occur to meet the needs of the population	40.1	43.0	41.5	33.1	38.5*	44.4	42.4	45.6	42.9	*20.0*	*36.1*	*36.1*

Table 12. Continued.

Evolutionary Theory Concepts and Misconceptions	Latino (n=563)				White (n=432)				Other (n=94)			
	1st	2nd	3 or more		1st	2nd	3 or more		1st	2nd	3 or more	
	L-2	L-3	L-4	L-5	L-2	L-3	L-4	L-5	L-2	L-3	L-4	L-5
GREAT REPRODUCTIVE POTENTIAL: **Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction surviving each generation**	*50.3*	43.0	*55.6*	*57.8*	*61.4*	*56.0*	*78.8*	*66.8*	*64.3*	*100*	*100*	*41.8*
Organisms work together (cooperate) and do not compete	*38.5*	**49.4**	*39.2*	*33.5*	*38.5*	*22.0*	*12.1*	*25.5*	*21.4*	-	-	*48.6*
There is often physical fighting among one species (or among different species) and the strongest ones win	*11.2*	**7.6**	*5.2*	*8.7*	-	*22.0*	*9.1*	*7.7*	*14.3*	-	-	*9.6*
CAUSES OF PHENOTYPIC VARIATION ***Random mutations and sexual reproduction produce variations; while many are harmful or of no consequences, few are beneficial in some environments***	***6.4***	***6.3***	**8.1**	***7.4***	***15.4***	***11.1***	***15.2***	***13.3***	***17.9***	***100***	-	***8.1***
Individuals of a population vary extensively in their characteristics	***41.2***	***41.7***	**56.3**	**46.3**	***69.2***	***22.2***	***45.5***	***48.3***	***42.9***	***50.0***	***50.0***	***48.4***
Mutations are intentional: an organism tries, needs, or wants to change genetically	69.0	68.4	76.3	74.7	61.5*	66.6	60.6	73.9	60.7	-	*50.1*	74.2
Mutations are adaptive responses to specific environmental agents	24.6	*25.3*	15.6	17.9	23.1*	22.3	24.2	12.8	21.4	-	*50.0*	17.7
All members of a population are nearly identical	13.5	5.1	13.3	14.2	7.7*	11.1	6.0	8.0	7.1	-	-	11.3
Variations only affect outward appearance; do not influence survival	45.3	53.2	30.4	39.5	23.1*	66.7	48.5	43.7	50.0	50.1	50.0	40.3

Table 12. Continued.

Evolutionary Theory Concepts and Misconceptions	**Latino (n=563)**				**White (n=432)**				**Other (n=94)**			
	1st	**2nd**	**3 or more**		**1st**	**2nd**	**3 or more**		**1st**	**2nd**	**3 or more**	
	L-2	**L-3**	**L-4**	**L-5**	**L-2**	**L-3**	**L-4**	**L-5**	**L-2**	**L-3**	**L-4**	**L-5**
HERITABILITY OF PHENOTYPIC VARIATION:												
Much variation is heritable	**39.2**	**44.9**	**38.1**	**41.1**	**76.9***	**44.5**	**36.4**	**56.7**	**46.4**	**50.0**	**100**	**45.2**
Traits acquired during an organism's lifetime will be inherited by offspring	10.2	11.5	11.2	17.3	7.7*	11.1	9.1	10.9	10.7	-	-	12.8
Traits that are positively influenced by the environment will be inherited by offspring	*15.1*	*10.0*	*15.6*	*13.2*	*7.7**	*11.1*	*18.1*	*10.6*	*14.3*	-	-	*19.4*
When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	*35.5*	*33.3*	*35.1*	*28.4*	*7.7**	*33.3*	*36.4*	*21.8*	*28.6*	*50.0*	-	*22.6*
SELECTIVE SURVIVAL BASED ON HERITABLE TRAITS:												
Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals	**32.1**	**36.7**	**42.2**	**44.5**	**38.5***	**33.3**	**48.7**	**60.6**	**64.3**	**-**	**-**	**38.7**
Organisms with many mates are biologically fit	62.0	55.7	54.1	3.7	53.8*	66.5	*47.3*	36.4	28.6	100	100	61.3
Fitness is equated with strength, speed, intelligence or longevity	5.9	7.6	46.9	8.6	7.7*	-	4.4	3.0	7.1	-	-	-

The number of generations born in the U.S. is denoted by 1st, 2nd, 3 or more categories. The acculturation levels are donated by the L-2 to L-5 which indicates the cultural orientation of two cultures. Note that Level-1 is not reported since it corresponds to foreign born individuals.
**indicates orientation towards another culture other than Mexican-American.*

The number one misconception between the groups was similar regardless if the students were first or third U.S. born—*mutations are intentional: an organism tries, needs, or wants to change genetically (genetics)* with the exception of Level-4 Other student group. Their number one misconception was that *organisms with many mates are biologically fit (evolutionary).* However, the second most prevalent misconception varied somewhat between the student groups. For example, all but the Level-5 acculturated Latino students believed that *organisms with many mates are biologically fit (evolutionary).* While the more Anglo acculturated students (Level-5) believed that *organisms can always obtain what they need to survive (ecological).* Meanwhile the Leve-2 and Level-3 of the Whites students held the same belief. However, the more Anglo-acculturated Whites believed that m*utations occur to meet the needs of the population (evolutionary).* The Other Level-3 and Level-5 believed that *organisms with many mates are biologically fit (evolutionary).*

In general, the less Anglo-acculturated Latinos and Other students (level-2) answered more correct questions than the Level-2 White students. Furthermore, the Level-5 Anglo-acculturated Latino and Other students performed similarly; with the exception of the students who answered more than five correct concepts. In this case, the Anglo Level-5 students did much better, but the percent difference between the Latino and White students was less 13.2 percent cumulative difference. Once again, no statistical significant differences were found between or among the student groups.

Table 13. Absolute percentage and total number of natural selection concepts by acculturation levels.

Number of Correct Concepts	Latinos (n=563)				White (n=432)				Other (n=94)			
	1st	2nd	3 or more		1st	2nd	3 or more		1st	2nd	3 or more	
	L-2	L-3	L-4	L-5	L-2	L-3	L-4	L-5	L-2	L-3	L-4	L-5
0	4.3	-	.7	.6	-	-	-	0.3	-	-	-	-
1	21.4	16.5	20.0	17.9	15.4	33.3	9.1	8.0	3.6	-	-	17.7
2	22.5	34.2	25.9	18.5	15.4	-	24.2	17.8	25.0	-	-	24.2
3	24.6	22.8	25.9	28.4	38.5	33.3	27.3	26.3	25.0	50.0	50.0	29.0
4	10.2	7.6	7.4	14.2	15.4	-	6.1	14.6	14.3	-	50.0	21.0
5	11.8	12.7	16.3	14.8	-	33.3	21.2	20.7	21.4	50.0	-	3.2
6	5.3	6.3	3.7	5.6	15.4	-	9.1	10.1	10.7	-	-	4.8
7	-	-	-	-	-	-	3.0	2.4	-	-	-	-

The number of generations born in the U.S. is denoted by 1st, 2nd, 3 or more categories. The acculturation levels are donated by the L-2 to L-5 which indicates the cultural orientation of two cultures. Note that Level-1 is not reported since it corresponds to foreign born individuals.

The absolute percentages of correct responses are illustrated in Figures 14 through 16. Mean comparisons are reported in Figures 17 through 22; while, discriminability p-values are illustrated in Figures 23 through 26. The analyses results are reported separately in order to avoid crowding the Figures with too much information. Even though different patterns exist between the student groups, the differences are not statistically significant as illustrated by the mean raw results. Nonetheless, it is interesting to note that the more acculturated an individual becomes, the less varying the results; hence students' conceptual understanding of natural selection seem to converge as students become more acculturated in the U.S. mainstream culture. The NSPQ scores are detailed in Table 14 and Figure 27.

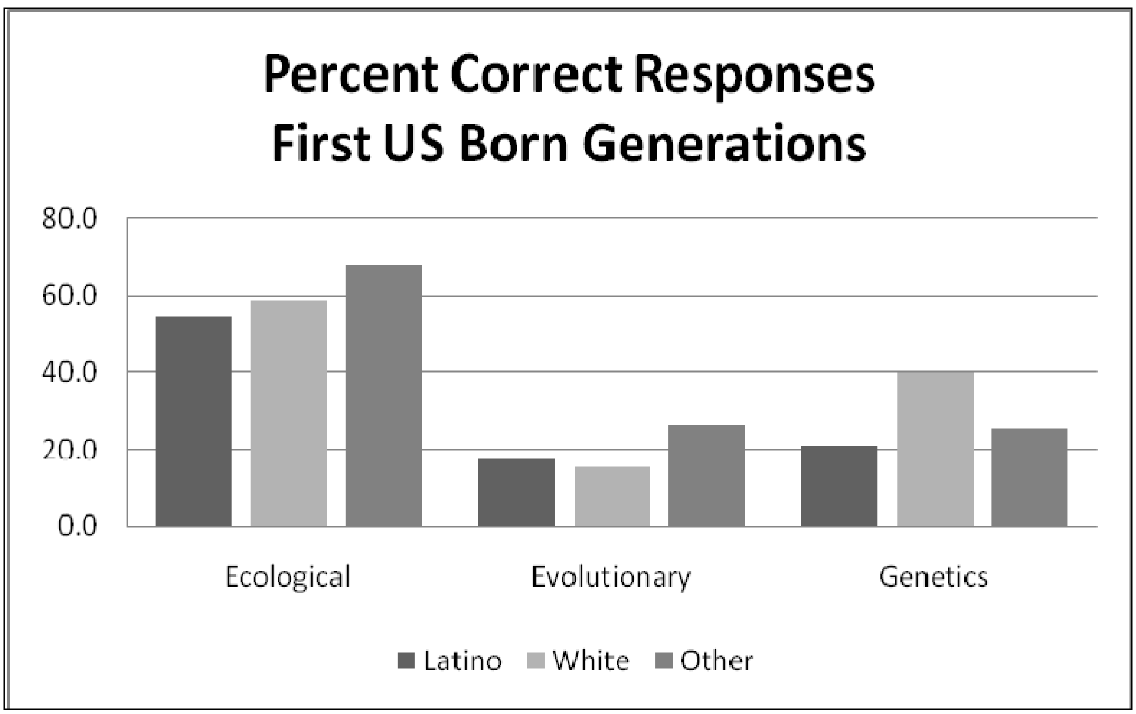

Figure 14. *Absolute percentage of evolutionary concepts by ethnicity and first U.S. born generations.*

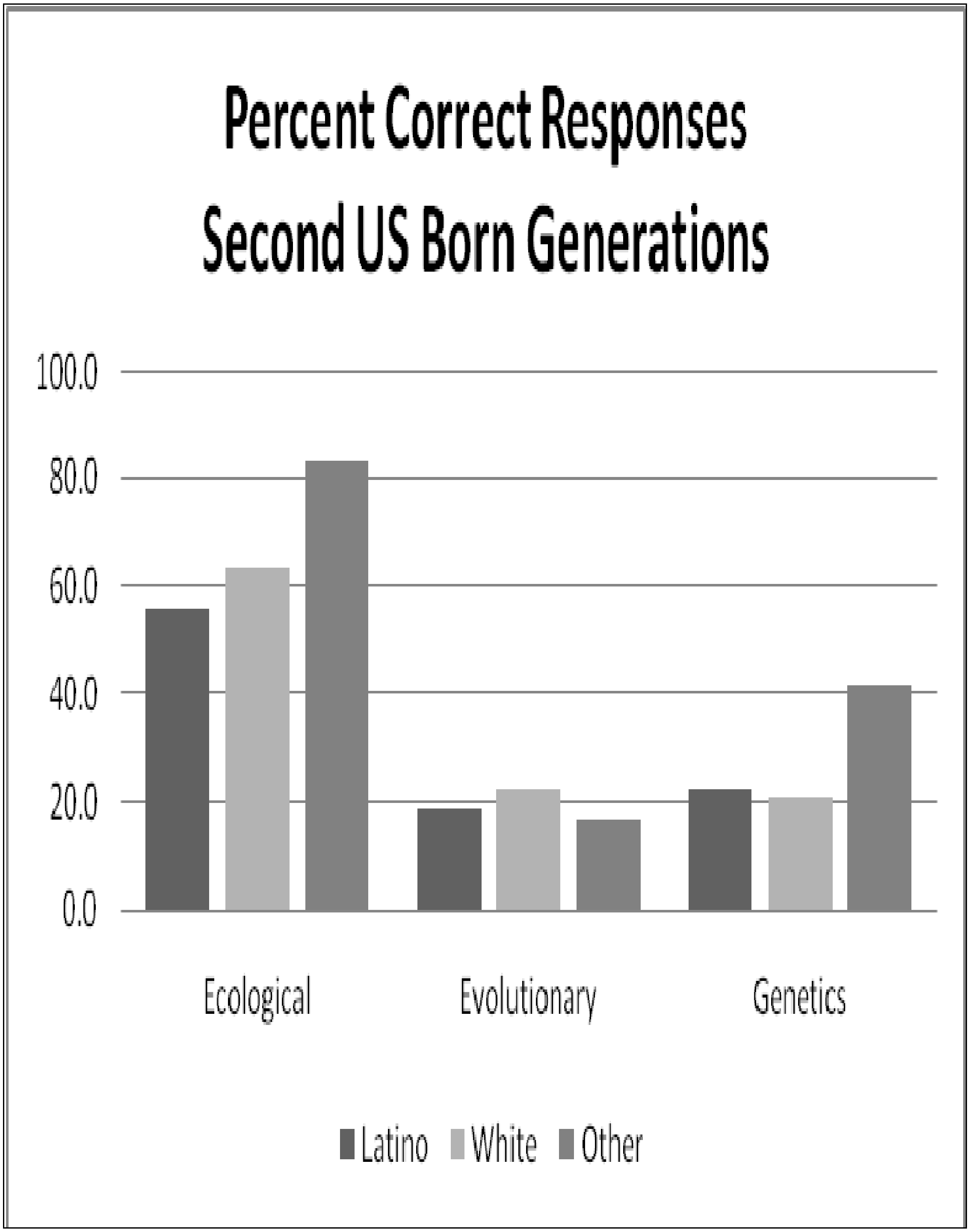

Figure 15. *Absolute percentage of evolutionary concepts by ethnicity and second U.S. born generations.*

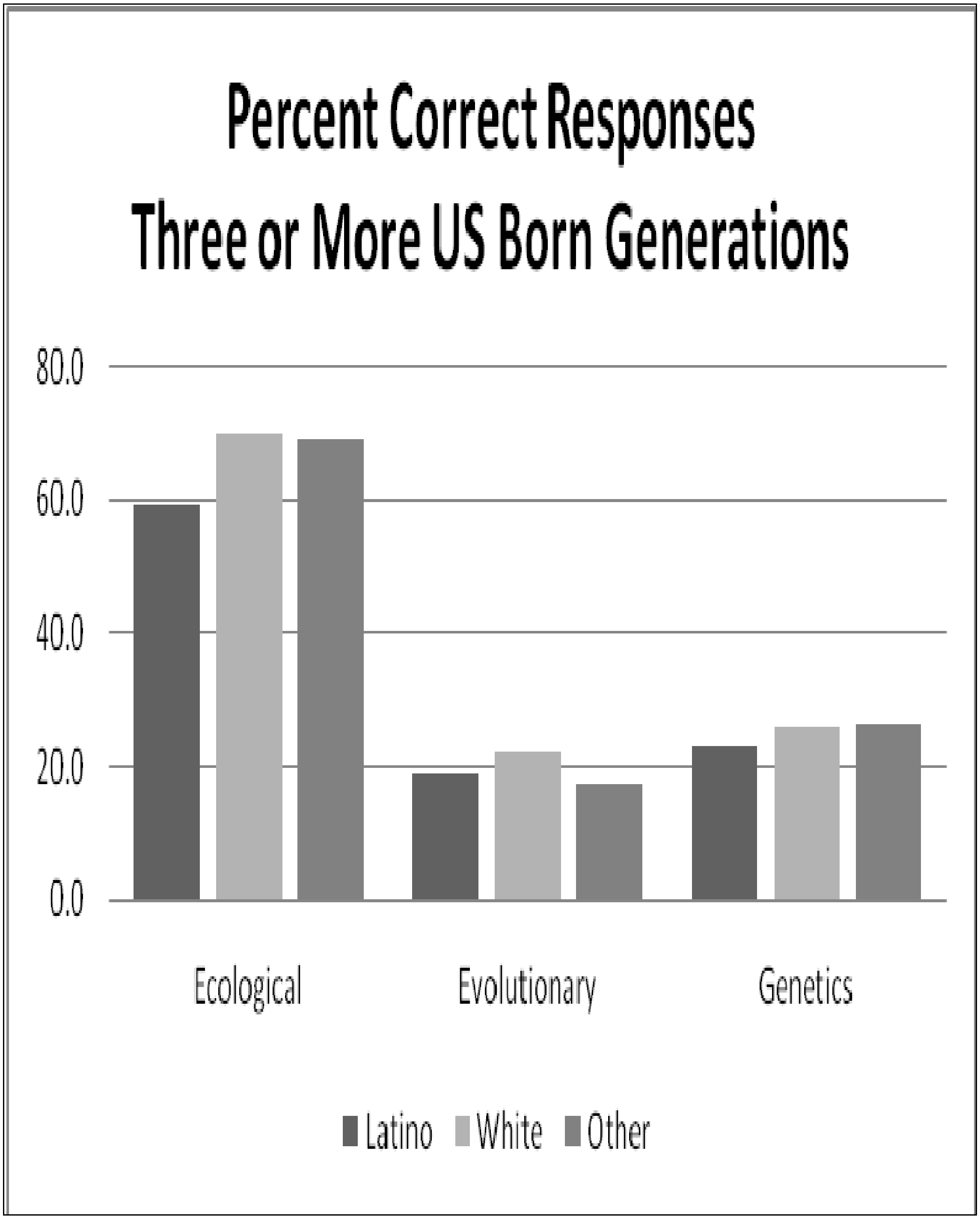

Figure 16. *Absolute percentage of correct responses by ethnicity and three or more U.S. born generations.*

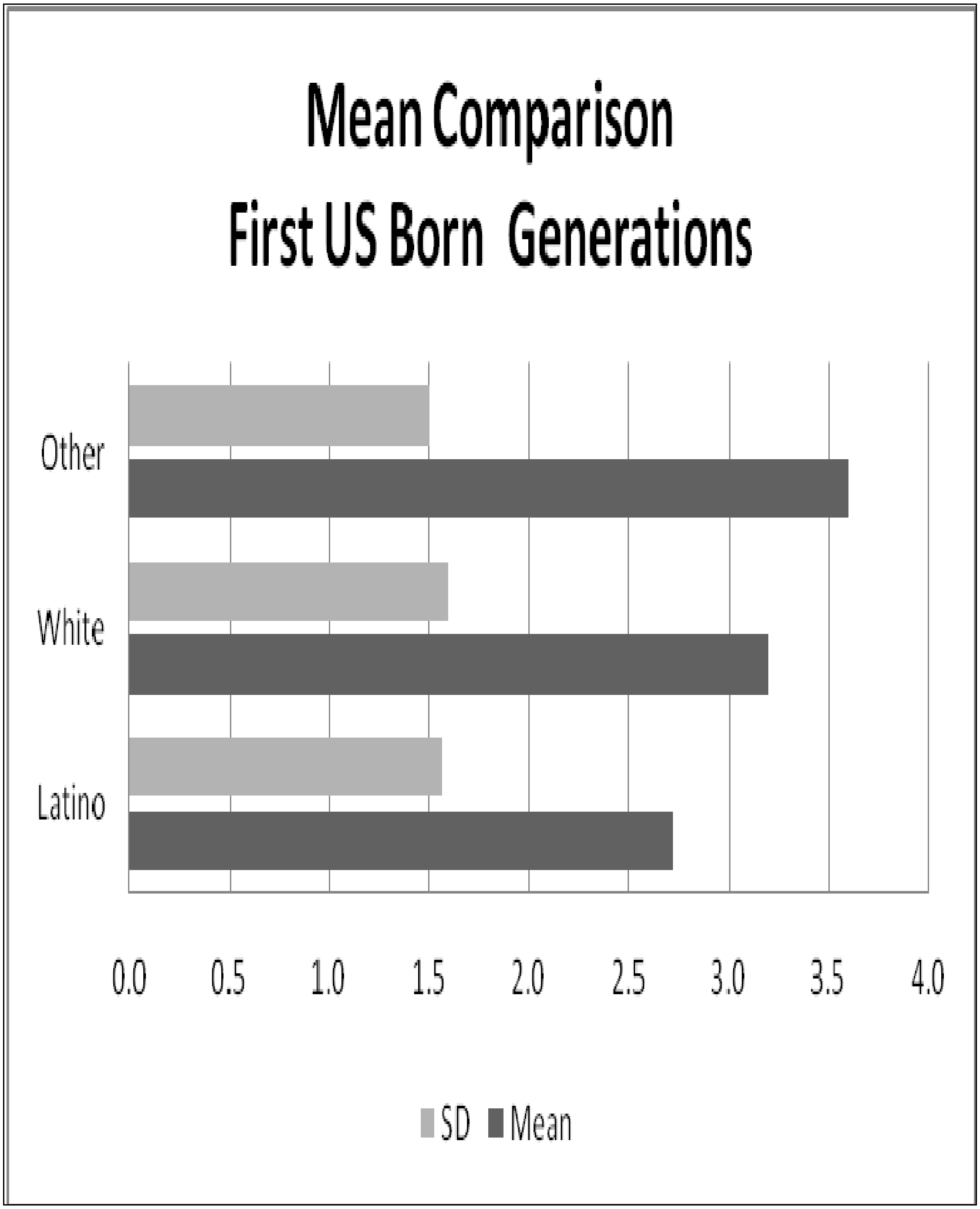

Figure 17. *Raw mean comparison of correct responses by ethnicity and first U.S. born generations.*

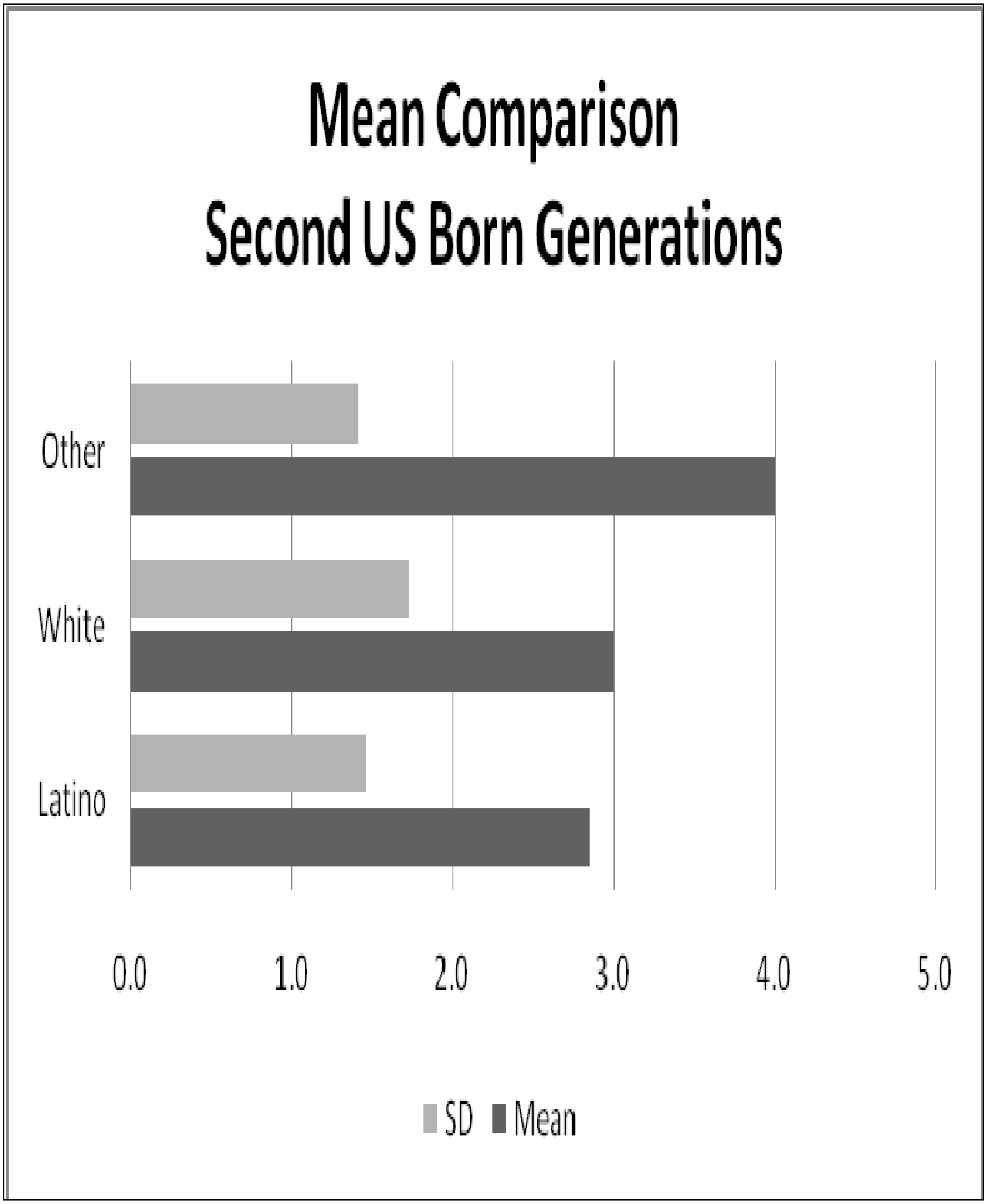

Figure 18. *Raw mean comparison of correct responses by ethnicity and second U.S born generations.*

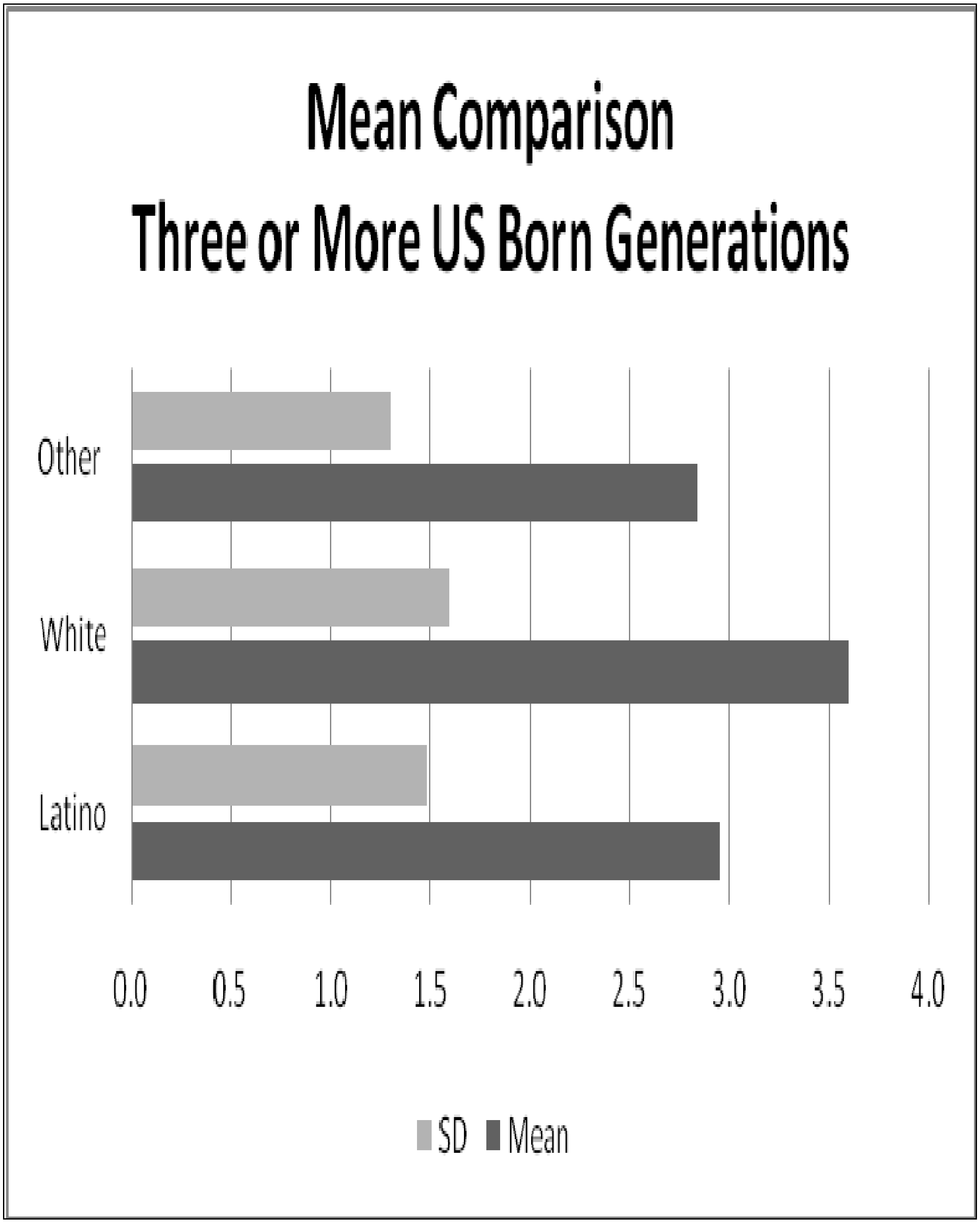

Figure 19. *Raw mean comparison of correct responsess by ethnicity and three or more U.S.born generations.*

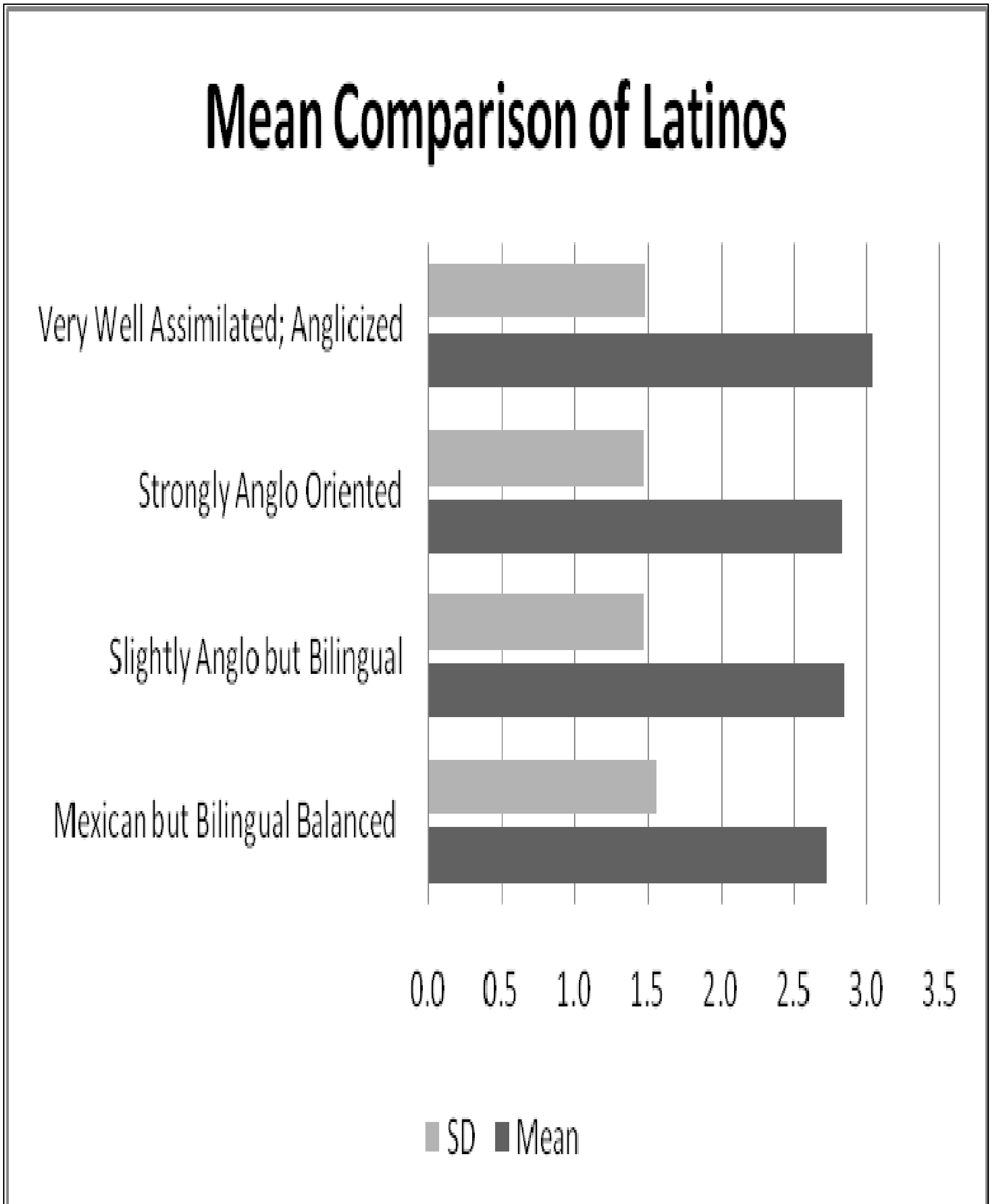

Figure 20. *Latino raw mean comparison of correct responses and acculturation level.*

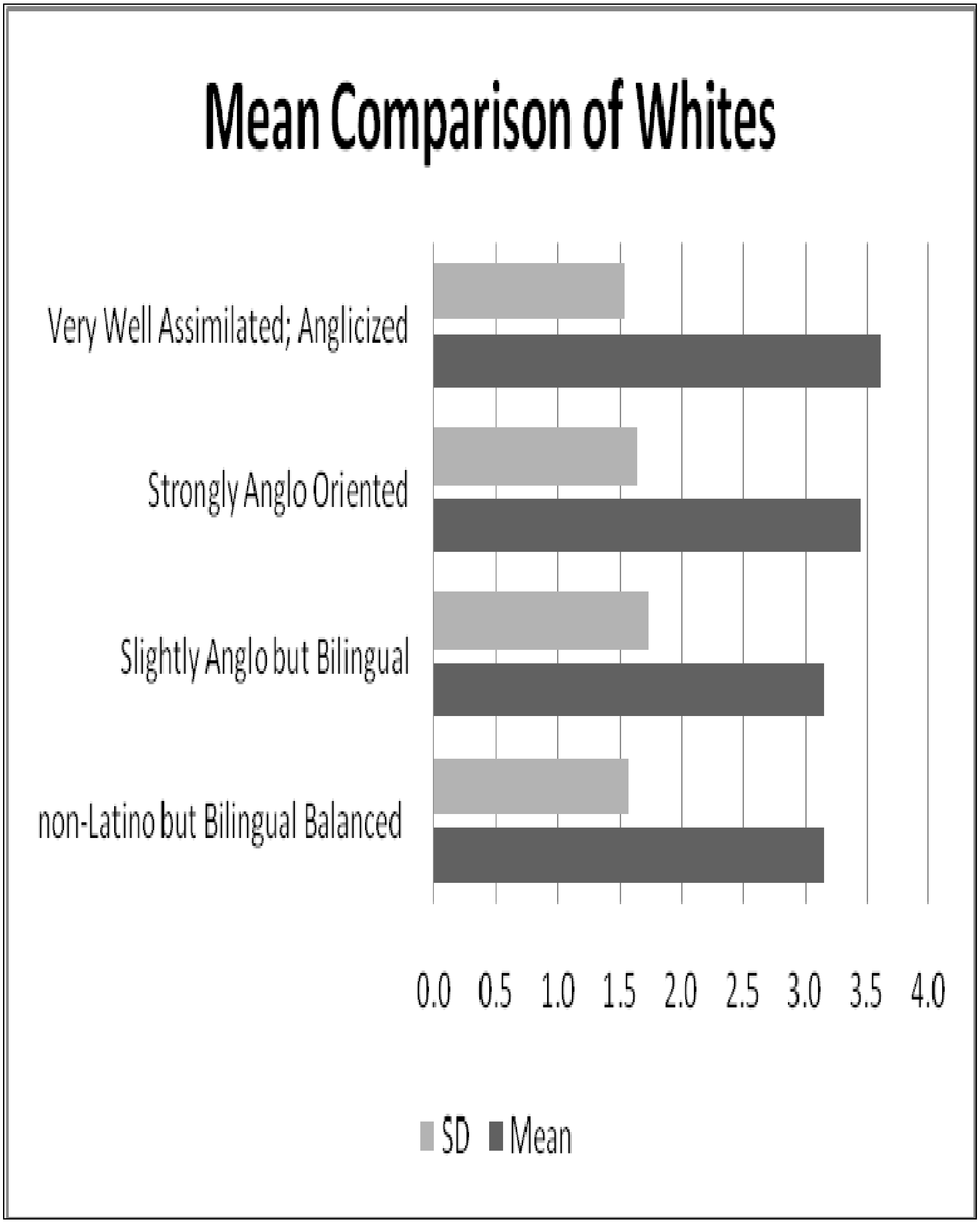

Figure 21. *White raw mean comparison of correct responses and acculturation level. Bilingual balance towards another cultural other than Mexican-American.*

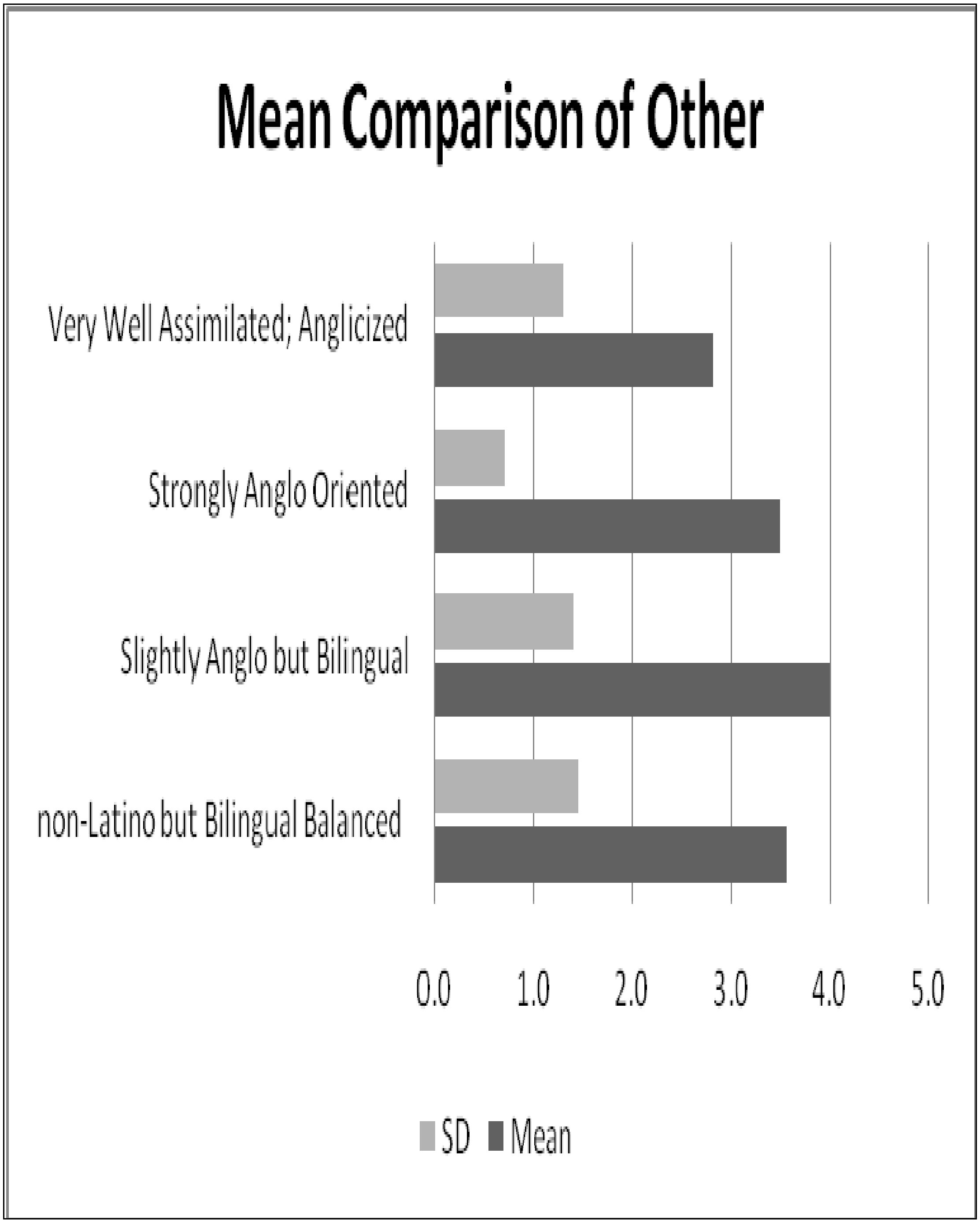

Figure 22. *Other raw mean comparison of correct responses and acculturation level. Bilingual balance towards another cultural other than Mexican-American.*

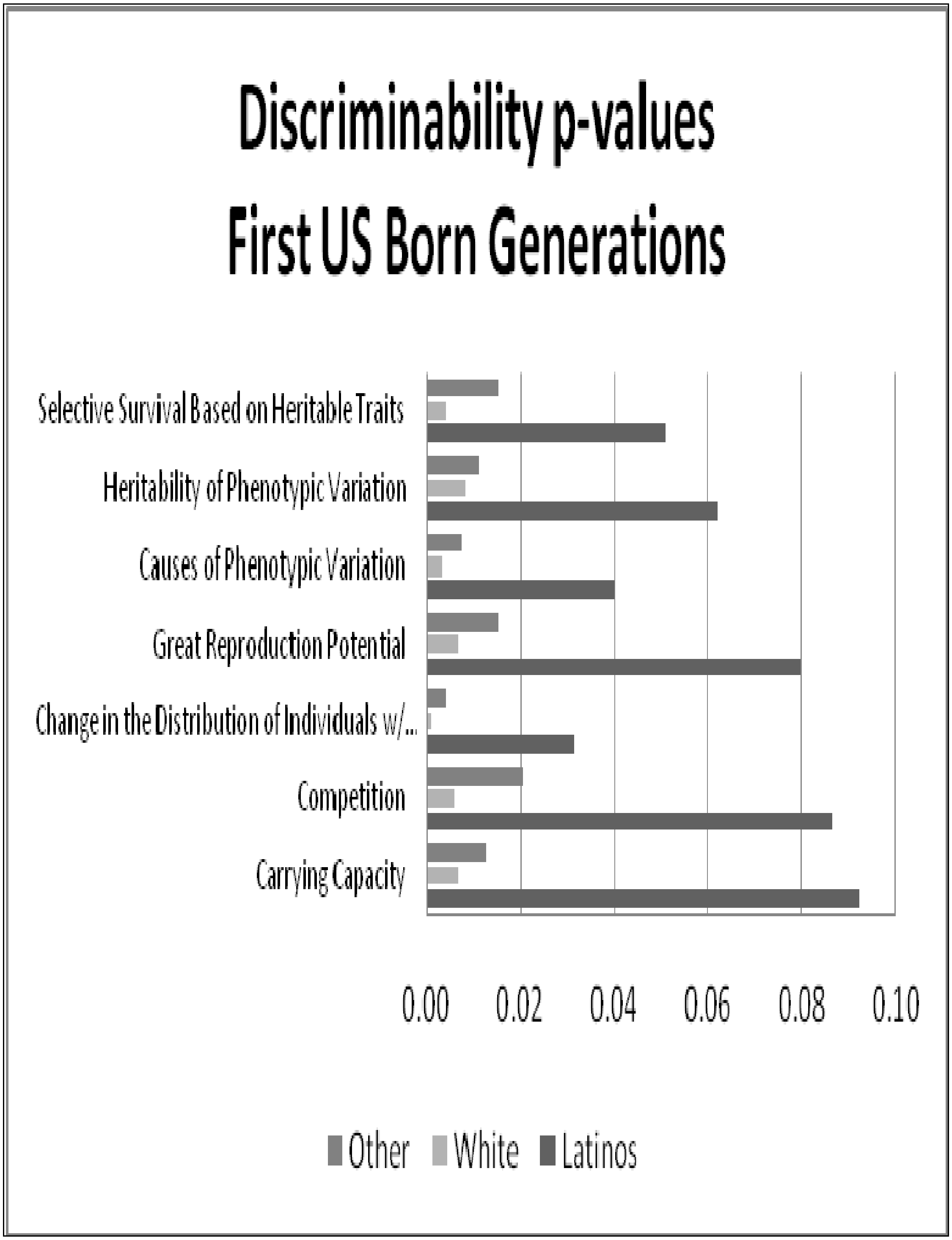

Figure 23. *Discriminability p-values for evolutionary theory by natural selection concepts for first U.S .born generations. Low p-values identify difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

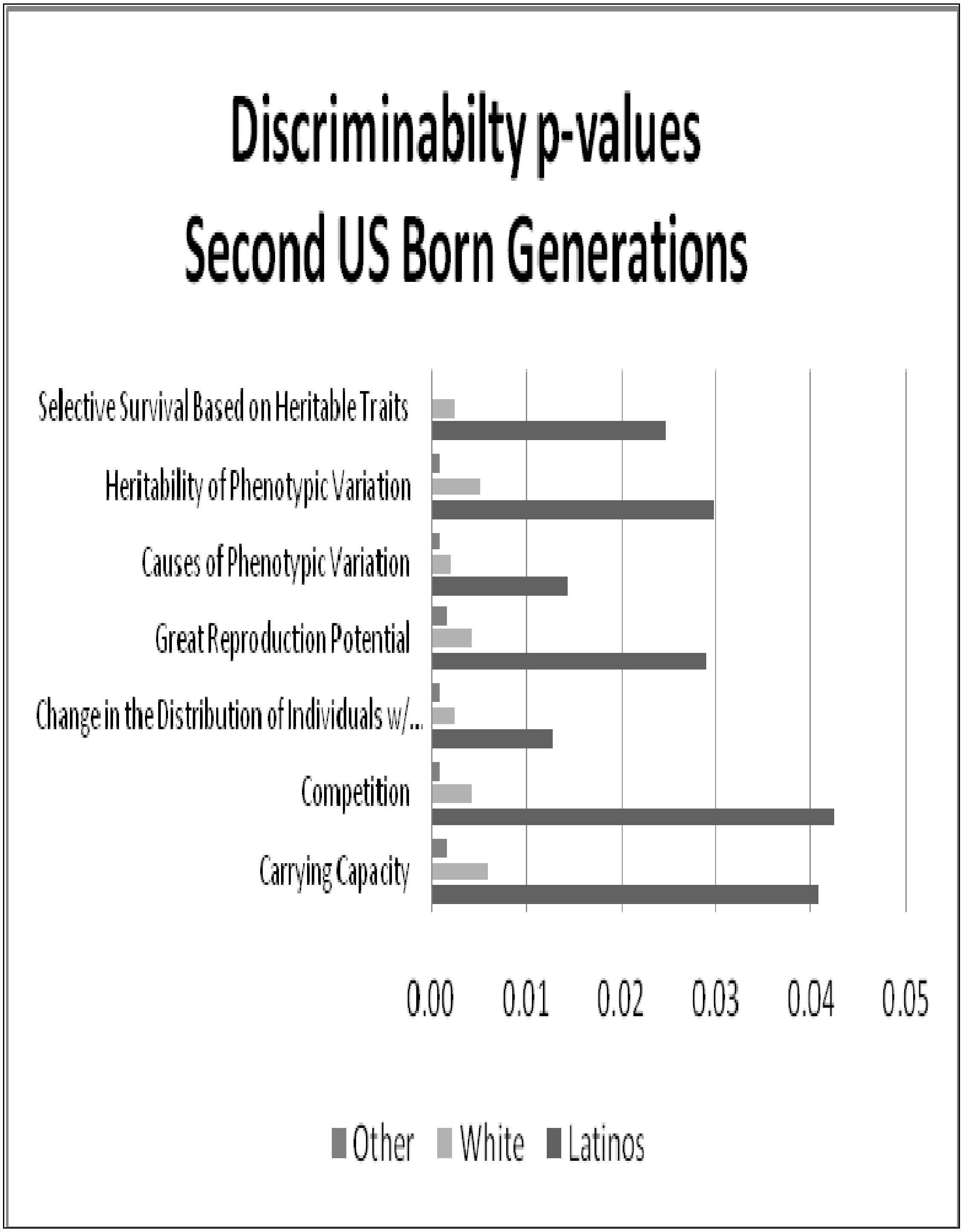

Figure 24. *Discriminability p-values for evolutionary theory by natural selection concepts for second U.S .born generations. Low p-values identify difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

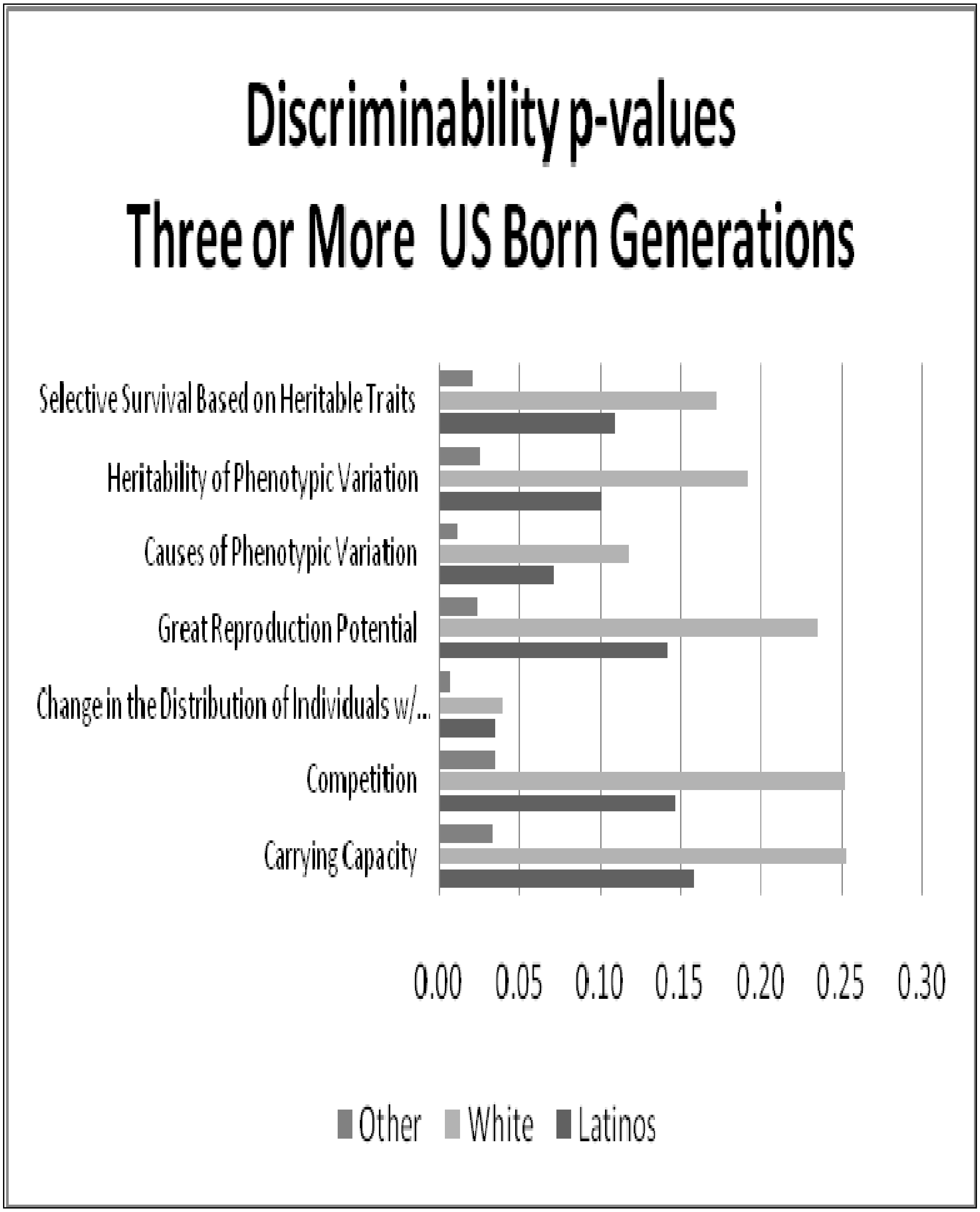

Figure 25. *Discriminability p-values for evolutionary theory by natural selection concepts for three or more U.S .born generations. Low p-values identify difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

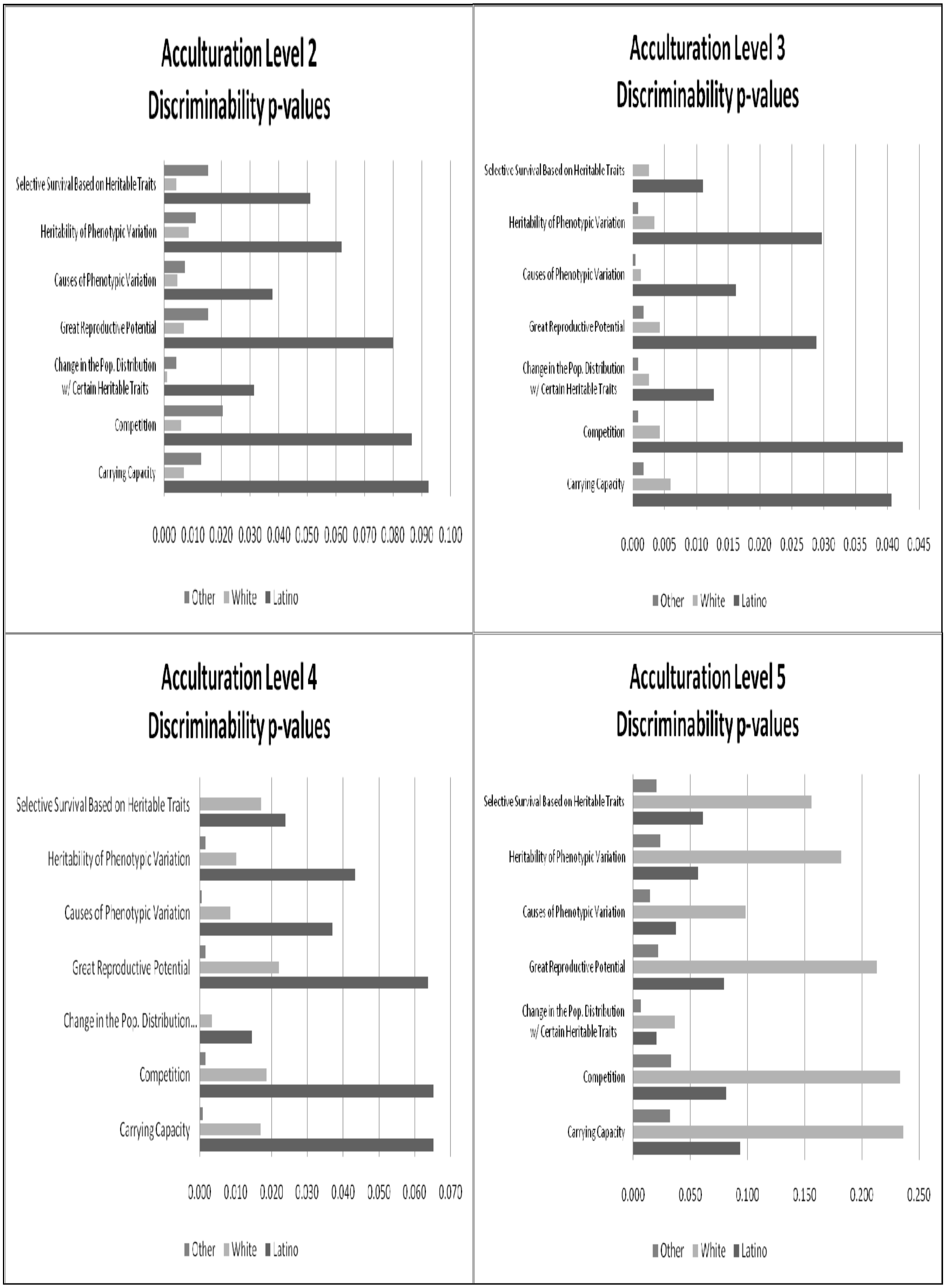

Figure 26. Discriminability p-values for evolutionary theory by natural selection concepts for acculturation levels. Low p-values identify difficutlt concepts since these values take into account the percentage of students choosing the correct response.

Table 14. Percent of NSPQ scores by ethnicity and number of U.S. born generations.

Actual Score	Ethnicity	First Generation	Second Generation	Three or More US Born Generations
0.00	Latino	4.3	-	0.7
	White	-	-	0.2
	Other	-	-	-
0.25	Latino	-	-	-
	White	-	-	-
	Other	-	-	-
0.42	Latino	21.4	16.4	18.9
	White	15.4	33.3	8.0
	Other	3.6	-	17.2
0.54	Latino	22.5	34.2	21.9
	White	15.4	-	18.3
	Other	25.0	-	23.4
0.65	Latino	24.6	22.8	27.3
	White	38.5	33.3	26.3
	Other	25.0	50.0	29.7
0.75	Latino	10.2	7.6	11.1
	White	15.4	-	13.9
	Other	14.3	-	21.9
0.84	Latino	11.8	12.7	15.5
	White	-	33.3	20.7
	Other	21.4	50.0	3.1
0.93	Latino	5.3	6.3	4.7
	White	15.4	-	10.0
	Other	10.7	-	4.7
1.00	Latino	-	-	-
	White	-	-	2.4
	Other	-	-	-

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

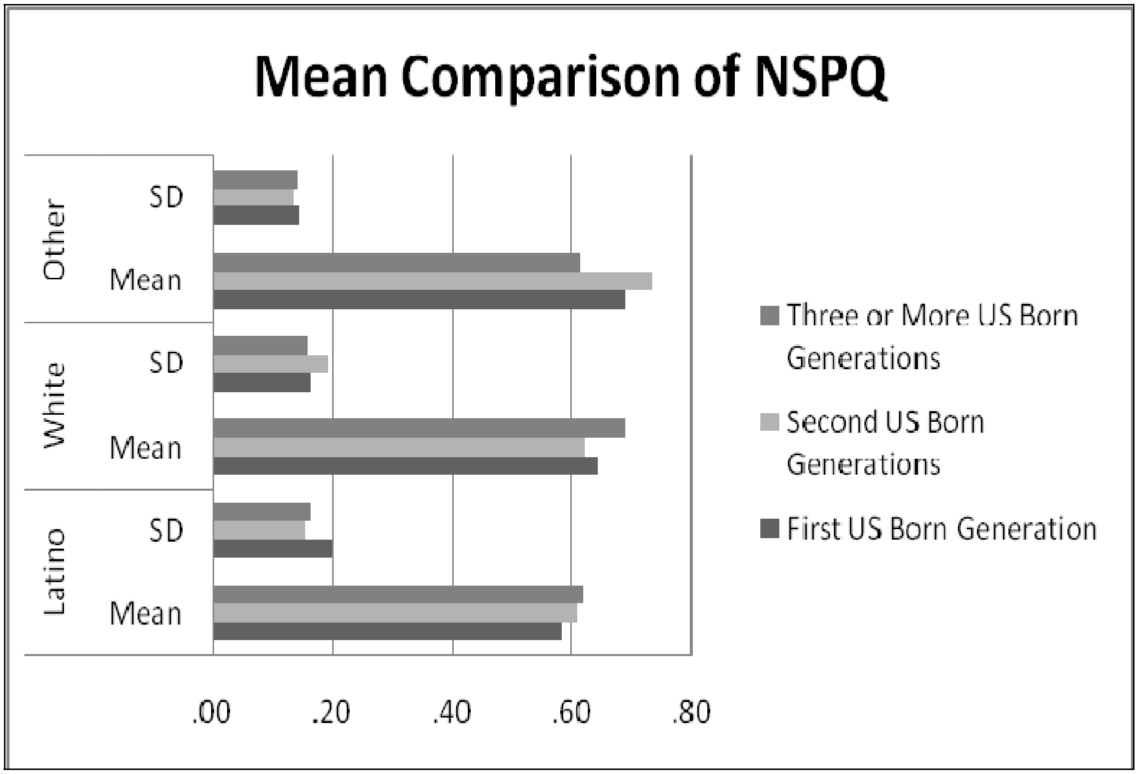

Figure 27. *Raw mean comparison of NSPQ scores by ethnicity and number of generations born in the U.S.*

The Influence of Parents' Education and Combined Income

Parent education and combined income was assessed the same way as the previous demographic variables. Hence the series of Tables 15 through 25 and Figures 28 through 41 found below illustrate the various statistical analyses. Note once again that no statistical significant differences were found among the student groups and/or between the various variable assessments. Nonetheless, some data pattern variances emerged and thus in general, students' correct responses increased with parents' increased education and combined income. However, some exceptions were noted and thus such was not true for each evolutionary theory concept.

***Table 15. Absolute percentage of correct responses and misconceptions for the carrying capacity concept by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized*.**

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
All species have great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully	< than High School	<$9,999	**58.3**	**62.3**	**100**	**66.7**	**100**	**100**
		$10K-$24,999	**55.5**	**47.1**	**75.0**	**60.0**	**50.0**	**50.0**
		$25K-$49,999	**88.9**	**82.6**	**0.0**	**75.0**	**100**	-
		>50K	**80.0**	**50.0**	**75.0**	**55.6**	**0.0**	**0.0**
	High School Diploma	<$9,999	**64.7**	**54.2**	**50.0**	**80.0**	**75.0**	**75.0**
		$10K-$24,999	**70.0**	**60.0**	**81.8**	**54.5**	**0.0**	**28.6**
		$25K-$49,999	**63.9**	**61.3**	**74.3**	**62.7**	**66.7**	**55.6**
		>50K	**60.0**	**47.6**	**71.9**	**80.0**	**100**	**80.0**
	Some College/ Technical School, but no degree	<$9,999	**62.5**	**80.0**	**85.7**	**100**	**50.0**	**66.7**
		$10K-$24,999	**48.1**	**62.2**	**54.5**	**92.3**	**80.0**	**100**
		$25K-$49,999	**57.4**	**57.1**	**73.9**	**80.9**	**40.0**	**37.5**
		>50K	**57.1**	**71.4**	**73.5**	**76.5**	**50.0**	**50.0**
	College or Prof. Degree	<$9,999	**50.0**	**75.0**	**80.0**	**100**	**100**	-
		$10K-$24,999	**64.3**	**70.0**	**54.5**	**37.5**	**50.0**	**0.0**
		$25K-$49,999	**60.5**	**55.9**	**66.7**	**71.1**	**75.0**	**87.5**
		>50K	**78.1**	**79.4**	**75.3**	**71.8**	**33.3**	**0.0**
Organisms only replace themselves	< than High School	<$9,999	8.3	5.3	-	-	-	-
		$10K-$24,999	2.5	2.0	-	-	-	-
		$25K-$49,999	0.0	4.3	0.0	25.0	0.0	-
		>50K	0.0	0.0	0.0	0.0	-	-
	High School Diploma	<$9,999	0.0	4.2	-	-	-	-
		$10K-$24,999	2.5	4.4	-	-	-	-
		$25K-$49,999	1.6	0.0	0.0	2.0	16.7	11.1
		>50K	0.0	9.5	0.0	2.9	-	-

Table 15. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Organisms only replace themselves	Some College/ Technical School, but no degree	<$9,999	6.3	0.0	-	-	-	-
		$10K-$24,999	3.7	2.7	-	-	-	-
		$25K-$49,999	1.6	0.0	2.9	0.0	0.0	0.0
		>50K	8.6	4.8	2.9	0.0	-	-
	College or Prof. Degree	<$9,999	0.0	0.0	-	-	-	-
		$10K-$24,999	0.0	0.0	-	-	-	-
		$25K-$49,999	5.3	8.8	2.8	2.6	0.0	0.0
		>50K	-	-	1.4	2.4	-	-
Population level off	< than High School	<$9,999	33.3	31.6	0.0	33.3	0.0	0.0
		$10K-$24,999	42.5	51.0	25.0	40.0	50.0	50.0
		$25K-$49,999	11.1	13.0	100	0.0	0.0	33.3
		>50K	20.0	50.0	25.0	44.4	100	100
	High School Diploma	<$9,999	35.3	41.7	50.0	20.0	25.0	25.0
		$10K-$24,999	27.5	35.6	18.2	45.5	100	71.4
		$25K-$49,999	34.4	38.7	25.7	35.3	16.7	62.5
		>50K	40.0	42.9	28.1	17.1	0.0	20.0
	Some College/ Technical School, but no degree	<$9,999	31.3	20.0	14.3	0.0	50.0	33.0
		$10K-$24,999	48.1	35.1	45.5	7.7	20.0	0.0
		$25K-$49,999	41.0	42.9	23.2	19.1	60.0	12.5
		>50K	34.3	23.8	23.5	23.5	50.0	50.0
	College or Prof. Degree	<$9,999	50.0	25.0	20.0	0.0	0.0	-
		$10K-$24,999	35.7	30.0	45.5	62.5	50.0	100
		$25K-$49,999	34.2	35.3	30.6	26.3	25.0	-
		>50K	21.9	20.6	23.3	25.9	66.7	80.0

Table 16. Absolute percentage of correct responses and misconceptions for the competition concept by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Natural resources are limited; nutrients, water, oxygen, etc. necessary for living organisms are limited in supply at any given time	< than High School	<$9,999	**62.5**	**68.4**	**33.3**	**50.0**	**0.0**	**0.0**
		$10K-$24,999	**55.0**	**47.1**	**50.0**	**60.0**	**100**	**100**
		$25K-$49,999	**66.7**	**69.6**	**0.0**	**75.0**	**100**	-
		>50K	**100**	**66.7**	**87.5**	**88.9**	**100**	**10.0**
	High School Diploma	<$9,999	**64.7**	**66.7**	**50.0**	**100**	**75.0**	**75.0**
		$10K-$24,999	**50.0**	**57.8**	**63.6**	**72.7**	**50.0**	**42.9**
		$25K-$49,999	**67.2**	**48.4**	**85.7**	**76.5**	**83.3**	**77.8**
		>50K	**70.0**	**61.9**	**59.4**	**65.7**	**100**	**100**
	Some College/ Technical School, but no degree	<$9,999	**62.5**	**70.0**	**85.7**	**66.7**	**100**	**100**
		$10K-$24,999	**53.7**	**51.4**	**54.5**	**69.2**	**80.0**	**85.7**
		$25K-$49,999	**60.7**	**73.5**	**71.0**	**70.2**	**60.0**	**62.5**
		>50K	**51.4**	**57.1**	**76.4**	**72.5**	**62.5**	**50.0**
	College or Prof. Degree	<$9,999	**50.0**	**50.0**	**80.0**	**66.7**	**100**	-
		$10K-$24,999	**57.1**	**70.0**	**63.6**	**25.0**	**50.0**	**50.0**
		$25K-$49,999	**55.3**	**64.7**	**75.0**	**78.9**	**87.5**	**87.5**
		>50K	**59.4**	**58.8**	**75.3**	**76.5**	**88.9**	**80.0**
Organisms can always obtain what they need to survive	< than High School	<$9,999	37.5	31.6	66.7	50.0	100	100
		$10K-$24,999	45.0	52.9	50.0	40.0	0.0	0.0
		$25K-$49,999	33.3	30.4	100	25.0	0.0	-
		>50K	0.0	33.3	12.5	11.1	0.0	0.0
	High School Diploma	<$9,999	35.3	33.3	50.0	0.0	25.0	25.0
		$10K-$24,999	50.0	42.2	36.4	27.3	50.0	57.1

Table 16. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Organisms can always obtain what they need to survive	High School Diploma	$25K-$49,999	32.8	51.6	14.3	23.5	16.7	22.2
		>50K	30.0	38.1	40.6	34.3	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	37.5	30.0	14.3	33.3	0.0	0.0
		$10K-$24,999	46.3	48.6	45.5	30.8	20.0	14.3
		$25K-$49,999	39.3	26.5	29.0	29.8	40.0	37.5
		>50K	48.6	42.9	23.5	27.5	37.5	50.0
	College or Prof. Degree	<$9,999	50.0	50.0	20.0	33.3	0.0	-
		$10K-$24,999	42.9	30.0	36.4	75.0	50.0	50.0
		$25K-$49,999	44.7	35.3	25.0	21.1	12.5	12.5
		>50K	40.6	41.2	24.7	23.5	11.1	20.0

Table 17. Absolute percentage of correct responses and misconceptions for the change in a population with certain traits concept by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations	< than High School	<$9,999	**25.0**	**26.3**	**0.0**	**0.0**	**0.0**	**100**
		$10K-$24,999	**10.0**	**15.7**	**0.0**	**20.0**	**0.0**	**25.0**
		$25K-$49,999	**22.2**	**13.0**	**0.0**	**50.0**	**0.0**	-
		>50K	**40.0**	**50.0**	**25.0**	**11.1**	**100**	**100**
	High School Diploma	<$9,999	**5.9**	**12.5**	**0.0**	**0.0**	**50.0**	**25.0**
		$10K-$24,999	**22.5**	**11.1**	**0.0**	**0.0**	**25.0**	**14.3**
		$25K-$49,999	**6.6**	**8.1**	**5.7**	**3.9**	**16.7**	**11.1**
		>50K	**10.0**	**23.8**	**15.6**	**8.6**	**0.0**	**20.0**
	Some College/Technical School, but no degree	<$9,999	**25.0**	**30.0**	**0.0**	**33.3**	**0.0**	**0.0**
		$10K-$24,999	**14.8**	**21.6**	**9.1**	**7.7**	**10.0**	**0.0**
		$25K-$49,999	**9.8**	**10.2**	**11.6**	**14.9**	**20.0**	**25.0**
		>50K	**28.6**	**19.0**	**14.7**	**15.7**	**12.5**	**0.0**
	College or Prof. Degree	<$9,999	**0.0**	**0.0**	**20.0**	**0.0**	**0.0**	-
		$10K-$24,999	**35.7**	**40.0**	**9.1**	**0.0**	**25.0**	**50.0**
		$25K-$49,999	**15.8**	**14.7**	**11.1**	**7.9**	**25.0**	**25.0**
		>50K	**12.5**	**14.7**	**11.0**	**15.3**	**0.0**	**10.0**
Changes in a population occur through a gradual change in all members of a population	< than High School	<$9,999	16.7	26.3	100	50.0	0.0	0.0
		$10K-$24,999	27.5	31.4	0.0	0.0	50.0	25.0
		$25K-$49,999	44.4	39.1	0.0	25.0	0.0	-
		>50K	0.0	0.0	25.0	33.3	-	-

Table 17. Continued.

Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Changes in a population occur through a gradual change in all members of a population	High School Diploma	<$9,999	35.3	33.3	0.0	40.0	25.0	25.0
		$10K-$24,999	25.0	26.7	9.1	18.2	50.0	42.9
		$25K-$49,999	32.8	29.0	28.6	19.6	16.7	33.3
		>50K	50.0	28.6	21.9	22.9	-	-
	Some College/Technical School, but no degree	<$9,999	25.0	10.0	28.6	33.3	0.0	33.3
		$10K-$24,999	22.2	16.2	9.1	7.7	20.0	14.3
		$25K-$49,999	21.3	26.5	17.4	17.0	30.0	12.5
		>50K	25.7	19.0	17.6	23.5	-	-
	College or Prof. Degree	<$9,999	50.0	25.0	20.0	0.0	100	-
		$10K-$24,999	7.1	0.0	9.1	0.0	0.0	0.0
		$25K-$49,999	31.6	26.5	13.9	18.4	12.5	0.0
		>50K	15.6	26.5	20.5	15.3	-	-
Learned behaviors are inherited	< than High School	<$9,999	20.8	15.8	0.0	33.3	100	0.0
		$10K-$24,999	15.0	15.7	75.5	20.0	0.0	25.0
		$25K-$49,999	11.1	13.0	0.0	0.0	0.0	-
		>50K	60.0	16.7	12.5	11.1	0.0	0.0
	High School Diploma	<$9,999	23.5	20.8	100	20.0	0.0	25.0
		$10K-$24,999	10.0	17.8	27.3	9.1	25.0	42.9
		$25K-$49,999	16.4	24.2	20.0	29.4	0.0	11.1
		>50K	20.0	19.0	21.9	25.7	0.0	20.0
	Some College/Technical School, but no degree	<$9,999	18.8	30.0	14.3	0.0	50.0	33.3
		$10K-$24,999	22.2	8.1	18.2	38.5	50.0	42.9
		$25K-$49,999	21.3	16.3	27.5	19.1	20.0	0.0
		>50K	17.1	28.6	20.6	17.6	25.0	25.0
	College or Prof. Degree	<$9,999	25.0	25.0	20.0	33.3	0.0	-
		$10K-$24,999	14.3	40.0	9.1	25.0	50.0	50.0

Table 17. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Learned behaviors are inherited	College or Prof. Degree	$25K-$49,999	13.2	5.9	19.4	23.7	25.0	37.5
		>50K	34.4	32.4	23.3	22.4	44.4	40.0
Mutations occur to meet the needs of the population	< than High School	<$9,999	37.5	31.6	0.0	16.7	0.0	0.0
		$10K-$24,999	47.5	37.3	25.0	60.0	50.0	25.0
		$25K-$49,999	22.2	34.8	100	25.0	100	-
		>50K	0.0	33.3	37.5	44.4	0.0	0.0
	High School Diploma	<$9,999	35.3	33.3	0.0	40.0	25.0	25.0
		$10K-$24,999	42.5	44.4	63.6	72.7	0.0	0.0
		$25K-$49,999	44.3	38.7	45.7	47.1	66.7	44.4
		>50K	20.0	28.6	40.6	42.9	100	60.0
	Some College/Technical School, but no degree	<$9,999	31.3	30.0	57.1	33.3	50.0	33.3
		$10K-$24,999	40.7	54.1	63.6	46.2	20.0	42.9
		$25K-$49,999	47.5	46.9	43.5	48.9	30.0	62.5
		>50K	28.6	33.3	47.1	43.1	62.5	75.0
	College or Prof. Degree	<$9,999	25.0	50.0	40.0	66.7	0.0	-
		$10K-$24,999	42.9	20.0	72.7	75.0	25.0	0.0
		$25K-$49,999	39.5	52.9	55.6	50.0	37.5	37.5
		>50K	37.5	26.5	45.2	47.1	55.6	50.0

Table 18. Absolute percentage of correct responses and misconceptions for the great reproductive potential concept by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction surviving each generation	< than High School	<$9,999	**54.2**	**52.6**	**100**	**83.3**	**100**	**0.0**
		$10K-$24,999	**35.0**	**39.2**	**25.0**	**20.0**	**100**	**50.0**
		$25K-$49,999	**55.6**	**62.2**	**100**	**50.0**	**100**	-
		>50K	**60.0**	**33.3**	**62.5**	**66.7**	**100**	**100**
	High School Diploma	<$9,999	**76.5**	**62.5**	**50.0**	**100**	**25.0**	**50.0**
		$10K-$24,999	**52.5**	**51.1**	**90.9**	**81.8**	**75.0**	**28.6**
		$25K-$49,999	**63.9**	**62.9**	**74.3**	**70.6**	**66.7**	**55.6**
		>50K	**60.0**	**42.9**	**50.0**	**65.7**	**50.0**	**60.0**
	Some College/ Technical School, but no degree	<$9,999	**43.8**	**60.0**	**71.4**	**33.3**	**100**	**66.7**
		$10K-$24,999	**51.9**	**48.6**	**72.7**	**100**	**30.0**	**71.4**
		$25K-$49,999	**55.7**	**55.1**	**65.2**	**66.0**	**60.0**	**75.0**
		>50K	**45.7**	**55.0**	**68.7**	**62.0**	**50.0**	**25.0**
	College or Prof. Degree	<$9,999	**25.0**	**50.0**	**80.0**	**66.7**	**0.0**	-
		$10K-$24,999	**50.0**	**60.0**	**81.8**	**62.5**	**50.0**	**50.0**
		$25K-$49,999	**57.9**	**52.9**	**69.4**	**71.1**	**37.5**	**50.0**
		>50K	**58.1**	**61.8**	**68.5**	**67.1**	**33.3**	**50.0**
Organisms work together (cooperate) and do not compete	< than High School	<$9,999	29.2	31.6	0.0	0.0	0.0	100
		$10K-$24,999	47.5	45.1	25.0	40.0	0.0	50.0
		$25K-$49,999	44.4	30.4	0.0	50.0	0.0	-
		>50K	40.0	66.7	37.5	33.3	0.0	0.0
	High School Diploma	<$9,999	23.5	33.3	0.0	0.0	50.0	25.0
		$10K-$24,999	42.5	46.7	0.0	9.1	25.0	71.4
		$25K-$49,999	31.1	37.1	25.7	21.6	16.7	33.3
		>50K	20.0	42.9	40.6	28.6	50.0	20.0

Table 18. Continued.

Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Organisms work together (cooperate) and do not compete	Some College/ Technical School, but no degree	<$9,999	43.8	30.0	28.6	66.7	0.0	33.0
		$10K-$24,999	42.6	43.2	18.2	0.0	70.0	28.6
		$25K-$49,999	36.1	32.7	24.6	27.7	30.0	12.5
		>50K	42.9	35.0	23.9	32.0	37.5	50.0
	College or Prof. Degree	<$9,999	50.0	25.0	20.0	33.3	100	-
		$10K-$24,999	42.9	40.0	18.2	25.0	50.0	50.0
		$25K-$49,999	34.2	35.3	19.4	18.4	50.0	37.5
		>50K	35.5	29.4	23.3	23.5	33.3	30.0
There is often physical fighting among one species (or among different species) and the strongest ones win	< than High School	<$9,999	16.7	15.8	0.0	16.7	0.0	0.0
		$10K-$24,999	17.5	15.7	50.0	40.0	-	-
		$25K-$49,999	0.0	4.3	0.0	0.0	0.0	-
		>50K	0.0	0.0	0.0	0.0	0.0	0.0
	High School Diploma	<$9,999	0.0	4.2	50.0	0.0	25.0	25.0
		$10K-$24,999	5.0	2.2	9.1	9.1	-	-
		$25K-$49,999	4.9	0.0	0.0	7.8	16.7	11.1
		>50K	20.0	14.3	9.4	5.7	0.0	20.0
	Some College/ Technical School, but no degree	<$9,999	12.5	10.0	0.0	0.0	0.0	0.0
		$10K-$24,999	5.6	8.1	9.1	0.0	-	-
		$25K-$49,999	8.2	12.2	10.1	6.4	10.0	12.5
		>50K	11.4	10.0	7.5	6.0	12.5	25.0
	College or Prof. Degree	<$9,999	25.0	25.0	0.0	0.0	0.0	-
		$10K-$24,999	7.1	0.0	0.0	12.5	-	-
		$25K-$49,999	7.9	11.8	11.1	10.5	12.5	12.5
		>50K	6.5	8.8	8.2	9.4	33.3	20.0

Table 19. Absolute percentage of correct responses and misconceptions for the causes of phenotypic variation by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Random mutations and sexual reproduction produce variations; while many are harmful or of no consequence, a few are beneficial in some environments	< than High School	<$9,999	4.2	5.3	33.3	16.7	-	-
		$10K-$24,999	5.0	5.9	0.0	0.0	0.0	0.0
		$25K-$49,999	0.0	0.0	0.0	0.0	0.0	-
		>50K	0.0	16.7	0.0	11.1	50.0	0.0
	High School Diploma	<$9,999	5.9	4.2	0.0	0.0	-	-
		$10K-$24,999	10.0	4.4	0.0	0.0	25.0	28.6
		$25K-$49,999	4.9	11.3	17.1	23.5	16.7	-
		>50K	10.0	9.5	9.4	2.9	50.0	40.0
	Some College/ Technical School, but no degree	<$9,999	0.0	0.0	0.0	0.0	-	-
		$10K-$24,999	9.3	10.8	9.1	7.7	0.0	14.3
		$25K-$49,999	11.5	6.1	17.4	14.9	0.0	-
		>50K	8.6	4.8	14.7	19.6	0.0	0.0
	College or Prof. Degree	<$9,999	0.0	0.0	0.0	0.0	-	-
		$10K-$24,999	7.1	20.0	9.1	12.5	50.0	0.0
		$25K-$49,999	5.3	5.9	8.3	5.3	0.0	-
		>50K	3.1	2.9	19.2	17.6	11.1	10.0
Individuals of a population vary extensively in their characteristics	< than High School	<$9,999	54.2	42.1	66.7	50.0	0.0	0.0
		$10K-$24,999	57.5	49.0	25.0	20.0	0.0	50.0
		$25K-$49,999	66.7	39.1	100	0.0	0.0	-
		>50K	40.0	33.3	50.0	55.6	0.0	0.0

Table 19. Continued.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Individuals of a population vary extensively in their characteristics	High School Diploma	<$9,999	**41.2**	**50.0**	**50.0**	**40.0**	**75.0**	**75.0**
		$10K-$24,999	**45.0**	**40.0**	**63.6**	**72.7**	**0.0**	**14.3**
		$25K-$49,999	**44.3**	**46.8**	**45.7**	**47.1**	**50.0**	**44.4**
		>50K	**50.0**	**38.1**	**43.8**	**54.3**	**50.0**	**60.0**
	Some College/ Technical School, but no degree	<$9,999	**31.1**	**40.0**	**14.3**	**33.3**	**0.0**	**33.3**
		$10K-$24,999	**37.0**	**43.2**	**27.3**	**30.8**	**60.0**	**57.1**
		$25K-$49,999	**55.7**	**46.9**	**46.4**	**44.7**	**50.0**	**62.5**
		>50K	**54.3**	**57.1**	**54.4**	**56.9**	**50.0**	**25.0**
	College or Prof. Degree	<$9,999	**50.0**	**25.0**	**60.0**	**33.3**	**100**	-
		$10K-$24,999	**35.7**	**50.0**	**72.7**	**75.0**	**50.0**	**50.0**
		$25K-$49,999	**44.7**	**67.6**	**38.9**	**44.7**	**62.5**	**37.5**
		>50K	**43.8**	**52.9**	**47.8**	**43.5**	**44.4**	**50.0**
Mutations are intentional: an organism tries, needs, or wants to change genetically	< than High School	<$9,999	**70.8**	**73.7**	**66.7**	**83.3**	**100**	**100**
		$10K-$24,999	75.0	76.5	75.0	80.0	100	75.0
		$25K-$49,999	77.8	82.6	100	75.0	100	-
		>50K	80.0	66.7	75.0	77.8	50.0	100
	High School Diploma	<$9,999	64.7	70.8	100	100	75.0	75.0
		$10K-$24,999	62.5	73.3	81.8	90.9	50.0	71.4
		$25K-$49,999	78.7	71.0	68.6	56.9	66.7	66.7
		>50K	60.0	66.7	71.9	82.9	50.0	60.0
	Some College/ Technical School, but no degree	<$9,999	68.8	60.0	100	66.7	100	66.7
		$10K-$24,999	72.2	56.8	72.7	84.6	90.0	71.4
		$25K-$49,999	72.1	79.6	68.1	78.7	90.0	87.5
		>50K	65.7	71.4	75.0	66.7	62.5	100

Table 19. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Mutations are intentional: an organism tries, needs, or wants to change genetically	College or Prof. Degree	<$9,999	100	75.0	80.0	100	0.0	-
		$10K-$24,999	71.4	70.0	90.9	62.5	50.0	100
		$25K-$49,999	76.3	73.5	75.0	76.3	62.5	87.5
		>50K	81.3	76.5	67.1	68.2	66.7	50.0
Mutations are adaptive responses to specific environmental agents	< than High School	<$9,999	25.0	21.1	0.0	0.0	0.0	0.0
		$10K-$24,999	20.0	17.6	25.0	20.0	0.0	25.0
		$25K-$49,999	22.2	17.4	0.0	25.0	0.0	-
		>50K	20.6	16.7	25.0	11.1	0.0	0.0
	High School Diploma	<$9,999	29.4	25.0	0.0	0.0	25.0	25.0
		$10K-$24,999	27.5	22.2	18.2	9.1	25.0	0.0
		$25K-$49,999	16.4	17.7	14.3	19.6	16.7	33.3
		>50K	30.0	23.8	18.8	14.3	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	31.3	40.0	0.0	33.3	0.0	33.3
		$10K-$24,999	18.5	32.4	18.2	7.7	10.0	14.3
		$25K-$49,999	15.6	14.3	14.5	6.4	10.0	12.5
		>50K	25.7	23.8	10.3	13.7	37.5	0.0
	College or Prof. Degree	<$9,999	0.0	25.0	20.0	0.0	100	-
		$10K-$24,999	21.4	10.0	0.0	25.0	0.0	0.0
		$25K-$49,999	18.4	20.6	16.7	18.4	37.5	12.5
		>50K	16.5	20.6	13.7	14.1	22.2	40.0
All members of a population are nearly identical	< than High School	<$9,999	8.3	15.8	0.0	16.7	-	-
		$10K-$24,999	12.5	15.7	25.0	60.0	50.0	0.0
		$25K-$49,999	22.2	8.7	0.0	25.0	0.0	-
		>50K	0.0	0.0	0.0	11.1	0.0	0.0

Table 19. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
All members of a population are nearly identical	High School Diploma	<$9,999	11.8	8.3	0.0	0.0	-	-
		$10K-$24,999	12.5	15.6	9.1	0.0	0.0	14.3
		$25K-$49,999	16.4	12.9	14.3	5.9	16.7	22.2
		>50K	0.0	4.8	12.5	5.7	50.0	0.0
	Some College/ Technical School, but no degree	<$9,999	25.0	30.0	28.6	0.0	-	-
		$10K-$24,999	22.2	27.0	9.1	0.0	10.0	14.3
		$25K-$49,999	6.6	12.2	7.2	12.8	10.0	0.0
		>50K	8.6	4.8	7.4	9.8	0.0	25.0
	College or Prof. Degree	<$9,999	0.0	0.0	0.0	33.3	-	-
		$10K-$24,999	28.6	10.0	0.0	0.0	0.0	0.0
		$25K-$49,999	7.9	8.8	5.6	5.3	12.5	12.5
		>50K	9.4	11.8	9.6	9.4	0.0	0.0
Variations only affect outward appearance; do not influence survival	< than High School	<$9,999	37.5	42.1	33.3	33.3	100	100
		$10K-$24,999	30.0	35.3	50.0	20.0	50.0	50.0
		$25K-$49,999	11.1	52.2	0.0	75.0	100	-
		>50K	60.0	66.7	50.0	33.3	100	100
	High School Diploma	<$9,999	47.1	41.7	50.0	60.0	25.0	25.0
		$10K-$24,999	42.5	44.4	27.3	27.3	100	71.4
		$25K-$49,999	39.3	40.3	40.0	47.1	33.3	33.3
		>50K	50.0	57.1	43.8	40.0	0.0	40.0
	Some College/ Technical School, but no degree	<$9,999	43.8	30.0	57.1	66.7	100	66.7
		$10K-$24,999	40.7	29.7	63.6	69.2	30.0	28.6
		$25K-$49,999	37.7	40.8	46.4	42.6	40.0	37.5
		>50K	37.1	38.1	38.2	33.3	50.0	50.0

Table 19. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Variations only affect outward appearance; do not influence survival	College or Prof. Degree	<$9,999	50.0	75.0	40.0	33.3	0.0	-
		$10K-$24,999	35.7	40.0	27.3	25.0	50.0	50.0
		$25K-$49,999	47.4	23.5	55.6	50.0	25.0	50.0
		>50K	46.9	35.3	42.5	47.1	55.6	50.0

Table 20. Absolute percentage of correct responses and misconceptions for the heritability of phenotypic variation by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Much variation is heritable	< than High School	<$9,999	**41.7**	**36.8**	**66.7**	**50.0**	**0.0**	**0.0**
		$10K-$24,999	**40.0**	**43.1**	**75.0**	**40.0**	**50.0**	**100**
		$25K-$49,999	**22.2**	**43.5**	**100**	**75.0**	**0.0**	**-**
		>50K	**60.0**	**50.0**	**75.0**	**77.8**	**50.0**	**0.0**
	High School Diploma	<$9,999	**31.3**	**43.5**	**50.0**	**60.0**	**25.0**	**25.0**
		$10K-$24,999	**42.5**	**40.0**	**36.4**	**45.5**	**75.0**	**42.9**
		$25K-$49,999	**34.4**	**41.9**	**65.7**	**54.9**	**50.0**	**44.4**
		>50K	**55.6**	**38.1**	**53.1**	**54.3**	**50.0**	**100**
	Some College/ Technical School, but no degree	<$9,999	**37.5**	**30.0**	**71.4**	**66.7**	**50.0**	**33.3**
		$10K-$24,999	**38.9**	**35.1**	**27.3**	**46.2**	**60.0**	**57.1**
		$25K-$49,999	**49.2**	**36.7**	**58.0**	**638**	**50.0**	**62.5**
		>50K	**45.7**	**33.3**	**58.8**	**51.0**	**37.5**	**0.0**

Table 20. Continued

Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
<u>Much variation is heritable</u>	College or Prof. Degree	<$9,999	**<u>50.0</u>**	**<u>50.0</u>**	**<u>40.0</u>**	**<u>66.7</u>**	**<u>0.0</u>**	**-**
		$10K-$24,999	**<u>50.0</u>**	**<u>60.0</u>**	**<u>45.5</u>**	**<u>25.0</u>**	**<u>50.0</u>**	**<u>50.</u>**
		$25K-$49,999	**<u>31.6</u>**	**<u>29.4</u>**	**<u>58.3</u>**	**<u>60.5</u>**	**<u>37.5</u>**	**<u>25.0</u>**
		>50K	**<u>32.3</u>**	**<u>50.0</u>**	**<u>52.1</u>**	**<u>56.5</u>**	**<u>42.2</u>**	**<u>40.0</u>**
Traits acquired during an organism's lifetime will be inherited by offspring	< than High School	<$9,999	20.8	15.8	0.0	16.7	100	0.0
		$10K-$24,999	5.0	5.9	25.0	20.0	50.0	0.0
		$25K-$49,999	11.1	0.0	0.0	25.0	0.0	-
		>50K	0.0	0.0	12.5	0.0	0.0	0.0
	High School Diploma	<$9,999	25.0	21.7	50.0	20.0	25.0	50.0
		$10K-$24,999	10.0	15.6	9.1	9.1	0.0	14.3
		$25K-$49,999	13.1	14.5	14.3	11.8	16.7	11.1
		>50K	0.0	4.8	12.5	11.4	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	18.8	30.0	0.0	0.0	0.0	33.3
		$10K-$24,999	7.4	2.7	9.1	0.0	10.0	14.3
		$25K-$49,999	16.4	14.3	8.7	4.3	0.0	0.0
		>50K	5.7	4.8	7.4	5.9	0.0	0.0
	College or Prof. Degree	<$9,999	0.0	0.0	20.0	0.0	100	-
		$10K-$24,999	7.1	0.0	0.0	12.5	0.0	0.0
		$25K-$49,999	15.8	26.5	5.6	10.5	12.5	12.5
		>50K	6.5	6.3	13.7	15.3	11.1	10.0
When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	< than High School	<$9,999	12.5	15.8	33.3	16.7	-	-
		$10K-$24,999	17.5	15.7	0.0	20.0	0.0	0.0
		$25K-$49,999	11.1	21.7	0.0	0.0	50.0	-
		>50K	20.0	0.0	0.0	11.1	50.0	100
	High School Diploma	<$9,999	12.5	8.7	0.0	20.0	-	-
		$10K-$24,999	10.0	11.1	18.2	9.1	0.0	14.3

Table 20. Continued.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino Mom (n=550)	Latino Dad (n=539)	White Mom (n=436)	White Dad (n=424)	Other Mom (n=93)	Other Dad (n=91)
When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	High School Diploma	$25K-$49,999	23.0	16.1	2.9	11.8	16.7	11.1
		>50K	11.1	23.8	3.1	2.9	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	12.5	20.0	0.0	33.3	-	-
		$10K-$24,999	13.0	13.5	36.4	23.1	30.0	28.6
		$25K-$49,999	13.1	16.3	14.5	10.6	10.0	0.0
		>50K	22.9	33.3	11.8	17.6	25.0	50.0
	College or Prof. Degree	<$9,999	25.0	25.0	40.0	0.0	-	-
		$10K-$24,999	21.4	10.0	18.2	37.5	25.0	50.0
		$25K-$49,999	13.2	14.7	11.1	10.5	12.5	25.0
		>50K	16.1	9.4	11.0	7.1	22.2	20.0
Traits that are positively influenced by the environment will be inherited by offspring	< than High School	<$9,999	25.0	31.6	0.0	16.7	0.0	100
		$10K-$24,999	37.5	35.3	0.0	20.0	0.0	0.0
		$25K-$49,999	55.6	34.8	0.0	0.0	50.0	-
		>50K	20.0	50.0	12.5	11.1	0.0	0.0
	High School Diploma	<$9,999	31.3	26.1	0.0	0.0	50.0	25.0
		$10K-$24,999	37.5	33.3	36.4	36.4	25.0	28.6
		$25K-$49,999	29.5	27.4	17.1	21.6	16.7	33.3
		>50K	33.3	33.3	31.3	31.4	50.0	0.0
	Some College/ Technical School, but no degree	<$9,999	31.3	20.0	28.6	0.0	50.0	33.3
		$10K-$24,999	40.7	48.6	27.3	30.8	0.0	0.0
		$25K-$49,999	21.3	32.7	18.8	21.3	40.0	37.5
		>50K	25.7	28.6	22.1	25.5	37.5	50.0
	College or Prof. Degree	<$9,999	25.0	25.0	0.0	33.3	0.0	-
		$10K-$24,999	21.4	30.0	36.4	25.0	25.0	0.0
		$25K-$49,999	39.5	29.4	25.0	18.4	37.5	37.5
		>50K	45.2	34.4	23.3	21.2	22.2	30.0

Table 21. Absolute percentage of correct responses and misconceptions for the selective survival on heritability traits by students and parent educational and combined income. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions	Parent Education	Combined Income	Latino Mom (n=550)	Latino Dad (n=539)	White Mom (n=436)	White Dad (n=424)	Other Mom (n=93)	Other Dad (n=91)
Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals	< than High School	<$9,999	**33.3**	**26.3**	**66.7**	**50.0**	**0.0**	**0.0**
		$10K-$24,999	**35.0**	**45.1**	**25.0**	**0.0**	**100**	**50.0**
		$25K-$49,999	**33.3**	**43.5**	**0.0**	**50.0**	**50.0**	-
		>50K	**0.0**	**33.3**	**62.5**	**22.2**	**50.0**	**100**
	High School Diploma	<$9,999	**35.3**	**33.3**	**50.0**	**80.0**	**50.0**	**50.0**
		$10K-$24,999	**45.0**	**28.9**	**45.5**	**72.7**	**50.0**	**42.9**
		$25K-$49,999	**41.0**	**38.7**	**48.6**	**45.1**	**33.3**	**22.2**
		>50K	**30.0**	**38.1**	**34.4**	**34.3**	**0.0**	**40.0**
	Some College/ Technical School, but no degree	<$9,999	**31.3**	**40.0**	**42.9**	**66.7**	**50.0**	**66.7**
		$10K-$24,999	**42.6**	**56.8**	**81.8**	**38.5**	**30.0**	**42.9**
		$25K-$49,999	**34.4**	**44.9**	**50.7**	**57.4**	**30.0**	**37.5**
		>50K	**40.0**	**42.9**	**50.0**	**60.8**	**75.0**	**50.0**
	College or Prof. Degree	<$9,999	**25.0**	**50.0**	**80.0**	**33.3**	**100**	-
		$10K-$24,999	**50.0**	**40.0**	**27.3**	**62.5**	**50.0**	**50.0**
		$25K-$49,999	**52.6**	**35.3**	**50.0**	**47.4**	**50.0**	**50.0**
		>50K	**37.5**	**29.4**	**52.1**	**49.4**	**44.4**	**60.0**
Fitness is equated with strength, speed, intelligence or longevity	< than High School	<$9,999	66.7	68.4	33.3	33.3	100	100
		$10K-$24,999	55.0	49.0	75.0	80.0	0.0	50.0
		$25K-$49,999	66.7	52.2	100	0.0	50.0	-
		>50K	100	66.7	37.5	77.8	50.0	0.0
	High School Diploma	<$9,999	52.9	62.5	50.0	20.0	50.0	50.0
		$10K-$24,999	47.5	60.0	54.5	18.2	50.0	57.1
		$25K-$49,999	54.1	53.2	45.7	49.0	66.7	77.8
		>50K	70.0	47.6	62.5	65.7	100	60.0

Table 21. Continued.								
Evolutionary Theory Concepts and Misconceptions	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
Fitness is equated with strength, speed, intelligence or longevity	Some College/ Technical School, but no degree	<$9,999	68.8	60.0	42.9	33.3	50.0	33.3
		$10K-$24,999	50.0	37.8	0.0	61.5	70.0	57.1
		$25K-$49,999	55.7	46.9	44.9	40.4	70.0	62.5
		>50K	54.3	57.1	48.5	33.3	25.0	50.0
	College or Prof. Degree	<$9,999	75.0	50.0	20.0	66.7	0.0	-
		$10K-$24,999	42.9	40.0	72.7	37.5	50.0	50.0
		$25K-$49,999	39.5	58.8	44.4	50.0	37.5	37.5
		>50K	56.3	67.6	45.2	49.4	55.6	40.0
Organisms with many mates are biologically fit	< than High School	<$9,999	0.0	5.3	0.0	16.7	-	-
		$10K-$24,999	10.0	5.9	0.0	20.0	-	-
		$25K-$49,999	0.0	4.3	0.0	50.0	0.0-	-
		>50K	0.0	0.0	0.0	0.0	-	-
	High School Diploma	<$9,999	11.8	4.2	0.0	0.0	-	-
		$10K-$24,999	7.5	11.1	0.0	9.1	-	-
		$25K-$49,999	4.9	8.1	5.7	5.9	0.0	0.0
		>50K	0.0	14.3	3.1	0.0	-	-
	Some College/ Technical School, but no degree	<$9,999	0.0	0.0	14.3	0.0	-	-
		$10K-$24,999	7.4	5.4	18.2	0.0	-	-
		$25K-$49,999	9.8	8.2	4.3	2.1	0.0	0.0
		>50K	5.7	0.0	1.5	5.9	-	-
	College or Prof. Degree	<$9,999	0.0	0.0	0.0	0.0	-	-
		$10K-$24,999	7.1	20.0	0.0	0.0	-	-
		$25K-$49,999	7.9	5.9	5.6	2.6	12.5	12.5
		>50K	6.3	2.9	2.7	1.2	-	-

***Table 22.* Absolute percentage and total number of correct natural selection concepts.**								
Number of Correct Concepts	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
0	< than High School	<$9,999	4.2	-	-	-	-	-
		$10K-$24,999	0.0	0.0	-	-	-	-
		$25K-$49,999	0.0	0.0	-	-	-	-
		>50K	0.0	0.0	0.0	0.0	-	-
	High School Diploma	<$9,999	0.0	-	-	-	-	-
		$10K-$24,999	0.0	0.0	-	-	-	-
		$25K-$49,999	1.6	0.0	-	-	-	-
		>50K	0.0	0.0	3.1	0.0	-	-
	Some College/ Technical School, but no degree	<$9,999	0.0	-	-	-	-	-
		$10K-$24,999	1.9	2.7	-	-	-	-
		$25K-$49,999	3.3	4.1	-	-	-	-
		>50K	0.0	4.8	0.0	2.0	-	-
	College or Prof. Degree	<$9,999	0.0	-	-	-	-	-
		$10K-$24,999	0.0	0.0	-	-	-	-
		$25K-$49,999	0.0	2.9	-	-	-	-
		>50K	3.1	0.0	0.0	0.0	-	-
1	< than High School	<$9,999	20.8	21.1	0.0	16.7	-	-
		$10K-$24,999	32.5	27.5	25.0	40.0	0.0	0.0
		$25K-$49,999	11.1	8.7	0.0	0.0	0.0	-
		>50K	0.0	33.3	0.0	0.0	0.0	0.0
	High School Diploma	<$9,999	5.9	16.7	50.0	0.0	0.0	-
		$10K-$24,999	15.0	28.9	9.1	18.2	25.0	28.6
		$25K-$49,999	14.8	17.7	2.9	5.9	0.0	22.2
		>50K	20.0	33.3	15.6	11.4	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	18.8	10.0	0.0	0.0	0.0	-
		$10K-$24,999	24.1	16.2	27.3	0.0	10.0	0.0
		$25K-$49,999	18.0	16.3	7.2	6.4	30.0	12.5
		>50K	28.6	23.8	5.9	3.9	25.0	50.0
	College or Prof. Degree	<$9,999	50.0	25.0	0.0	0.0	-	-
		$10K-$24,999	7.1	0.0	18.2	37.5	25.0	50.0
		$25K-$49,999	21.1	23.5	5.6	5.3	0.0	0.0
		>50K	18.8	11.8	11.0	12.9	22.5	20.0

Table 22. Continued.								
Number of Correct Concepts	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
2	< than High School	<$9,999	12.5	21.1	0.0	16.7	100	100
		$10K-$24,999	22.5	27.5	25.0	20.0	0.0	0.0
		$25K-$49,999	11.1	13.0	100	25.0	0.0	-
		>50K	0.0	0.0	0.0	11.1	0.0	0.0
	High School Diploma	<$9,999	23.5	16.7	0.0	0.0	50.0	50.0
		$10K-$24,999	25.0	20.0	9.1	0.0	25.0	42.9
		$25K-$49,999	21.3	29.0	11.4	19.6	16.7	11.1
		>50K	30.0	19.0	25.0	22.9	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	31.3	20.0	28.6	0.0	50.0	33.3
		$10K-$24,999	25.9	24.3	0.0	15.4	20.0	14.3
		$25K-$49,999	23.0	14.3	20.3	19.1	10.0	25.0
		>50K	17.1	9.5	17.6	21.6	25.0	25.0
	College or Prof. Degree	<$9,999	25.0	25.0	0.0	0.0	0.0	-
		$10K-$24,999	35.7	40.0	27.3	25.0	25.0	0.0
		$25K-$49,999	23.7	26.5	19.4	15.8	25.0	12.5
		>50K	15.6	23.5	15.1	12.9	11.1	10.0
3	< than High School	<$9,999	25.0	31.6	33.3	16.7	0.0	0.0
		$10K-$24,999	27.5	27.5	25.0	40.0	0.0	25.0
		$25K-$49,999	55.6	43.5	0.0	25.0	50.0	-
		>50K	60.0	16.7	62.5	66.7	50.0	0.0
	High School Diploma	<$9,999	58.8	45.8	0.0	0.0	25.0	25.0
		$10K-$24,999	30.0	26.7	36.4	18.2	0.0	14.3
		$25K-$49,999	34.4	29.0	28.6	37.3	33.3	44.4
		>50K	0.0	14.3	21.9	22.9	0.0	0.0
	Some College/ Technical School, but no degree	<$9,999	18.8	20.0	0.0	33.3	0.0	33.3
		$10K-$24,999	25.9	27.0	18.2	23.1	40.0	28.6
		$25K-$49,999	26.2	32.7	29.0	14.9	30.0	25.0
		>50K	17.1	28.6	25.0	19.6	12.5	25.0
	College or Prof. Degree	<$9,999	0.0	0.0	20.0	0.0	100	-
		$10K-$24,999	14.3	10.0	18.2	25.0	0.0	0.0
		$25K-$49,999	21.1	17.6	27.8	34.2	50.0	50.0
		>50K	34.4	29.4	26.0	27.1	44.4	50.0

Table 22. Continued.								
Number of Correct Concepts	**Parent Education**	**Combined Income**	**Latino**		**White**		**Other**	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
4	< than High School	<$9,999	8.3	0.0	33.3	33.3	-	-
		$10K-$24,999	7.5	7.8	25.0	0.0	100	50.0
		$25K-$49,999	11.1	17.4	0.0	0.0	50.0	-
		>50K	0.0	33.3	0.0	0.0	50.0	100
	High School Diploma	<$9,999	5.9	8.3	50.0	40.0	-	-
		$10K-$24,999	10.0	13.3	18.2	27.3	25.0	14.3
		$25K-$49,999	8.2	11.3	17.1	7.8	50.0	22.2
		>50K	10.0	9.5	6.3	11.4	50.0	40.0
	Some College/ Technical School, but no degree	<$9,999	18.8	30.0	57.1	33.3	-	-
		$10K-$24,999	9.3	8.1	36.4	38.5	10.0	14.3
		$25K-$49,999	9.8	12.2	10.1	14.9	20.0	25.0
		>50K	14.3	14.3	16.2	13.7	0.0	0.0
	College or Prof. Degree	<$9,999	0.0	25.0	20.0	66.7	-	-
		$10K-$24,999	14.3	0.0	9.1	0.0	0.0	0.0
		$25K-$49,999	13.2	0.0	11.1	15.8	12.5	25.0
		>50K	9.4	5.9	13.7	14.1	22.2	10.0
5	< than High School	<$9,999	20.8	15.8	33.3	16.7	0.0	0.0
		$10K-$24,999	25.0	5.9	0.0	0.0	0.0	25.0
		$25K-$49,999	11.1	13.0	0.0	50.0	0.0	-
		>50K	40.0	0.0	12.5	11.1	50.0	0.0
	High School Diploma	<$9,999	5.9	12.5	0.0	60.0	0.0	0.0
		$10K-$24,999	17.5	8.9	27.3	27.3	25.0	0.0
		$25K-$49,999	18.0	9.7	31.4	19.6	0.0	0.0
		>50K	30.0	19.0	21.9	20.0	0.0	40.0
	Some College/ Technical School, but no degree	<$9,999	12.5	20.0	5.9	33.3	50.0	33.3
		$10K-$24,999	9.3	16.2	18.2	23.1	20.0	28.6
		$25K-$49,999	11.5	16.3	15.9	27.7	10.0	0.0
		>50K	14.3	4.8	17.6	23.5	12.5	0.0
	College or Prof. Degree	<$9,999	25.0	25.0	60.0	0.0	0.0	-
		$10K-$24,999	21.4	30.0	18.2	12.5	25.0	50.0
		$25K-$49,999	17.4	23.5	30.6	18.4	0.0	12.5
		>50K	12.5	26.5	17.6	14.1	0.0	0.0

Table 22. Continued.

Number of Correct Concepts	Parent Education	Combined Income	Latino		White		Other	
			Mom (n=550)	Dad (n=539)	Mom (n=436)	Dad (n=424)	Mom (n=93)	Dad (n=91)
6	< than High School	<$9,999	8.3	10.5	-	-	0.0	0.0
		$10K-$24,999	7.5	3.9	0.0	0.0	0.0	0.0
		$25K-$49,999	0.0	4.3	0.0	0.0	0.0	-
		>50K	0.0	16.7	12.5	11.1	0.0	0.0
	High School Diploma	<$9,999	0.0	0.0	-	-	25.0	25.0
		$10K-$24,999	2.5	2.2	0.0	9.1	0.0	0.0
		$25K-$49,999	1.6	3.2	8.6	9.8	0.0	0.0
		>50K	10.0	4.8	3.1	11.4	0.0	20.0
	Some College/ Technical School, but no degree	<$9,999	0.0	0.0	-	-	0.0	0.0
		$10K-$24,999	3.7	5.4	0.0	0.0	0.0	14.3
		$25K-$49,999	8.2	4.1	15.9	17.0	0.0	12.5
		>50K	8.6	14.3	14.7	11.8	25.0	0.0
	College or Prof. Degree	<$9,999	0.0	0.0	-	-	0.0	-
		$10K-$24,999	7.1	20.0	9.1	0.0	25.0	0.0
		$25K-$49,999	2.6	5.9	5.6	7.9	12.5	0.0
		>50K	6.3	2.9	13.7	12.9	0.0	10.0
7	< than High School	<$9,999	-	-	-	-	-	-
		$10K-$24,999	-	-	-	-	-	-
		$25K-$49,999	-	-	0.0	0.0	-	-
		>50K	-	-	12.5	0.0	-	-
	High School Diploma	<$9,999	-	-	-	-	-	-
		$10K-$24,999	-	-	-	-	-	-
		$25K-$49,999	-	-	0.0	0.0	-	-
		>50K	-	-	3.1	0.0	-	-
	Some College/ Technical School, but no degree	<$9,999	-	-	-	-	-	-
		$10K-$24,999	-	-	-	-	-	-
		$25K-$49,999	-	-	1.4	0.0	-	-
		>50K	-	-	2.9	3.9	-	-
	College or Prof. Degree	<$9,999	-	-	-	-	-	-
		$10K-$24,999	-	-	-	-	-	-
		$25K-$49,999	-	-	0.0	2.6	-	-
		>50K	-	-	4.1	5.9	-	-

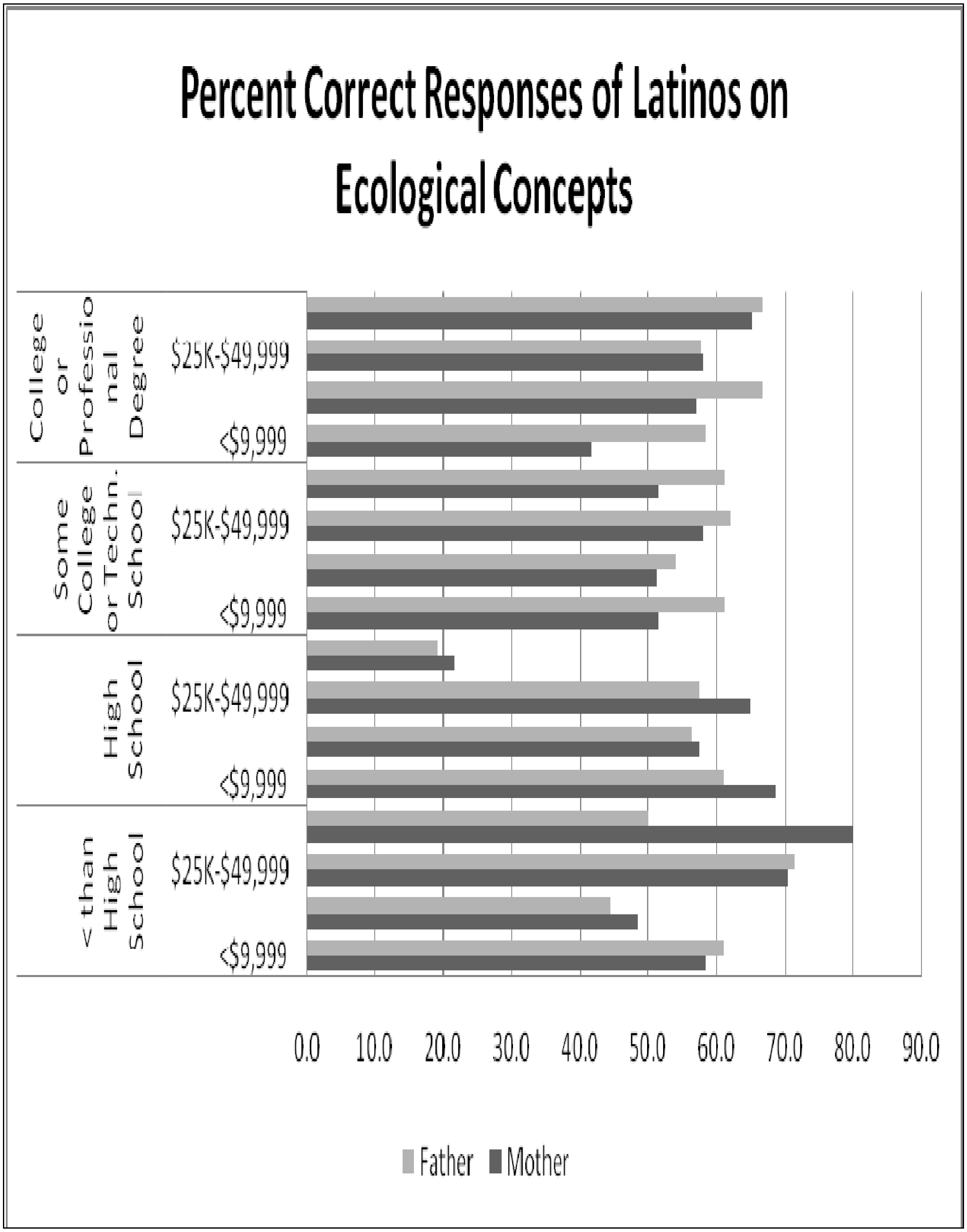

Figure 28. *Absolute percentage of Latinos on ecological concepts by parents' education and combined income.*

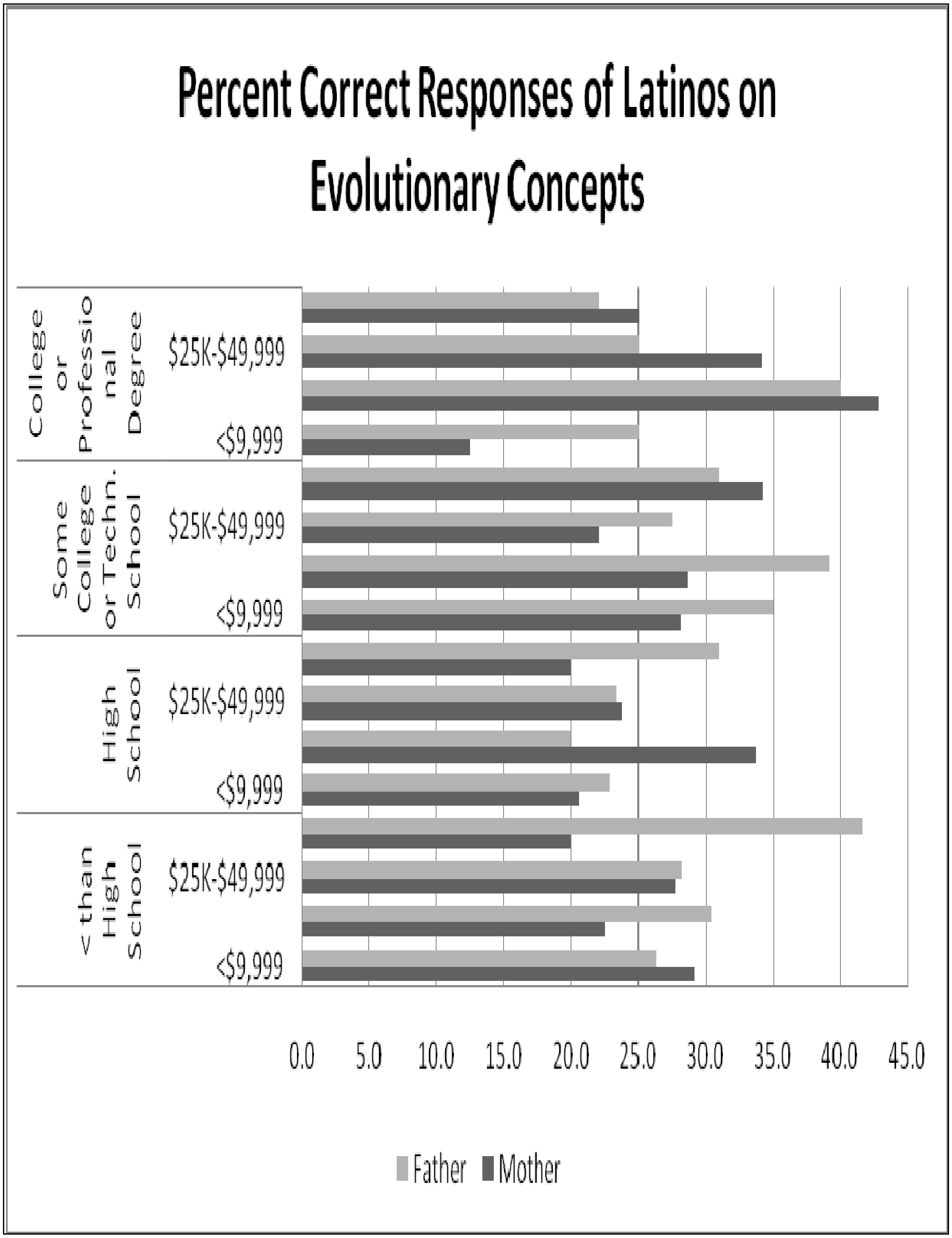

Figure 29. *Absolute percentage of Latinos on evolutionary concepts by parents' education and combined income.*

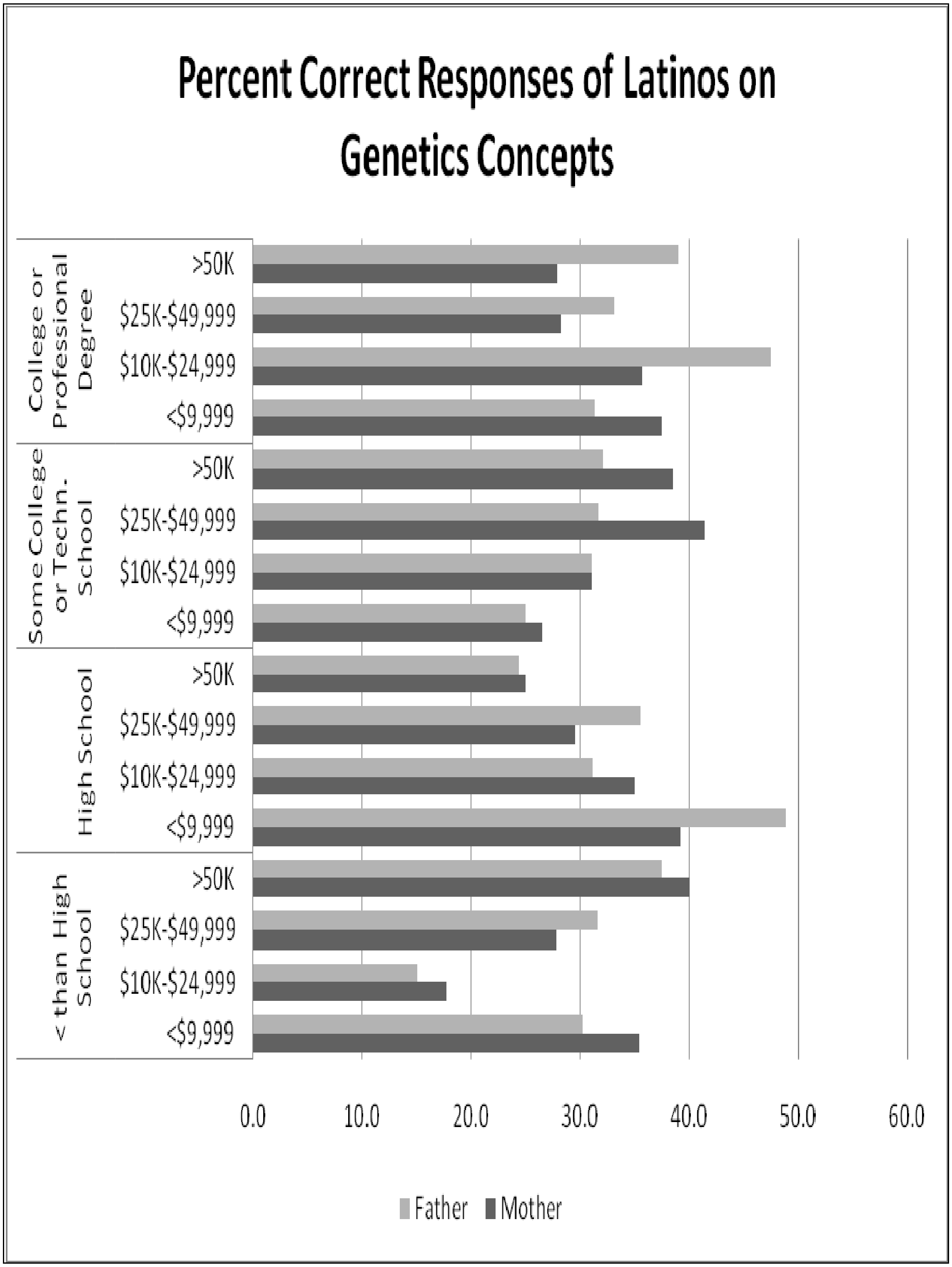

Figure 30. *Absolute percentage of Latinos on genetics concepts by parents' education and combined income.*

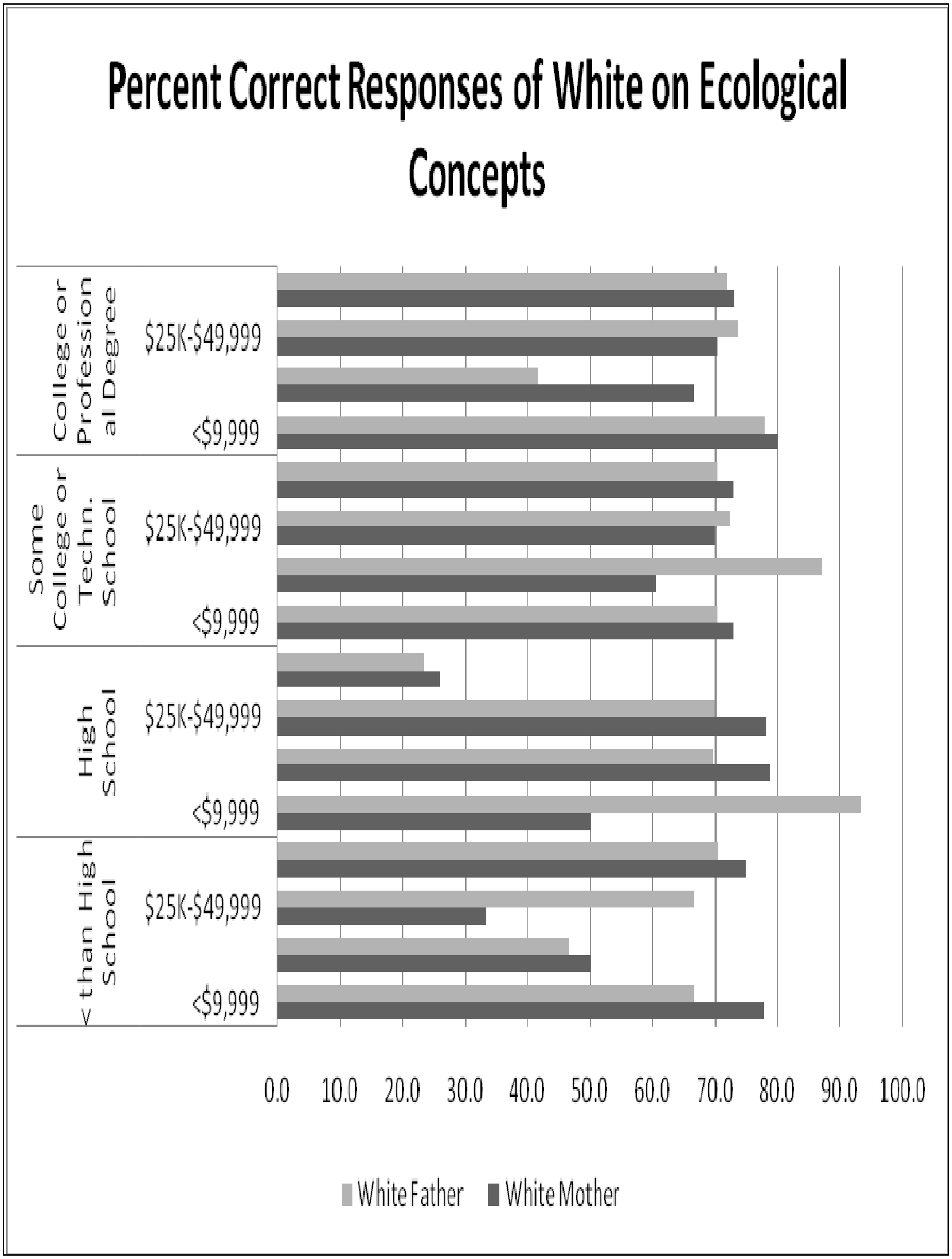

Figure 31. *Absolute percentage of Whites on ecological concepts by parents' education and combined income.*

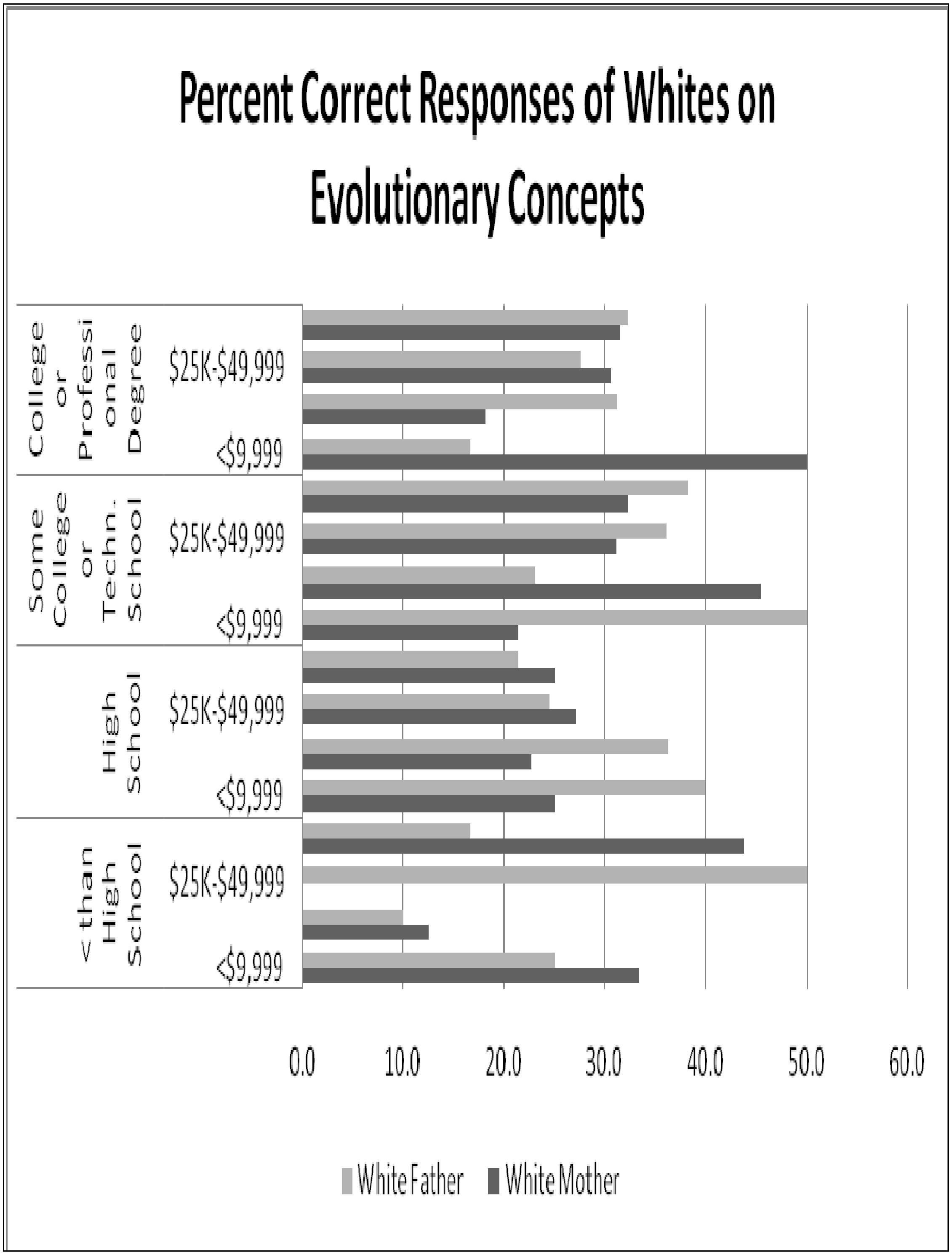

Figure 32. Absolute percent of Whites on evolutionary concepts by parents' education and combined income.

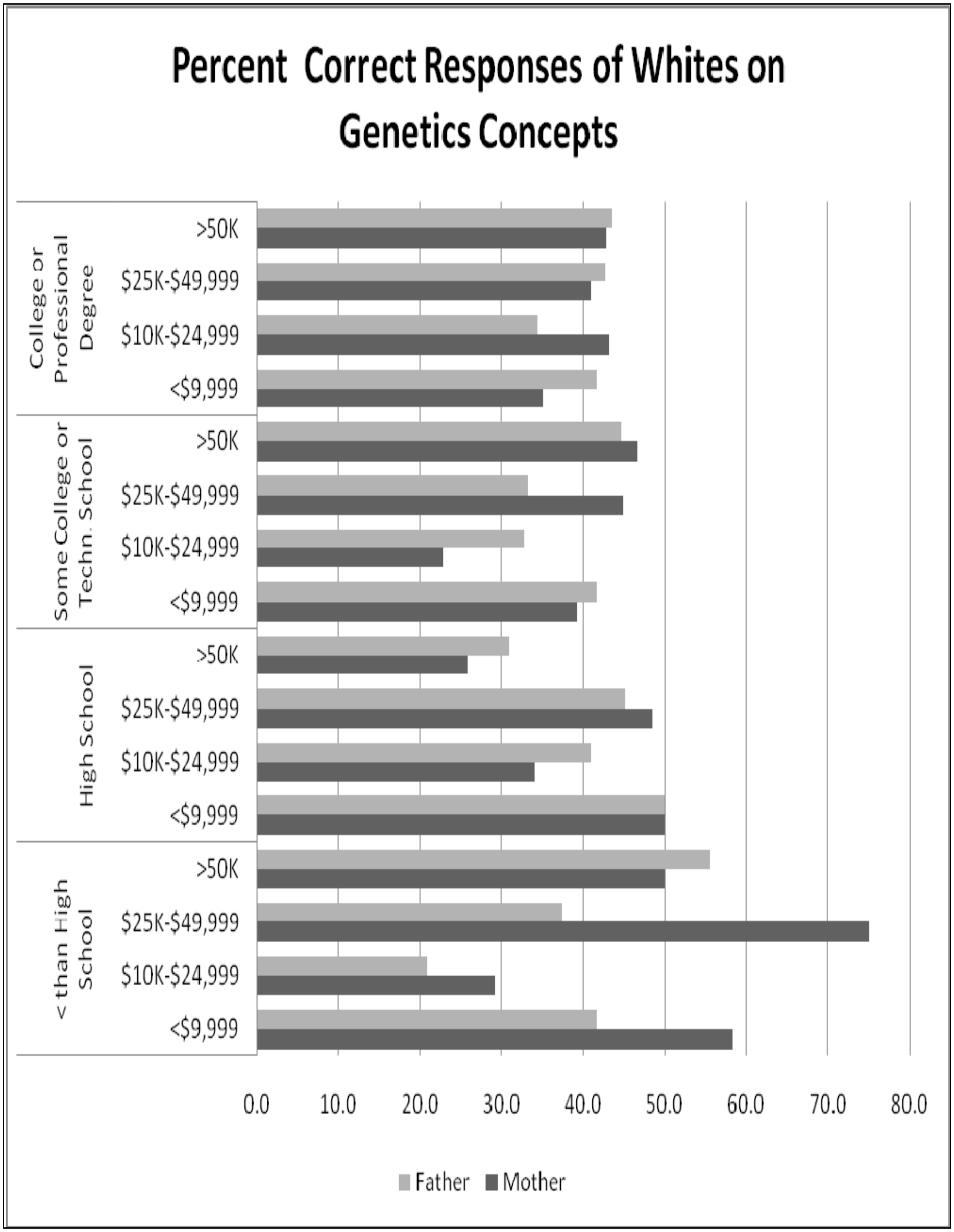

Figure 33. Absolute percentage of Whites on genetics concepts by parents' education and combined income.

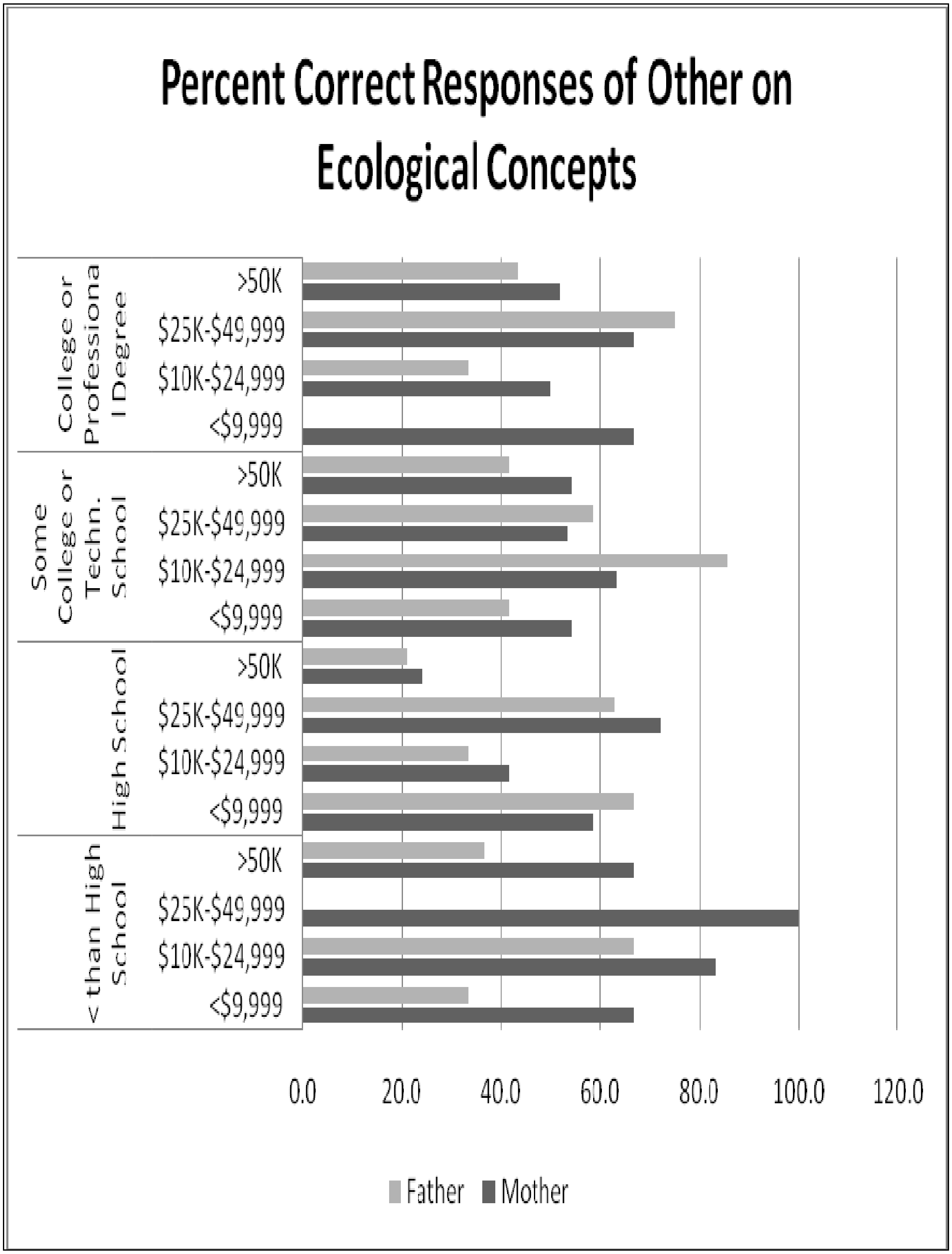

Figure 34. *Absolute percentage of other on ecological concepts by parents' education and combined income.*

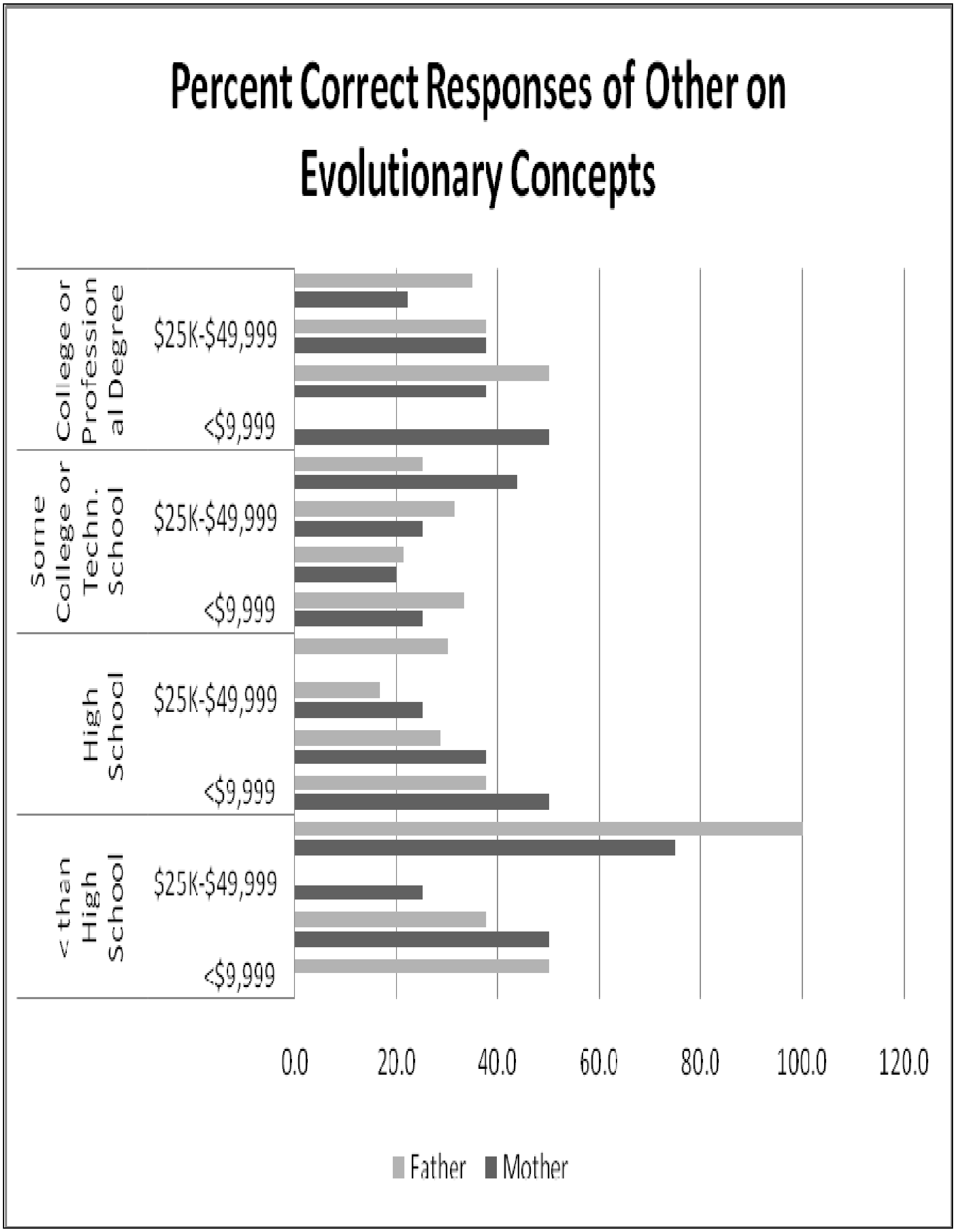

Figure 35. *Absolute percentage of other on evolutionary concepts by parents' education and combined income.*

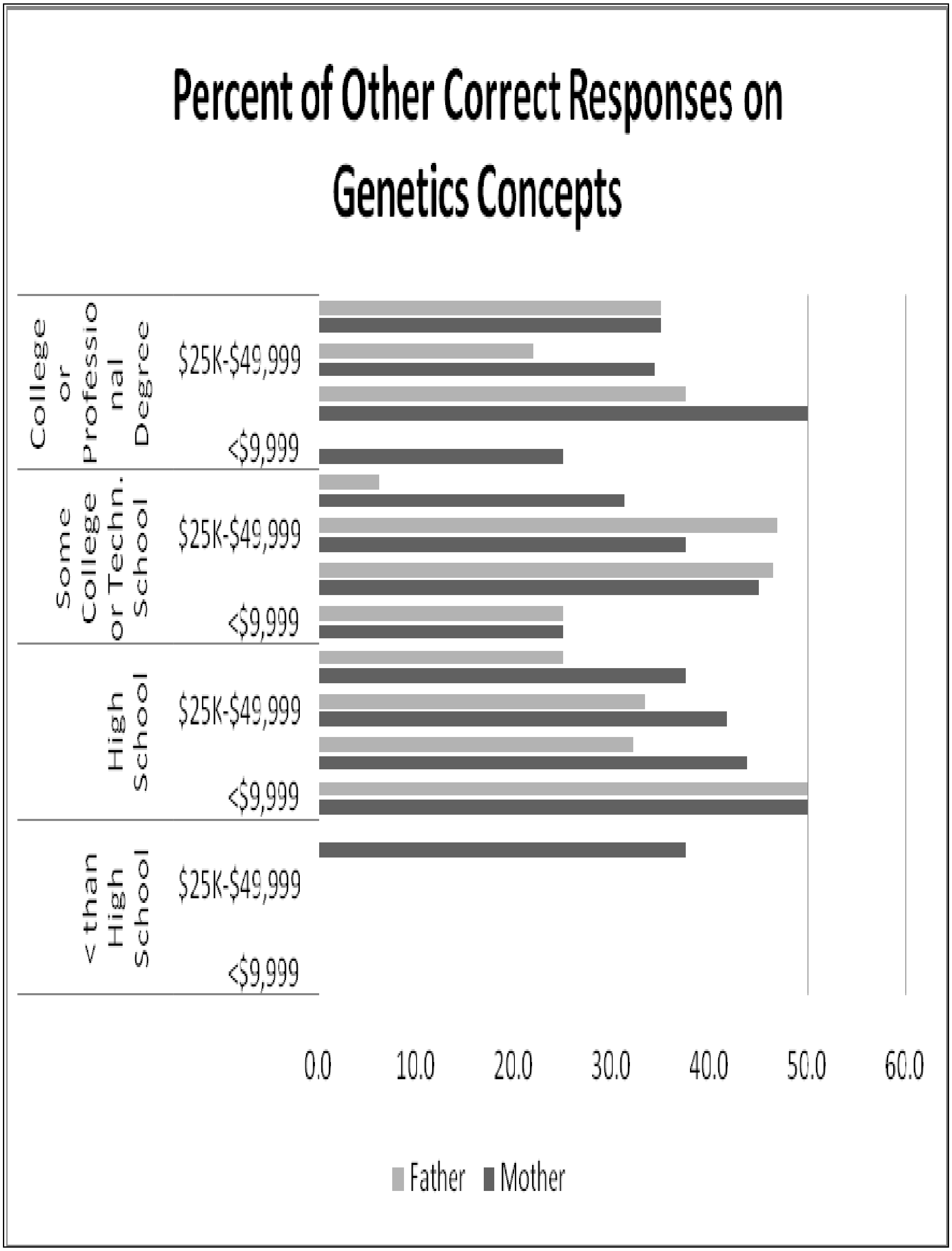

Figure 36. *Absolute percentage of other on genetics concepts by parents' education and combined income.*

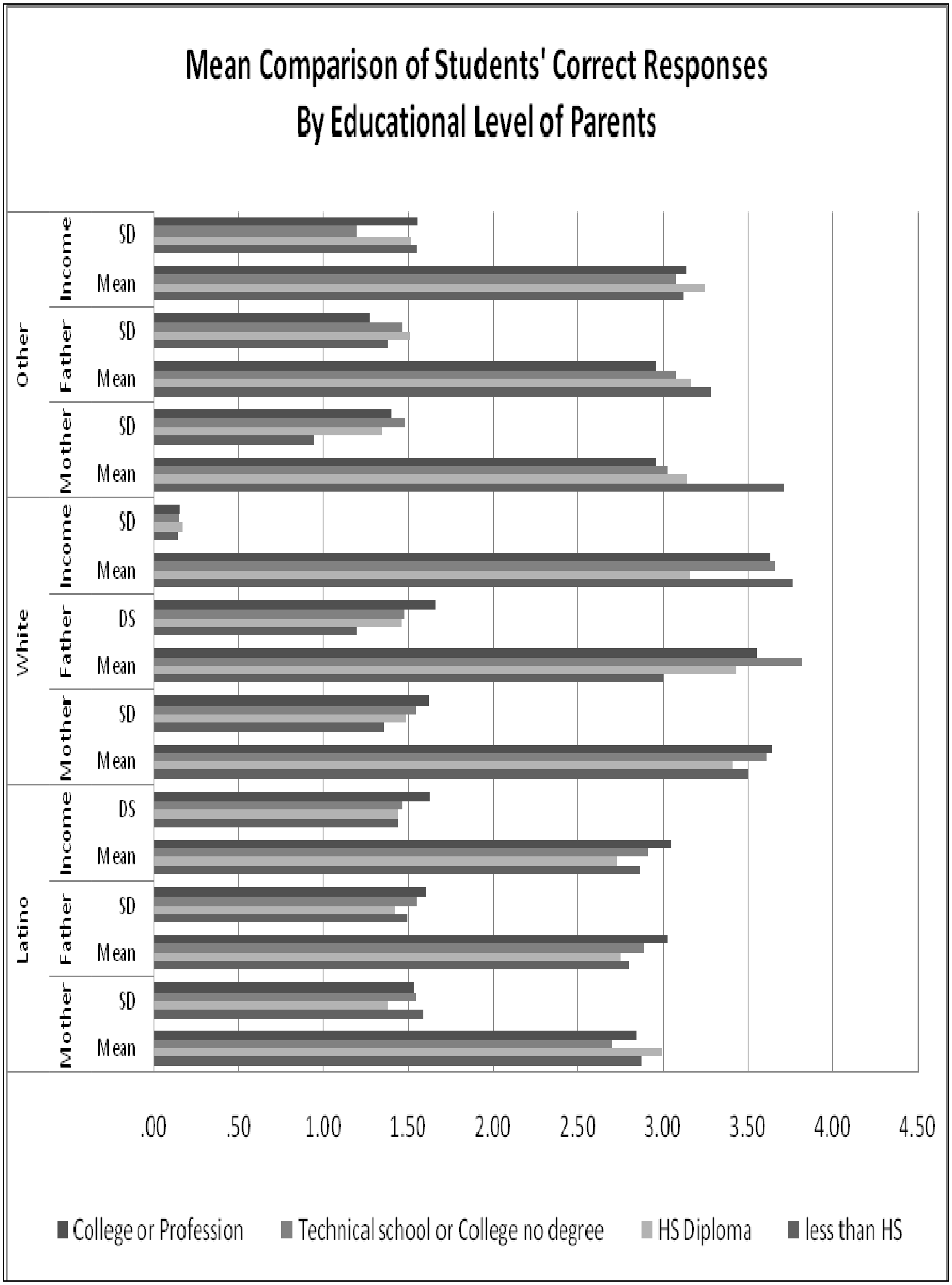

Figure 37. *Raw mean comparison of correct responses by ethnicity and parents' education level.*

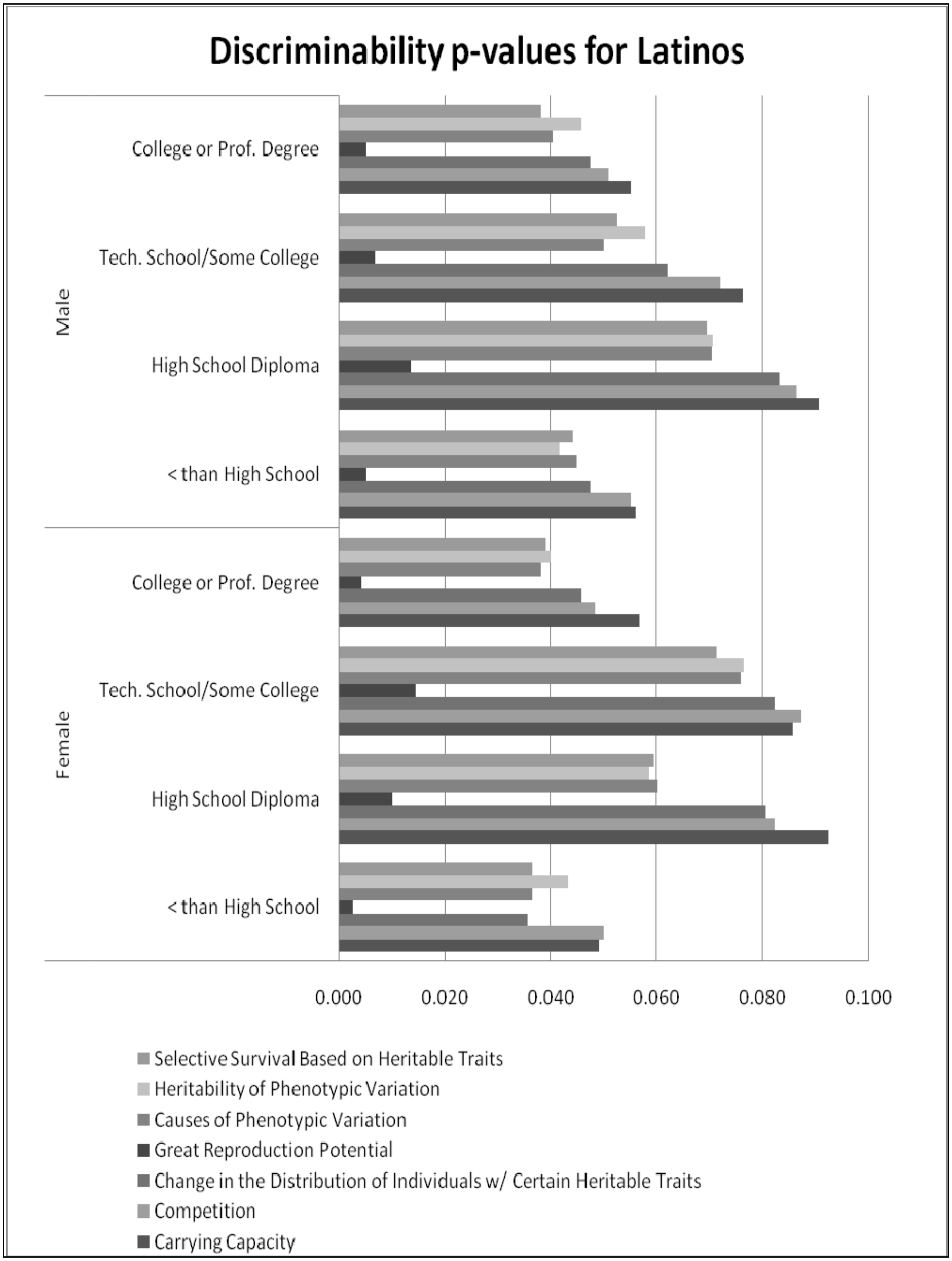

Figure 38. *Latino discriminability p-values by parents' education. Low p-values indicate difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

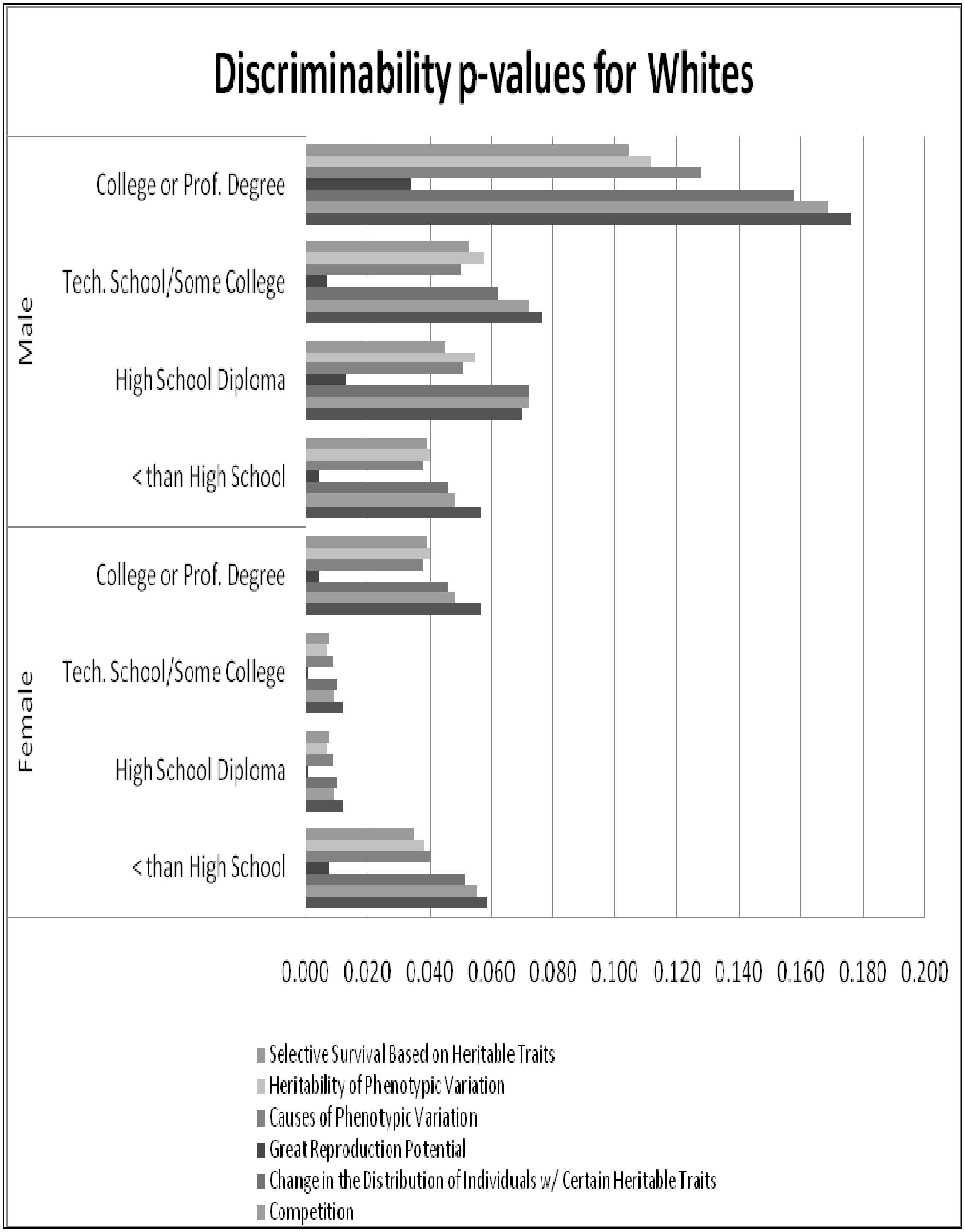

Figure 39. *White discriminability p-values by parents' education. Low p-values indicate difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

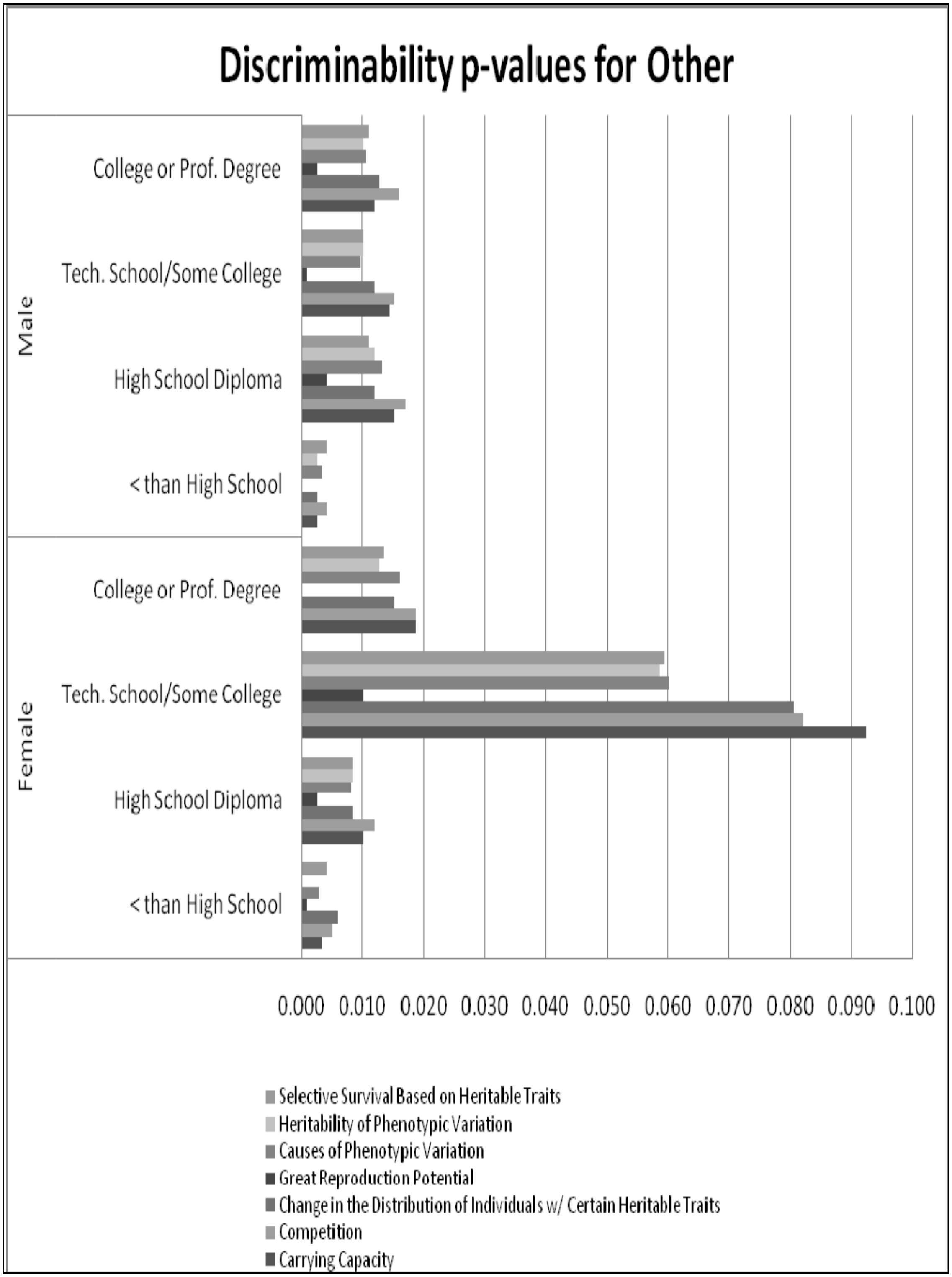

Figure 40. Other discriminability p-values by parents' education. Low p-values indicate difficutlt concepts since these values take into account the percentage of students choosing the correct response.

Table 23. Latino absolute percentage of NSPQ scores by parent education and combined income.

Parent Income	**NSPQ Score**	**< than HS**		**HS Diploma**		**Some College/ Tech. School**		**College or Prof. Degree**	
		Mom (n=95)	Dad (n=116)	Mom (n=160)	Dad (n=181)	Mom (n=191)	Dad (n=141)	Mom (n=104)	Dad (n=101)
<$9,999	0.00	4.2	-	0.0	-	0.0	-	0.0	-
	0.25	20.8	21.1	5.9	16.7	18.8	10.0	50.0	25.0
	0.54	12.5	21.1	23.5	16.7	31.3	20.0	25.0	25.0
	0.42	-	-	-	-	-	-	-	-
	0.65	25.0	31.6	58.8	45.8	18.8	20.0	0.0	25.0
	0.75	8.3	0.0	5.9	8.3	18.8	30.0	0.0	25.0
	0.84	20.8	15.8	5.9	12.5	12.5	20.0	25.0	25.0
	0.93	8.3	10.5	0.0	0.0	0.0	0.0	0.0	0.0
$10,000-$24,999	0.00	0.0	0.0	0.0	0.0	1.9	2.7	0.0	0.0
	0.25	32.5	27.5	15.0	28.9	24.1	16.2	7.0	0.0
	0.42	-	-	-	-	-	-	-	-
	0.54	22.5	27.5	25.0	20.0	25.9	24.3	35.7	40.0
	0.65	27.5	27.5	30.0	26.7	25.9	27.0	14.3	10.0
	0.75	7.5	7.8	10.0	13.3	9.3	8.1	14.3	0.0
	0.84	2.5	5.9	17.5	8.9	9.3	16.2	21.4	30.0
	0.93	7.5	3.9	2.5	2.2	3.7	5.4	7.1	20.0
$25K-$49,999	0.00	0.0	0.0	1.6	0.0	3.3	4.1	0.0	2.9
	0.25	11.1	8.7	14.8	17.7	18.0	16.3	21.1	23.5
	0.42	-	-	-	-	-	-	-	-
	0.54	11.1	13.0	21.3	29.0	23.0	14.3	23.7	26.5
	0.65	55.6	43.5	34.4	29.0	26.2	32.7	21.2	17.6
	0.75	11.1	17.4	8.2	11.3	9.8	12.2	13.2	0.0
	0.84	11.1	13.0	18.0	9.7	11.5	16.3	18.4	23.5
	0.93	0.0	4.3	1.6	3.2	8.2	4.1	20.6	5.9
>50K	0.00	0.0	0.0	0.0	0.0	0.0	4.8	3.1	0.0
	0.25	0.0	33.3	20.0	33.3	28.6	23.8	18.8	11.8
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	0.0	30.0	19.0	17.1	9.5	15.6	23.5
	0.65	60.0	16.7	0.0	14.3	17.1	28.6	34.4	29.4
	0.75	0.0	33.3	10.0	9.5	14.3	14.3	9.4	5.9
	0.84	40.0	0.0	30.0	19.0	14.3	4.8	12.5	26.5
	0.93	0.0	16.7	10.0	4.8	8.6	14.3	6.3	2.9

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

Table 24. White absolute percent of NSPQ scores by parent education and combined income.

Parent Income	NSPQ Score	< than HS		HS Diploma		Some College/ Tech. School		College or Prof. Degree	
		Mom (n=18)	Dad (n=27)	Mom (n=93)	Dad (n=120)	Mom (n=180)	Dad (n=132)	Mom (n=135)	Dad (n=145)
<$9,999	0.25	0.0	16.7	50.0	0.0	0.0	0.0	0.0	0.0
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	16.7	0.0	0.0	28.6	0.0	0.0	33.3
	0.65	33.3	16.7	0.0	0.0	0.0	33.3	20.0	0.0
	0.75	33.3	33.3	50.0	40.0	57.1	33.3	20.0	66.7
	0.84	33.3	16.7	0.0	60.0	14.3	33.3	60.0	0.0
$10,000-$24,999	0.25	25.0	40.0	9.1	18.2	27.3	0.0	18.2	37.5
	0.42	-	-	-	-	-	-	-	-
	0.54	25.0	20.0	9.1	0.0	0.0	15.4	27.3	25.0
	0.65	25.0	40.0	36.4	18.2	18.2	23.1	18.2	25.0
	0.75	25.0	0.0	18.2	27.3	36.4	28.5	9.1	0.0
	0.84	0.0	0.0	27.3	27.3	18.2	23.1	18.2	12.5
	0.93	0.0	0.0	0.0	9.1	0.0	0.0	9.1	0.0
$25K-$49,999	0.25	0.0	0.0	2.9	5.9	7.2	6.4	5.6	5.3
	0.42	-	-	-	-	-	-	-	-
	0.54	100	25.0	11.4	19.6	20.3	19.1	19.4	15.8
	0.65	0.0	25.0	28.8	37.3	29.0	14.9	27.8	34.2
	0.75	0.0	0.0	17.1	7.8	10.1	14.9	11.1	15.8
	0.84	0.0	50.0	31.4	19.6	15.9	27.7	30.6	18.4
	0.93	0.0	0.0	8.6	9.8	15.9	17.0	5.6	7.9
	100	0.0	0.0	0.0	0.0	1.4	0.0	0.0	2.6
>50K	0.00	0.0	0.0	3.1	0.0	0.0	2.0	0.0	0.0
	0.25	0.0	0.0	15.6	11.4	5.9	3.9	11.0	12.9
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	11.1	25.0	22.9	17.6	21.6	15.1	12.9
	0.65	62.5	66.7	21.9	22.9	25.0	19.6	26.0	27.1
	0.75	0.0	0.0	6.3	11.4	16.2	13.7	13.7	14.1
	0.84	12.5	11.1	21.9	20.0	17.6	23.5	16.4	14.1
	0.93	12.5	11.1	3.1	11.4	14.7	11.8	13.7	12.9
	100	12.5	0.0	3.1	0.0	2.9	3.9	4.1	5.9

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

Table 25. Other absolute percent of NSPQ scores by parent education and combined income.

Parent Income	NSPQ Score	< than HS		HS Diploma		Some College/ Tech. School		College or Prof. Degree	
		Mom (n=7)	Dad (n=7)	Mom (n=20)	Dad (n=29)	Mom (n=35)	Dad (n=25)	Mom (n=31)	Dad (n=30)
<$9,999	0.25	100	-	50.0	-	50.0	-	0.0	-
	0.42	-	-	-	-	-	-	-	-
	0.54	-	100	-	50.0	-	33.3	-	-
	0.65	0.0	0.0	25.0	25.0	0.0	33.3	100	-
	0.84	0.0	0.0	0.0	0.0	50.0	33.3	0.0	-
	0.93	0.0	-	25.0	-	0.0	-	0.0	-
$10,000-$24,999	0.25	0.0	0.0	25.0	28.6	10.0	0.0	25.0	50.0
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	0.0	25.0	42.9	20.0	14.3	25.0	0.0
	0.65	0.0	25.0	0.0	14.3	40.0	28.6	0.0	0.0
	0.75	100	50.0	25.0	14.3	10.0	14.3	0.0	0.0
	0.84	0.0	25.0	25.0	0.0	20.0	28.6	25.0	50.0
	0.93	0.0	0.0	25.0	0.0	20.0	14.3	25.0	0.0
$25K-$49,999	0.25	0.0	-	0.0	22.5	30.0	12.5	0.0	0.0
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	-	16.7	11.1	10.0	25.0	25.0	12.5
	0.65	50.0	-	33.3	44.4	30.0	25.0	50.0	50.0
	0.75	50.0	-	50.0	22.2	20.0	25.0	12.5	25.0
	0.84	0.0	-	0.0	0.0	10.0	0.0	0.0	12.5
	0.93	0.0	-	0.0	0.0	0.0	12.5	12.5	0.0
>50K	0.25	0.0	0.0	0.0	0.0	25.0	50.0	22.2	-
	0.42	-	-	-	-	-	-	-	-
	0.54	0.0	0.0	0.0	0.0	25.0	25.0	11.1	10.0
	0.65	0.0	0.0	50.0	0.0	12.5	25.0	44.4	50.0
	0.75	50.0	100	50.0	40.0	0.0	0.0	22.2	10.0
	0.84	50.0	0.0	0.0	40.0	12.5	0.0	0.0	0.0
	0.93	0.0	0.0	0.0	20.0	25.0	0.0	0.0	10.0

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

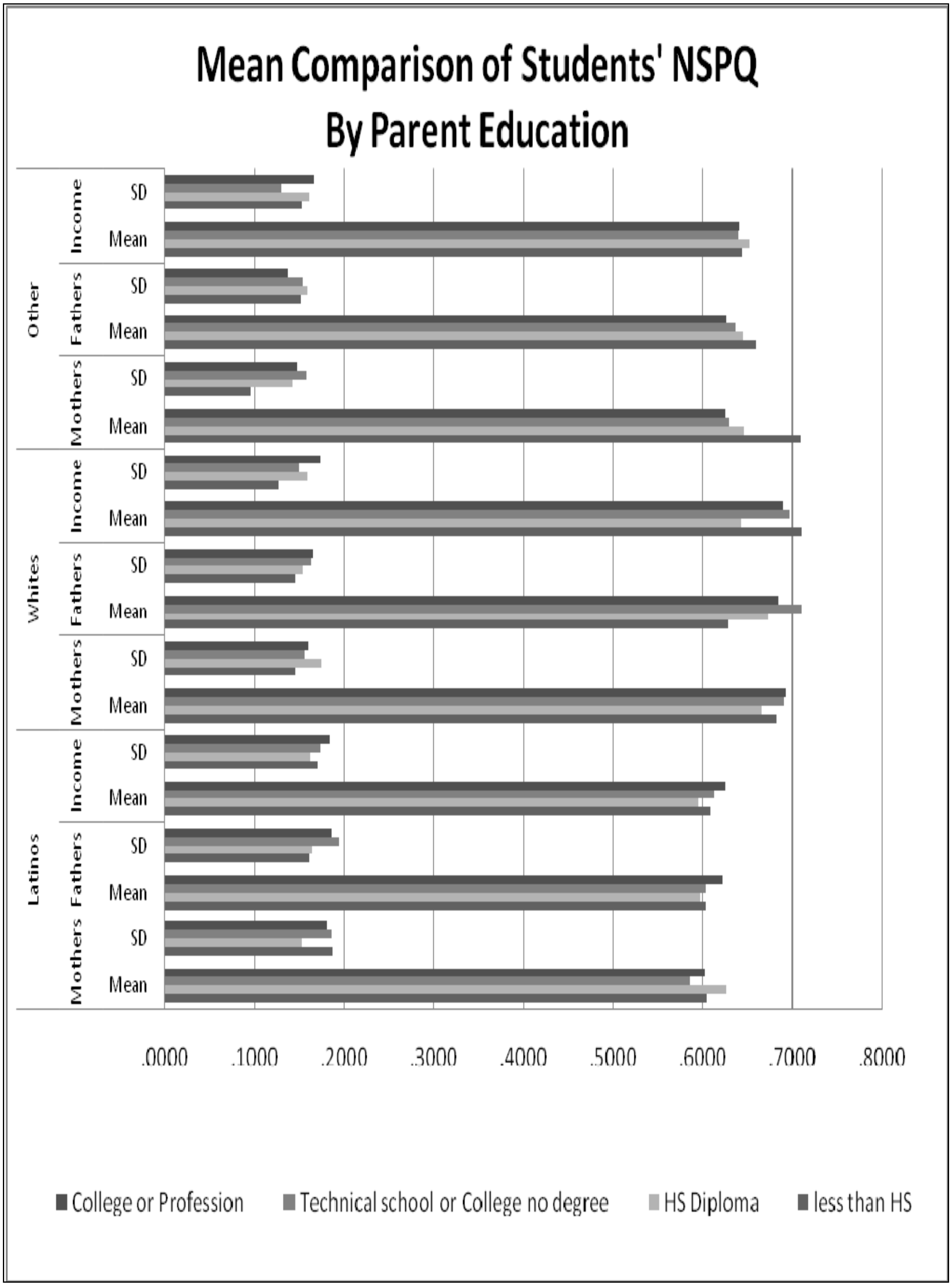

Figure 41. *Raw mean comparison of NSPQ scores by ethnicity and parents' educational level.*

The Influence of Religion

The assessment of students' religious beliefs were also found not to be statistically significantly different and therefore no direct correlation was found to link the students' religious beliefs and their poor understanding of evolutionary theory. In addition, the two top misconceptions were exactly the same for each religious group. The third most common misconception was the same for the Catholics and non-Christians as these two student groups believed *mutations occur to meet the needs of the population (evolutionary);* while the non-Catholic Christians believed that va*riations only affect outward appearance; do not influence survival (genetics).* Table 26 lists the students' correct responses and misconceptions by religious preferences. While Table 27 reports the total correct concepts and Table 28 reveals the NSPQ scores.

Table 26. Absolute percentage of correct responses by ethnicity and student religious affiliation. Correct responses are bolded and underlined; misconceptions are italicized.

Evolutionary Theory Concepts and Misconceptions		**Catholic** (n=596)	**Other Christian Religions** (n=388)	**non-Christians** (n=121)
Carrying Capacity	**All species have great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully**	**62.4**	**67.5**	**77.7**
	Organisms only replace themselves	*2.7*	*2.3*	*0.8*
	Population level off	*34*	*30.2*	*21.5*
Competition	**Natural resources are limited; nutrients, water, oxygen, etc. necessary for living organisms are limited in supply at any given time**	**59.1**	**67.0**	**74.4**
	Organisms can always obtain what they need to survive	*41.0*	*33.0*	*25.6*
Change in Pop. w/ Certain Traits	**The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations**	**14.5**	**12.4**	**17.4**
	Changes in a population occur through a gradual change in all members of a population	*24.7*	*21.6*	*16.5*
	Learned behaviors are inherited	*19.0*	*24.0*	*28.1*
	Mutations occur to meet the needs of the population	*41.8*	*42.0*	*38.0*
Great Reproductive Potential	**Production of more individuals than the environment can support leads to a struggle for existence among individuals of a population, with only a fraction surviving each generation**	**56.0**	**58.9**	**67.8**
	Organisms work together (cooperate) and do not compete	*36.1*	*31.0*	*23.9*
	There is often physical fighting among one species (or among different species) and the strongest ones win	*7.9*	*10.1*	*8.3*

Table 26. Continued.

Evolutionary Theory Concepts and Misconceptions		Catholic (n=596)	Other Christian Religions (n=388)	non-Christians (n=121)
Causes of Phenotypic Variation	**Random mutations and sexual reproduction produce variations; while many are harmful or of no consequence, a few are beneficial in some environments**	**7.9**	**9.0**	**19.8**
	Individuals of a population vary extensively in their characteristics	**48.7**	**44.2**	**57.0**
	Mutations are intentional: an organism tries, needs, or wants to change genetically	*71.8*	*76.0*	*62.8*
	Mutations are adaptive responses to specific environmental agents	*20.3*	*14.9*	*17.4*
	All members of a population are nearly identical	*11.4*	*7.8*	*6.6*
	Variations only affect outward appearance; do not influence survival	*40.0*	*48.0*	*36.3*
Heritability of Phenotypic Variation	**Much variation is heritable**	**42.2**	**51.0**	**57.9**
	Traits acquired during an organism's lifetime will be inherited by offspring	*11.0*	*11.3*	*9.1*
	Traits that are positively influenced by the environment will be inherited by offspring	*32.4*	*22.7*	*23.1*
	When a trait (organ) is no longer beneficial for survival, the offspring will not inherit the trait	*14.5*	*14.9*	*9.9*
Selective Survival Based on Heritable Traits	**Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals**	**39.4**	**47.9**	**43.8**
	Organisms with many mates are biologically fit	*6.7*	*3.4*	*4.1*
	Fitness is equated with strength, speed, intelligence or longevity	*53.8*	*48.7*	*52.0*

Table 27. Absolute percentage and total number of correct concepts by student religious affiliation, ethnicity, and gender.

Number of Correct Concepts	**Ethnicity**	**Catholic (n=596)**		**Other Christian Religions (n=388)**		**non Christian (n=121)**	
		M	**F**	**M**	**F**	**M**	**F**
0	Latino	1.9	2.1	2.7	0.0	0.0	0.0
	White	2.0	-	0.0	-	0.0	-
	Other	-	-	-	-	-	-
	Intl.	-	-	-	-	-	-
1	Latino	20.1	23.3	13.5	20.0	22.2	10.0
	White	7.8	5.2	2.2	13.2	13.6	7.9
	Other	12.5	11.8	7.1	21.7	0.0	6.3
	Intl.	18.5	25.0	0.0	10.0	22.2	16.7
2	Latino	24.5	24.7	21.6	16.0	22.2	10.0
	White	15.7	27.6	22.8	14.6	9.1	10.5
	Other	12.5	23.5	35.7	13.0	20.0	25.0
	Intl.	18.5	25.0	33.3	10.0	22.2	33.3
3	Latino	24.2	26.0	29.7	28.0	22.2	30.0
	White	29.4	22.4	25.0	34.0	18.2	15.8
	Other	25.0	41.2	21.4	34.8	20.0	25.0
	Intl.	33.3	25.0	16.7	50.0	22.2	25.0
4	Latino	7.8	11.6	10.8	20.0	11.1	0.0
	White	11.8	12.1	15.2	16.0	4.5	10.5
	Other	25.0	17.6	28.6	26.1	0.0	6.3
	Intl.	-	15.0	-	0.0	-	0.0
5	Latino	15.6	8.2	17.6	8.0	22.2	40.0
	White	19.6	25.9	20.7	16.7	22.7	26.3
	Other	12.5	5.9	7.1	4.3	20.0	25.0
	Intl.	29.6	10.0	33.3	30.0	11.1	16.7
6	Latino	5.9	4.1	4.1	8.0	0.0	10.0
	White	9.8	5.2	13.0	4.2	31.8	21.1
	Other	12.5	0.0	0.0	0.0	40.0	12.5
	Intl.	0.0	0.0	16.7	0.0	22.2	8.3
7	Latino	-	-	-	-	-	-
	White	3.9	1.7	1.1	1.4	0.0	7.9
	Other	-	-	-	-	-	-
	Intl.	-	-	-	-	-	-

As noted in Figures 42 through 43, regardless of student religious beliefs, the evolutionary concepts were more challenging than the questions on genetics. Even though, non-Christians had higher percent correct response, no statistical significant differences were observed. The discriminability p-values also clearly demonstrates that students encountered problems in the same evolutioanry concept area and the evolutionary and genetics concepts were considerd the most problematic regardless of their religious beliefs. The NSPQ scores mean comparison in Figure 44 also illustrates similar findings.

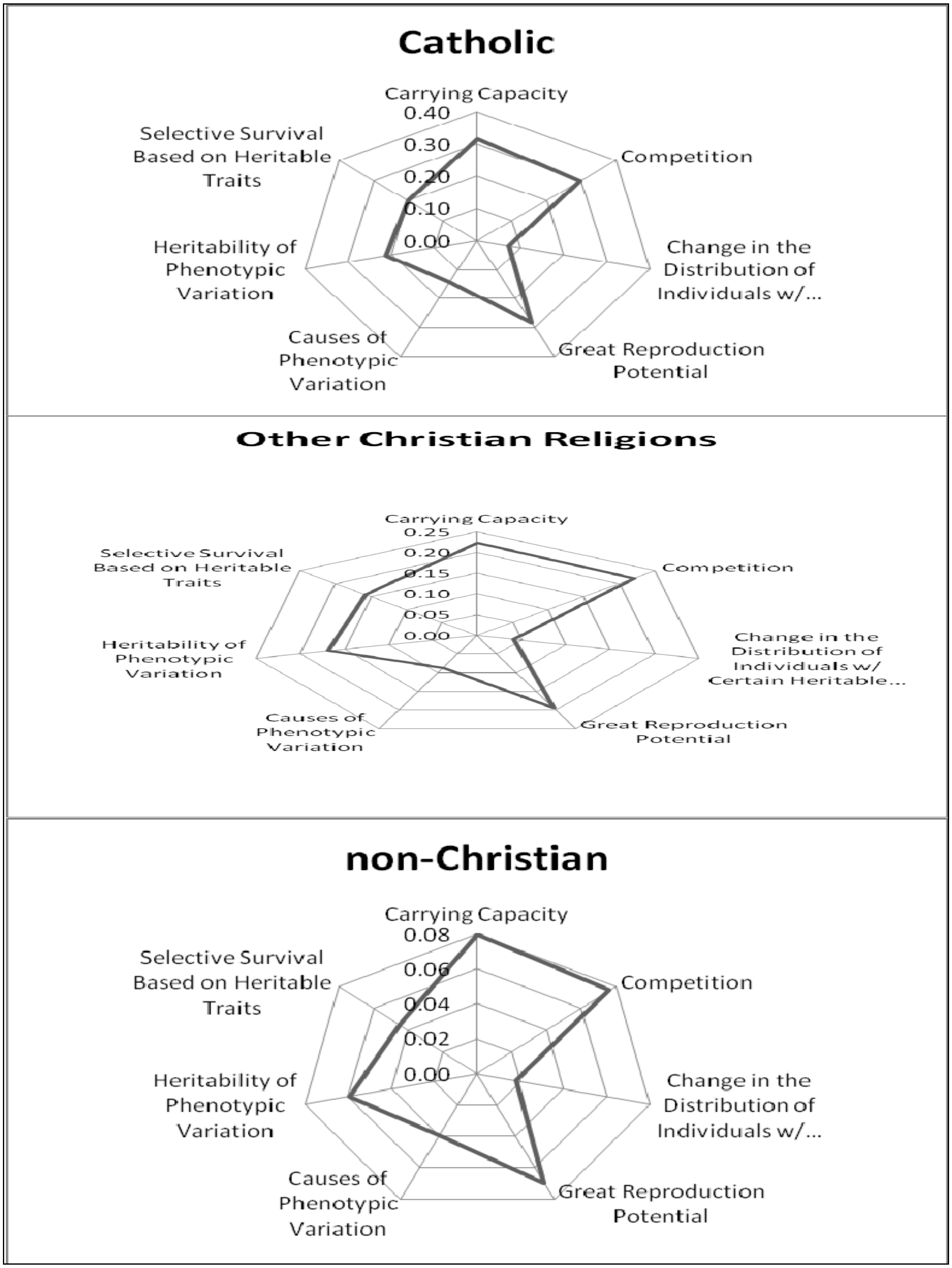

Figure 42. *Discriminability p-values by student's religious affiliation. Low p-values indicate difficutlt concepts since these values take into account the percentage of students choosing the correct response.*

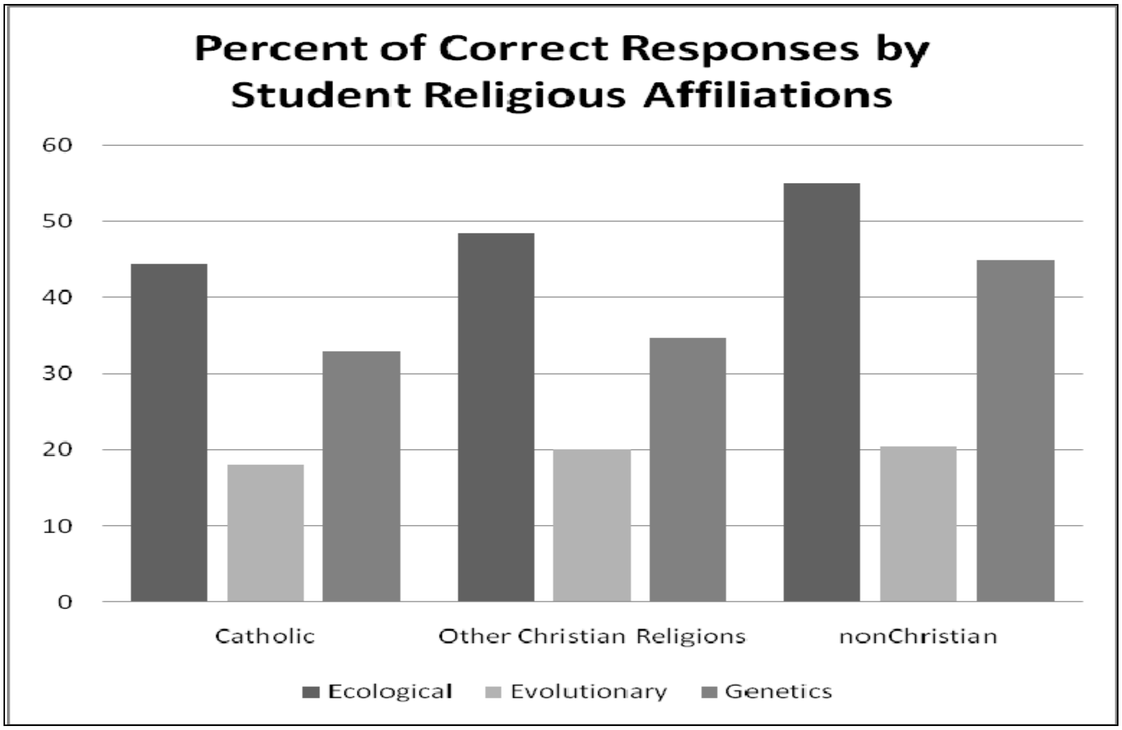

Figure 43. Raw percentage of correct responses by student's religious affiliation.

Table 28. Absolute percentage of NSPQ scores by student religious affiliations.

Actual Score	**Catholics** (n=596)	**Other Christian Religious** (n=338)	**non-Christians** (n=121)
0.00	1.5	0.5	-
0.25	18.1	11.1	11.6
0.42	-	-	-
0.54	23.7	18.8	16.5
0.65	25.8	30.4	20.7
0.75	9.9	15.5	5.8
0.84	15.3	16.8	24.0
0.93	5.2	6.2	19.0
1.00	0.5	0.8	2.5

Score index: 0.0 = 0 correct responses and 8 total misconceptions; .25 = 1 correct responses and 7 misconceptions; .42 = 2 correct responses and 6 misconceptions; .54 = 3 correct responses and 5 misconceptions; .65 = 4 correct responses and 4 misconceptions; .75 = 5 correct responses and 3 misconceptions; .84 = 6 correct responses and 2 misconceptions; .93 = 7 correct response and 1 misconception; and 1.0 = to 8 correct responses with no misconceptions.

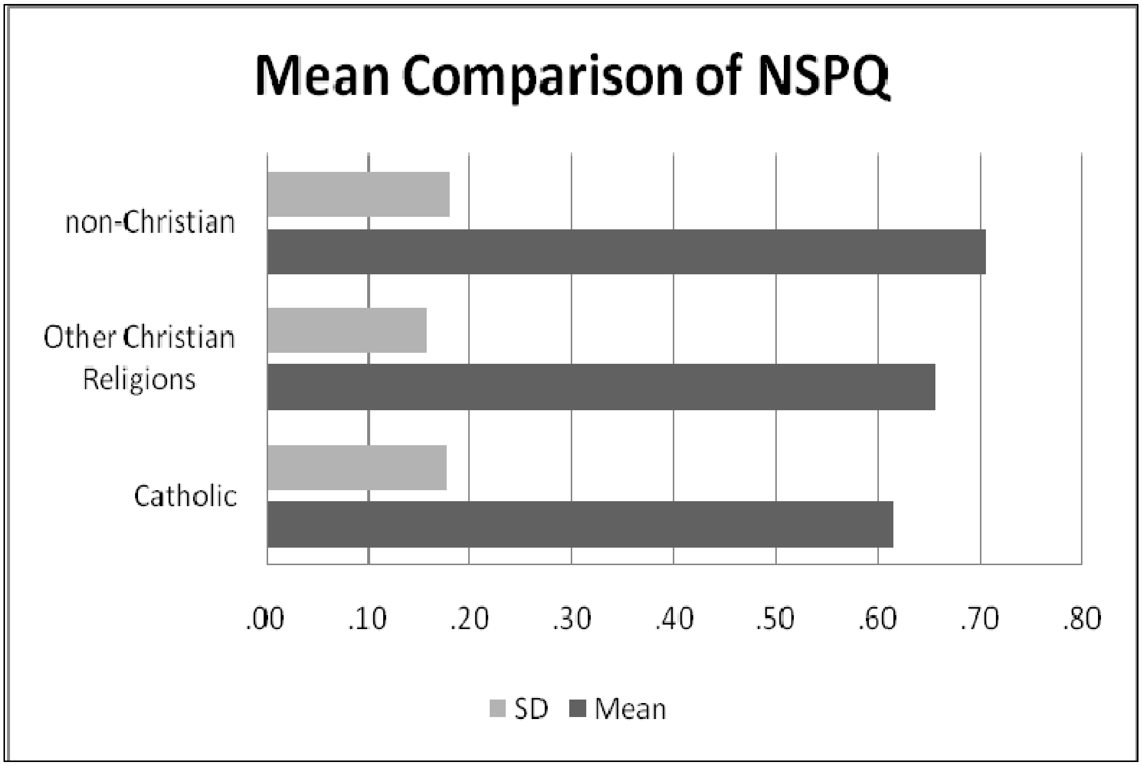

Figure 44. Raw mean comparison of NSPQ by students'religious affiliation.

CHAPTER V

CONCLUSIONS

The purpose of this study was to investigate and determine if cultural factors affect conceptual understanding of evolutionary theory. In particular, the researcher attempts to determine if Latino and non-Latino college students at 4 year public HSI universities in Texas differed in their misconceptions of natural selection and, if so, could cultural factors be one of the reasons why differences exist between the student groups. Hence, this study was exploratory in nature and stemmed from the theoretical framework that culture is learned and reflects different perceptions of the world and as a result, different individuals have different ways to analyze and interpret facts and knowledge (Gerace 2001, Gess-Newsome & Lederman 1999, Taylor 2001, Terezinha da Silva Bello Flores et al. 2008).

In order to ascertain the necessary information to conduct the study, three objectives were defined for this project. The first objective was to obtain permission to modify the CINS questionnaire developed and validated by Dr. Dianne L. Anderson. The second objective was to fine-tune the instrument to capture the necessary data to meet the purpose of this study. The third objective was to administer the questionnaires at the participating universities, collect, analyze, and report the data findings.

The descriptive analyses presented in the previous chapter are supported by other scholars, i.e., Liu, Sharkness, and Pryor (2008) for example discovered that nearly thirty-six percent (35.8%) of college students strengthened their religious beliefs or convictions after entering college. Hence, it was not surprising to report almost a third (28.4%) of the participants to practice religiosity weekly to several times per week. Regarding students' environmental position, the results were once again favorable and supported by other scholarly work as fifty percent (51.2%) of the participants considered environmental causes to be an important part of a political candidate's platform. Similar results were reported by Pryor and Hurtado, Sharkness, and Korn (2008) who discovered that over forty-five percent of the freshman studied considered adopting green practices as essential and/or very important. With regard to participants' political party affiliation, the study results were somewhat similar to Lambert, Baker, and Ventura (2008) which reported students' party affiliation to be 38% Democratic, 28% Republican, and 34% Independents.

The parents' level of education was higher than the national average which is currently 24.4% for adults older than 25 (USDA, Economic Research Service, http://www.ers.usda.gov/Data/Education/EducListPct.asp?ST=US&x=11&y=15, March 23, 2009). The present study found that 26.8% of fathers had either a college or professional degree compared to 25.9% of the mothers. In general, more fathers had high school diplomas than mothers had high school diplomas (31% to 25% percent respectively). The national average during the last census for high school completion by adults over 25 years of age was 28.6%. The percent of parents who had less than high school was about 12% for mothers and 15% for fathers. However, both of these percentages are still lower than the national average which was 19.6% in 2000 (USDA, Economic Research Service, http://www.ers.usda.gov/Data/Education/EducListPct.asp?ST=US&x=11&y=15, March 23, 2009).

However, the yearly income results illustrated a gloomy picture as the U.S. Census in 2000 reported an average annual income for Texas residents to be $30,412 for individuals with less than a high school diploma; $42,272 with a high school diploma or equivalent; $52,552 with some college or Associates Degree; and greater than $80K with a college or professional degree (Murdock, White, Hoque, Pecotte, You, and Balkan 2003). This study however discovered that forty-two percent of the parents earned less than $34,999. The national poverty household income in 2007 was $13,690 for a two-family member household; $17,170 for a three-family member household; $20,650 for a four-family member household and $24,180 for a five-family member household (http://aspe.hhs.gov/POVERTY/07poverty.shtml, March 25, 2009); hence without knowing the total number of family members for each participant, it is difficult to determine the exact percent of the students who would be considered from impoverished families. However, if all participants came from either a three, four, or five-family member household, nearly a third (32.2%) of the participants would be considered from impoverished families due to parents' household income being less than $25,000 dollars per year and as a result Latinos are more likely than Anglos to live below the poverty level (Kanellos, Weaver, and Esteva-Fabregat 1994).

The overall implications of parents' lower than average yearly incomes substantiates the reason that more college students work and as a result, 31% of college students enrolled in 4-year institutions and 55% of students enrolled in 2-year institutions worked in 2007 (Retrieved, March 23, 2009 from http://www.bls.gov/news.release/hsgec.nr0.htm). Indeed, more college students work today than in the mid 1980s as parents are more financially challenged now than in past decades to pay for their children's education (Orszag, Orszag, Whitmore, 2001).

Few varying differences between the Latino and non-Latino college student were discovered as the majority of them strongly believed that *mutations are intentional as organisms try, need, or wants to change genetically* thereby paralleling previous scholarly findings, i.e., Anderson et al (2002, 2003, Demastes, Good, & Peebles, 1996). Regardless of student's ethnicity, gender, or religion, acculturation, and parents' income or level of education, the majority of students ultimately believed that evolution is driven by "need". The second most common misconception was also shared as close to 50% of all the students also believe that *fitness is equated to strength, speed intelligence or longevity.* The same is for all of the other demographic variables even though at times the prevalent misconceptions from one group would alternate between the groups but always managed to be within the same evolutionary concept.

Thus the question becomes, does culture play a role in the formation of these misconceptions? Unfortunately, it is difficult to ascertain if culture plays a role without first assessing the students' first language since some scholars believe that children whose primarily language is not English to encounter communication barriers (Pert and Letts 2006).

Once again, one must ask if these misconceptions are correlated to students' cultural background. The results presented in the previous chapter do not suggest that misconceptions are correlated to a student's cultural background. And while the magnitude of the misconceptions varies among and between the groups as a result of being evaluated by different demographic variables, the misconceptions themselves do not. Explaining to some degree why some documented science misconceptions are widespread and have transcended racial, ethnic, class boundaries (Hehm and Schonfeld 2007), and acculturation levels. Furthermore, more homogeneous studies have also reported similar natural selection misconceptions. However, these evolutionary misconception similarities by no means suggest and/or imply that traditional and/or similar pedagogical teaching strategies yield equally and effective conceptual knowledge and understanding (at the breadth and depth level) to conceptualize evolutionary and natural selection concepts. On the other hand, culture does impact students' learning; therefore, making it is possible for cultural differences to distort communications. For example, language or vocabulary terms used out of context tend to confuse students (Saville-Troike 1982, 1986). However, it is beyond the scope of this research project to correctly assess such possible correlation. In addition, the MSNS did not incorporate a level of assessment for language and therefore cannot be extrapolated from the gathered data. Nonetheless, the teaching community should use caution when describing scientific concepts with everyday language as such words have different semantic features that are above lexical semantics (Swoyer 2003). Therefore, if an instructor lacks this knowledge, the risk exists that terms are content poor thereby causing students confusion and frustration when attempting to learn scientific concepts, theories, and ideas. In addition, culturally diverse students may not be able to translate key ideas as some cultures do not have direct translations or even have words for scientific words and-as a result, meaning is potentially lost if a student naturally translates to his/her native primary language in order to understand. Hence, scientific words should be defined, used, and expressed in the context of function, concept and application so that the learner has a more distinct meaning/process/ function/method of the word (Smith 2006).

Recommendations

Evolutionary theory poses challenges not only to U.S. students but also to students all over the world. International students also encounter similar challenges as they collectively scored lower on questions addressing *causes of phenotypic variation, selective survival based on heritable traits* and *change in the distribution of individual with certain heritable traits.* In general, international students scored somewhat similar to U.S. students. Hence, one can conclude that students encounter difficulties conceptualizing *natural selection* concepts not necessarily due to cultural factors or cultural background but more so-on the complexity of the theory manifesting teaching and learning challenges. Furthermore, the various studies, i.e., Francis and Greer 2001 (Ireland), Bizzo, 1994 (Portugal), etc. that have been conducted worldwide have yield similar findings. Perhaps no statistical significant differences were found in this study due to the fact that both targeted student populations (Latinos and Whites) ultimately belong to the same race (White) and therefore conceptualize evolutionary theory very similarly.

If race is not a factor, then perhaps the teaching community continues to confuse students and fails to dispel misconceptions if they themselves lack the expertise and/or preferred students to be taught creationism in school (Nehm and Schonfeld 2007, 2008); as even some biology teachers do not accept evolution as the foundation for the diversification of life (Eve and Dunn 1990, Brem et al. 2003, Alberts and Labov 2004, Miller et al. 2006, Balgopal 2007); while others evade teaching evolution altogether (McCormack 1982, Nelkin 1982, Johnson 1985, Nelson 1986, Scharmann 1990, Stallings 1996, Elgin 1983). Furthermore, not all teachers/instructors facilitate conceptual learning as a result of a variety of reasons, e.g., due to lack of training, lack of knowledge, lack of adequate training materials, or insufficient training materials, as well as teaching in a classroom environment not conducive to activate or engage learning.

The results do not reveal the causes for misconceptions nor a direct correlation between misconceptions. However, it has been demonstrated in the literature that students can positively hold both belief systems (*religious and scientific*) without lessening one or the other (Francis and Greer 2001). However, as Francis and Greer state, “if science educators are properly concerned with dismantling erroneous conceptions of the nature of science, they may also need to recognize how the prestige of their subject may be precariously poised on the basis of such erroneous conceptions.” This statement has profound implications and poses unique challenges for all biology and ecology educators.

Furthermore, evolutionary teaching terms and the colloquial interpretation of scientific words represent unacceptable scientific use of evolutionary language which in turn causes students' unique challenges and confusion. For example, Bizzo (1994) discovered that Brazilian high school students who were ready for college had difficulty recognizing the differences between biological *competition* and *fighting.* Other evolutionary terms that tend to confuse students are words like *adaptation, biological evolution, competition, fitness,* etc. Indeed, semantics influences how words are interpreted and understood (Anderson et al. 2002, Balgopal 2007); and therefore, different languages have different semantic features that are above lexical semantics (Swoyer 2003). Hence, many of the words used in evolutionary theory are at odds with scientific meaning (Demastes et at. 1996, Anderson 2003, Balgapol 2007). For example, the word *favorable*, represents "the ability to survive and reproduce…[but it is misleading as]…the only requirement for natural selection to work is for *certain* variants to do better than others, as opposed to random ones. [Hence,] as long as nonrandom subsets of the population survive better and leave more offspring, evolution will result." (Freeman and Herron 1998, p.46). As a result, students tend not to fully conceptualize the various processes of natural selection e.g., *mutations, variation, adaptation,* etc., which are the driving forces behind evolution (Demastes et at. 1996, Anderson 2003, Balgapol 2007).

Hence, traditional pedagogy instruction needs to "examine students' perceptions of their experience in science classrooms by exploring of their perceptions of the cultural practices of science, the epistemology of science, and the role of discourse in science education" (Brown, 2006, p. 106). Even when instructors/teachers are aware or claim to be sensitive to a diverse student population, they still view science as *value neutral* and unrelated to *ethnicity differences* (Gutiérrez, Torres, & Lopez 2009). Hence, it is futile to document students' science language discourse when the teaching community does not take it into account even after students indicate that science discourse is different compared to everyday language (Brown 2006).

Indeed, the goal to create conceptual change regarding evolutionary theory continues to challenge researchers and educators because *natural selection* remains the most misunderstood theory of evolution (McComas, 1994). Is it because the theory of natural selection varies in difficulty or is it because *causes of phenotypic variation* require a sound understanding of genetics (Anderson 2003, Balgopal, 2007)? Better yet, is it because traditional instruction fails students altogether by limiting hand-on activities and using poorly defined words? The theoretical framework used in this study supported the notion that scientific conceptual change develops when learners are able to transition from one paradigm to another and at the same time, replace existing knowledge structures to build new knowledge and skills (Huitt 2003, Orey 2001, Vosniadou 2007). Therefore, in order to facilitate conceptual change the teaching community needs to change its outdated and content poor teaching methods in order to assist students to "recognize that the origin and the persistence of new traits are controlled by separate mechanisms….[nor be] unable to explain how selective pressures act on variation within a population" (Balgopal, 2007, p. 8).

The literature clearly demonstrates that active classroom engagement or *active learning* as well as an adequate amount of time invested in age-appropriate academic tasks and academic activities (Alao and Guthrie 1999, Gerace 2001) facilitates conceptual learning. And as a result, students do not resort to memorization but instead are assisted to solve problems by working out solutions and reasoning (Alao and Guthrie 1999, Gerace 2001). Furthermore, members of the teaching community who do not know or understand constructivism fail to identify what it is possible for students to learn (Vygotsky 1978, Anderson 2003). Extrapolating from the literature, it is possible to state that most college and university professors who do not earn educational/psychology degrees have limited knowledge about the theoretical framework for how a student cognitively processes newly obtained knowledge (Rumelhart and Ortony 1977); thereby failing to recognize that schemas play a significant function in how information is interpreted and decoded (Halliday and Hasan 1989, Driscoll 1994). Furthermore, the manner in which knowledge is presented to a student has a strong correlation to how it is interpreted, coded, categorized, organized, and eventually used (Vosniadou and Brewer 1987).

This is one of the reasons that the literature on student cognition strongly suggests that a student's ability to understand complex concepts, i.e., theories, is directly attributed and correlated to his/her own level of reasoning—explaining that they are linked to students' *academic achievement* in the areas of biology, mathematics, English, and social sciences (Lawson 1985, Stallings 1996). Hence, many studies have investigated students' reasoning levels and how they impact scientific reasoning, biological misconceptions, and scientific beliefs (Lawson and Thompson 1988). For example, Lawson and Weser (1990) discovered that non-biology majors who were less skilled reasoners not only were less likely to change their perceived notions but were also less likely to commit to scientific beliefs. In another study, Lawson and Worsnop (1992) were able to document that reflective reasoning was positively correlated to scientific beliefs without ever changing students' religious beliefs, even after evolutionary theory instruction. Hence, as previously stated, conceptual understanding of evolutionary theory does not displace religious beliefs or practices.

Implications

The single most important implication of this research project is that most, if not every, student is capable of developing a sound and meaningful understanding of evolutionary theory through natural selection if the teaching community changes its outdated and content poor teaching methods. Furthermore, a student's cultural background should not impede him/her from truly conceptualizing at the breadth and depth level for "…biology and culture co-evolved, with the connection…[of the] social-cognitive processes…[providing] the ability to understand the self and others, to understand and use the accumulated knowledge of the group, [and] to transmit this knowledge to subsequent generations" (Gauvain 2000, p. 11). Nonetheless, effective instruction that it is engaging and rich in content is just as essential as providing students with adequate time on age appropriate educational tasks. In accordance to the relevant literature, evolutionary theory should not be taught as a single-block of time and/or towards the end of the semester, but instead it should be taught year-round and complex concepts should be presented early during the semester and revisited throughout the semester thereby providing students with sufficient time to conceptualize the theories.

In support of other researchers' findings and recommendations, it is critically important to teach the ecological concepts early in the semester which will facilitate conceptual learning by re-familiarizing students about topics and/or material they know something about and, thus, they will be more inclined or motivated to learn. In addition, students should be able to resolve issues dealing with differential survival and as a result acquire the basic knowledge to construct and understanding the evolutionary concepts of natural selection, i.e., *change in the distribution of individuals with certain heritable traits, selective survival based on heritable traits,* and *causes of phenotypic variation*. The teaching community also needs to incorporate effective and relevant use of hands-on activities, examples, and analogies. Moreover, teachers should incorporate as part of the course reading summaries of evolutionary theory, i.e., The Beak of the Finches, Darwin's' Ghost, etc. (Appendix E is a duplication of Anderson (2003) supplemental readings).

Nonetheless, in order to extend students' knowledge and concept problem solving, students must be able to acquire a conceptual understanding of abstract thinking (Alao and Guthrie 1999, Gerace 2001). Therefore, students' capacity and capability to conceptualize and address complex problems requires the use of very specialized skills to analytically assess and resolve issues. After all, "learning is the goal of all instruction. Accurate assessment of learning is an important first step in determining the link between learning and teaching…Some disciplines, primarily physics and math, have made significant headway into unraveling the complex relationships between learning and teaching, often through the application of learning research… (Libarkin and Anderson 2005, p. 394).

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APPENDIX A

IRB REQUEST FORM SUBMITTED TO TEXAS A&M UNIVERSITY

Revised 02/17/06

Texas A&M University
IRB Protocol Checklist and Application
Protocol for Human Subjects in Research

IRB PROTOCOLS: Submit the original and one copy of the complete IRB protocol (application and required documentation) to the Institutional Review Board, Office of Research Compliance, Centeq Building, 1500 Research Parkway, Suite B150, TAMU 1186, College Station, TX 77843-1186. Review will not begin until all required documentation is received. Applications requiring Full Review must be submitted a minimum of 15 business days before an IRB meeting, depending on workload. For assistance call (979)458-4067 or email irb@tamu.edu. Applications must be typed, single-sided, with pages numbered. Applications, consent documentation, surveys, etc. will not be accepted with spelling, grammatical and/or typographical errors.

IRB # 2007-0447
Received
JUL 25 2007
Research Compliance
IRB Office Use Only

CHECKLIST: Please check and attach all items that apply to your research.

☒ Part I: Summary Cover Sheet

☒ Part II: Detailed Study Description

☒ Conflict of Interest Statement (Principal and Co-Investigators)

☐ NIH Training Certificate and ☒ TAMU RCR Training Certificate; or
☐ CITI Training Certificate (Principal and Co-Investigators)

☐ Grant Proposal (if Federally funded)

Informed Consent Document(s) (must contain all elements of consent)

☒ Consent Form

☐ Parental Permission Form

☐ Assent Form (if research involves minors, ages 7-17)

☐ Cover Letter (for mail out surveys)

☐ Information Sheet

☐ Telephone Script (for telephone surveys)

☐ Videotape/Audiotape Release Form (if not included in the consent and/or assent documents)

☐ Justification for Waiver of Consent and/or Signed Consent

Note: If informed consent/assent documents are longer than one page, number each page in the format "page x of y" and blank space for date and initial "Date ____ Initial ____". Page #'s will be separate from IRB Application

☐ Debriefing form (if deception is used)

☒ Survey/Assessment Instruments

☒ Recruitment Media/Newspaper Advertisements

☐ Compensation conditions, schedule of payment

☐ FDA Form 1572 (for investigators involved in drug or biologic studies)

☐ Drug or Device Accountability Record

Email irb@tamu.edu or call (979) 458-4067 with any questions regarding this form.

Revised 02/17/06

Texas A&M University
IRB Application
Protocol for Human Subjects in Research

Part I: Summary Cover Sheet

IRB # 2007-0447

Received
Research Compliance
JUL 25 2007
HSPP

IRB Office Use Only

☐ **Request for Exemption (Exempt from Full Board Review)**
☒ **Request for review under an Expedited Review Category**
☐ **Request for Full Review**

New submission ☒ Re-submission ☐ (If protocol was disapproved)

Investigator Information
Principal Investigator Name: **Maria R. Gutierrez**
Faculty ☐ Staff ☐ Graduate Student ☒ Undergraduate Student ☐
Department **ESSM** College **AGRICULTURE AND LIFE SCIENCES** Mail Stop **2138**
Phone **210-279-4024** Email **mrgutierrez@ag.tamu.edu** Fax **NONE**
Is this study part of a Thesis or Dissertation? Yes ☒ No ☐
If Yes, do you have committee approval? Yes ☒ No ☐

Co-Investigator Name: ____
Faculty ☐ Staff ☐ Graduate Student ☐ Undergraduate Student ☐
Department ____ College ____ Mail Stop ____
Phone ____ Email ____ Fax ____

Graduate Committee Chair/Faculty Advisor Name (if student): **DR. CRUZ C. TORREZ & DR. BEN WU**
Department **RPTS / ESSM** College **AGRICULTURE AND LIFE SCIENCES** Mail Stop **2261 / 2138**
Phone **979-845-3255 & 979-845-7334** Email **cctorres@ag.tamu.edu & xbw@tamu.edu** Fax **979-845-0446 & 979-845-6430**

Project Title: **Cultural Factors Effects on Latino Knowledge of Evolution and Natural Selection**

Funding Status: Funded ☐ Not Funded ☒ Pending ☐ **(Please attach a copy of Grant Proposal)**
Funding Agency: ____ Funding Amount: ____
Funding Administrator: RF ☐ TAES ☐ TEES ☐ TAMU ☐ TTI ☐

Risk Management Matrix

Seriousness of Risk		Probability That Something Will Go Wrong			
		A Likely to occur immediately or in a short period of time, expected to occur frequently	**B** Probably will occur in time	**C** May occur in time	**D** Unlikely to occur
	I May Result in Death				3
	II May cause severe injury, major damage or loss, and/or result in negative publicity for the participant(s) involved			3	2
	III Participation presents a minimal threat to safety, health and well-being of participant(s)		3	2	1
	IV No more than minimal risk	3	2	1	1

Red Zone – 4 thru 5 Yellow Zone – 2 thru 3 Green Zone – 1
(If your protocol falls in the Red or Yellow Zone, please call (979) 458-4067 for further instructions)

Email irb@tamu.edu or call (979) 458-4067 with any questions regarding this form.

Revised 02/17/06

Seriousness of risk **IV** Probability that something will go wrong **D**
Objective Estimate of Risk to Subject: Low ☒ Medium ☐ High ☐

Activity	Associated Risks	Method to Manage

Will Existing Documents Be Used? Yes ☐ No ☒

Will Existing Specimens Be Used? Yes ☐ No ☒

Research Methodology: Qualitative ☐ Quantitative ☒ Both ☐

Gender of Subjects: Male ☐ Female ☐ Both ☒

Estimated Age of Subjects: **18-65+**

Location of Research: **Texas Hispanic Association of Colleges & Universities (HACU) Universities (list of Texas colleges and universities)**

Total Participants: **800 university students**

Subject Recruitment

Subjects Recruited From:
☐ Psychology Subject Pool
☐ Other Subject Pool ____
☐ Other TAMU Students
☐ Community
☐ Women/Fetuses
☐ Children
☐ Prisoners
☐ Hospitals
☐ Treatment Centers
☐ Schools
☒ Other **Texas colleges and universities**

Recruitment Method:
☐ Direct person-to-person contact
☐ Telephone solicitation (attach script)
☐ Newspaper Advertising (attach ad copy)
☐ Posted Notices (attach copy)
☐ Letter (attach copy)
☒ Other (describe) **Contact colleges & university professors via telephone and e-mail to solicit participation.**

Compensation/Course Credit
Yes ☐ No ☒ Compensation for Subjects (If Yes, attach regular payment schedule)
Yes ☐ No ☒ Research/Course Credit for Subjects

Deception
Yes ☐ No ☒ Deception Used (If Yes, attach debriefing form)

Invasive or Sensitive Procedures
☒ None used
☐ Blood Samples
☐ Urine Samples
☐ Physical Measurements (electrodes, etc.)
☐ Stress Exercise
☐ Review of Medical/Psychological Records
☐ rDNA
☐ Other (specify): ____

Sensitive Subject Matter
☒ None used
☐ Abortion
☐ AIDS/HIV
☐ Alcohol
☐ Body-composition
☐ Criminal-activity
☐ Psychological Inventory
☐ Other (specify): ____
☐ Sexual Activity
☐ Suicide
☐ Learning Disability
☐ Drugs
☐ Depression

Audio or Video Taping
☐ **Video Taping**
☐ **Audio Taping**
If yes, answer the following:
Retained: Yes ☐ No ☐
Length of time retained: ____
Destroy/Erase: Yes ☐ No ☐
Other ____

Provisions for Confidentiality/Anonymity
☐ Replies Coded
☐ Secure Storage
☐ Anonymous response **OR**
☒ Confidential
(Cannot be both anonymous and confidential)

Revised 02/17/06

Use specified in consent form: Yes ☐ No ☐

Revised 02/17/06

Consent Documentation

☒ Consent Form
☐ Cover Letter
☐ Videotape and/or Audiotape Release
☐ Parental Permission Form
☐ Information Sheet
☐ Assent Form
☐ Telephone Script

Location where consent forms will be filed: **Consent forms will be filed in principal's investigato's locked files.**

Note: Consent forms must be kept on file for 3 years after completion of the study.

Request of waiver of consent: Yes ☐ No ☒ Request of waiver of signed consent: Yes ☐ No ☒

If yes to either, attach a justification for waiver request. Criteria for waiver requests can be found in the Federal regulation 45 CFR 46.116 and 45 CFR 46.117 at the following Web address: http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm.

Do you have any relationship with any of the subjects, other than your investigator role? Yes ☐ No ☒
If yes, you must explain the relationship in Part II of the application and clarify how you will avoid any type of coercion (doctor-patient, teacher-student, counselor-student, etc.).

Other Compliance Issues

If the study involves the use of animals, infectious biohazards, and/or recombinant DNA, it is required that approval be granted for the use of such through the appropriate compliance committee. This information may be accessed through the Research Compliance Website at http://researchcompliance.tamu.edu.

This study also involves the use of animals. ☐Yes ☒ No
If yes, complete the following:
☐ An application has been submitted for review by the University Lab Animal Care Committee.
☐ An application has been reviewed and approved by the University Lab Animal Care Committee.
AUP Number: _____ Approval Date: _____

This study also involves the use of infectious biohazards or recombinant DNA. ☐Yes ☒ No
If yes, complete the following:
☐ A registration form has been submitted for review by the Institutional Biosafety Committee.
☐ An approved registration is currently on file with the Institutional Biosafety Committee.
Registration Number: _____ Approval Date: _____

Abstract

Please provide a brief statement, in lay terminology, outlining the purpose of this study. *(Why you are doing this research project and what you propose to learn.)*

Natural selection is the foundation of biology and student's knowledge and conceptions of this process is generally poorly understood; it is therefore critical that additional research be conducted in order to assess minority students' knowledge of natural selection. Evolution by means of natural selection is a paradox in which humanity advancement is directly threatened by our overall lack of knowledge. It is well established that students tend to hold preconceived notions about the nature of science and evolution. In addition, many of the misconceptions are not only resistant to instruction and difficult to change; but are also reinforced by the media, textbooks, and primary and secondary school teachers. Thus, it is critical that the educational community be provided with additional knowledge of how cultural factors impact the learning of science. It is essential that further research be conducted in this area especially since the demographics in the U.S. are rapidly changing to reflect an increase in the proportion of minority populations visa be non-minority. In addition, many universities are seeing an increase in student enrollment of ethnically diverse populations. However, despite its importance, little has been done to examine the effects of cultural factors on student misconceptions of natural selection. Even less research as been conducted on Latino polulations, which is one of the fastest growing ethnic populations in the U.S. It is imperative that further research be conducted to identify the knowledge and/or misconceptions that Latino students may have regarding evolution and natural selection.

The U.S. population is becoming increasingly culturally, linguistically, economically, and ethnically diverse. The research needs to make a concerted effort to ensure that research subjects reflect the population demographically, including these groups who have been traditionally under represented. However, it is recognized that the available pool of subjects may preclude having a balanced population. If you cannot use a diverse population in your research, you must justify this action in Part II, A, 1.

For answers to questions regarding the IRB application process, please check with the IRB office at (979) 458-4067 or irb@tamu.edu. All protocol applications require an original and one (1) copy of each instrument, i.e., protocol checklist, Part I, Part II (with signatures), Part III, consent documents, research instrument(s), recruitment materials, training certificates, etc.

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REQUEST FOR EXEMPTION (from full IRB review)

45 CFR 46.101(b) - Some research projects involving human subjects are exempt from full review by the IRB. The IRB makes the final decision whether or not a proposal is exempt from full IRB review. If the protocol cannot be reviewed under and exempt category, it will be placed on the next available IRB meeting agenda. *(Sensitive topics and subjects such as children or minors, pregnant women and prisoners are not considered for exempt research).*

Basis for Exemption (Do not check unless requesting an exemption from full IRB review.)

☐45 CFR 46.101(b)(1) - Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies, or (b) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
☒45 CFR 46.101(b)(2) - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.
☐45 CFR 46.101(b)(3) - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (2)(b) of this section, if: (a) the human subjects are elected or appointed public officials or candidates for public office; or (b) Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
☐45 CFR 46.101(b)(4) - Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.
☐45 CFR 46.101(b)(5) - Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (a) public benefit or service programs; (b) procedures for obtaining benefits or services under those programs; (c) possible changes in or alternatives to those programs or procedures; or (d) possible changes in methods or levels of payment for benefits or services under those programs.
☐45 CFR 46.101(b)(6) - Taste and food quality evaluation and consumer acceptance studies, (a) if wholesome foods without additives are consumed or (b) if a food is consumed that contains a food ingredient at or below the level and use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

REQUEST FOR EXPEDITED REVIEW UNDER THE FOLLOWING CATEGORIES

45 CFR 46.110 - Expedited review procedures for certain kinds of research involving no more than minimal risk, and for minor changes in approved research. The IRB makes the final decision whether or not a proposal may be expedited. If the protocol cannot be reviewed under an expedited category, it will be placed on the next available IRB meeting agenda.

Expedited Review Adjunct Categories (Do not check unless requesting expedited review)

☐1. Clinical studies of drug and medical devices only when condition (a) or (b) is met. (a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (Note: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review.) (b) Research on medical devices for which (i) an investigational device exemption application (21 CFR Part 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

☐2. Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as described. (a) From healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and
children, 2 considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.
☐3. Prospective collection of biological specimens for research purposes by non-invasive means. Examples: (a) hair and nail clippings in a non-disfiguring manner; (b) deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction; (c) permanent teeth if routine patient care indicates a need for extraction; (d) excreta and external secretions (including sweat); (e) uncannulated saliva collected either in an unstimulated fashion or stimulated by chewing gumbase or wax or by applying a dilute citric solution to the tongue; (f) placenta removed at delivery; (g) amniotic fluid obtained at the time of rupture of the membrane prior to or during labor; (h) supra- and subgingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylatic scaling of the teeth and the process is accomplished in accordance with accepted prophylactic techniques; (i) mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings; (j) sputum collected after saline mist nebulization.
☐4. Collection of data through non-invasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.
☐5. Research involving materials (data, documents, records, or specimens) that have been collected or will be collected solely for non-research purposes (such as medical treatment or diagnosis). *(Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b) (4). This listing refers only to research that is not exempt.)*
☐6. Collection of data from voice, video, digital, or image recordings made for research purposes.
☒7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation or quality assurance methodologies. *(Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b) (2) and (b) (3). This listing refers only to research that is not exempt.)*
☐8. Continuing review of research previously approved by the convened IRB as follows: (a) Where (i) the research is permanently closed to the enrollment of new subjects; (ii) all subjects have completed all research-related interventions; and (iii) the research remains active only for long-term follow-up of subjects; or (b) Where no subjects have been enrolled and no additional risks have been identified; or (c) Where the remaining research activities are limited to data analysis.
☐9. Continuing review of research, not conducted under an investigational device exemption where categories two (2) through eight (8) do not apply but the IRB has determined and documented at a convened meeting that the research involves no greater than minimal risk and no additional risks have been identified. *(Note: This category must be pre-approved by the IRB during initial protocol review and approval during a convened meeting.)*

Revised 02/17/06

Part II: Detailed Study Description

Part A – Protocol Information

1. Selection of Subjects

a. Source and number: **Texas colleges and universities (see attached List of Texas colleges and universities) professors and their students will participate in this study. Our goal is to obtain 800 completed surveys.**

b. Method of recruitment and selection: **The investigator will solicit solicit participation from Texas colleges and universities via e-mail and telephone calls. Participants will be based on a voluntary basis. Once professor gives permission to administer survey in their classroom, student participation will be voluntary.**

c. Ages and gender: **Both male and female college-age adults (ages 18-65+) will participate in this study.**

d. Compensation: **No compensation will be provided to professors or student participants.**

e. Location and duration of experiment: **Regular scheduled classroom setting for participanting Texas colleges and universities listed above (part II, A, 1a).**

f. Specific steps to ensure confidentiality or anonymity of responses of results: **Completed Conceptual Inventory of Natural Selection Surveys will be coded alphanumerically for the sole purpose of identifying only the specific Texas colleges and/or university. In no manner, shape, or form will participants be directly linked to their corresponding survey.**

g. The investigator's relationship to subjects: **None other than investigative role.**

2. Purpose of study: To meet the future demand for ethnic specific knowledge, we propose to determine Texas' Latino student attitudes toward evolution and natural selection by surveying college students from Texas rural, urban, and metropolitan areas. An understanding of Latino knowledge and attitudes will allow agencies to better surve their stakeholders and most importantly to protect our natural resources. Our findings will directly help natural resource agencies better reach the Texas Latino Population by filling in knowledge gaps in current research regarding Latino knowledge and attitudes toward biology of natural selection.

3. Research Procedures: Telephone and e-mail solicitations of Texas college and university professors will constitute the recruitment phase I of this project. Data collection, phase II, involves voluntary participation in the competion of written surveys by students during regularly scheduled classes in the Fall semester of 2007. A data entry and analysis phase will follow. The final product from this research will include a dissertation.

a. Physical/Behavioral Aspects: **Participants will be asked to complete a written, multiple-choice knowledge and attitude survey.**

b. Deception or Coercion: **None involved.**

4. Risks and Benefits to Subjects

a. A description of any potential risks or discomforts to the subject: **None**

b. A definition of benefits to the research subject or alternatives for participation in the study. *Note: Do not include broad benefits to society or potential research benefits to a group as a benefit to the subjects.* **No personal benefits are derived from participating in this study other than the satisfaction derived from offering their perspectives on important social and environmental issues.**

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Revised 02/17/06

Part B – Signature Assurance

Received
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***Principal Investigator/Graduate Student Assurance Statement**

I understand Texas A & M University's policy concerning research involving human subjects and I certify that:

1. *I have read The Belmont Report, "Ethical Principles and Guidelines for the Protection of Human Subjects of Research" and subscribe to the principles it contains. In light of this Declaration, I present for the Board's consideration this application, which will be explained to the subject about the proposed research.*
2. *I accept responsibility for the scientific and ethical conduct of this research study;*
3. *I will obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form:*
4. *I will immediately report to the IRB any serious adverse reactions and/or unanticipated effects on subjects which may occur as a result of this study;*
5. *I will complete, on request by the IRB, the Continuation/Final Review Forms.*

SIGNATURE: Maria R. Gutierrez DATE: **July 25, 2007**

TYPED NAME: **Maria R. Gutierrez**

CO-INVESTIGATOR SIGNATURE: ______ DATE: ______

TYPED NAME: ______

***Faculty/Research Advisor's Assurance Statement**

I certify that I have read and agree with this proposal, that the PI has received adequate training to perform this research, and will receive adequate supervision while performing this research.

SIGNATURE: ______ for Cruz C. Torres ______ DATE: **July 25, 2007**

TYPED NAME: **Dr. Cruz C. Torres and Dr. Ben Wu**

*** All investigators must have the signature from the department head for completion of the signature assurance. Undergraduate and graduate students must have faculty/research advisor's signature in addition to the signature of the department head.**

****Department Head**

This is to certify that I have reviewed this research protocol and agree that the research activity is within the mission of the Department and appropriate for the responsibilities and assigned duties of the principal investigator.

SIGNATURE: ______ for SAW DATE: 7-25-07

TYPED NAME: **Dr. David Scott-RPTS & Dr. Steve Whisenant-ESSM**

****If the principal investigator is also the Department Head, the College Dean or equivalent must sign the Signature Assurance Sheet.**

Revised 02/17/06

CONFLICT OF INTEREST STATEMENT

All Principal Investigators and Co-Investigators must complete a separate Conflict of Interest Statement, and comply with the conditions or restrictions imposed by the University to manage, reduce, or eliminate actual or potential conflicts of interest or forfeit IRB approval and possible funding. This disclosure must also be updated annually when the IRB protocol is renewed.

Principal Investigator: **Maria R. Gutierrez**

Co-Investigator: _____

Department: **ESSM** College: **AGRICULTURE AND LIFE SCIENCES**

Phone **210-279-4024** Email **mrgutierrez@ag.tamu.edu** Fax **none**
Mail Stop **2138**

Received
Research Compliance
JUL 25 2007
HSPP

IRB Office Use Only

Project Title:

Cultural Factors Effects on Latino Knowledge of Evolution and Narual Selection

Funding Agency: **None**

Funding Administrator: RF ☐ TAES ☐ TEES ☐ TAMU ☐ TTI ☐

☒ **I have no conflict of interest related to this project.**
☐ **I have a non-financial conflict of interest related to this project. (If checked, please describe below.)**

☐ I have a financial conflict of interest related to this project. (If checked, please provide information regarding the financial interest as described below and as it applies to this project. All items must be marked confidential and provided in a separate envelope or folder.)

a) The names of affected corporations, both for-profit and not-for-profit, for which the person serves as a member of the governing board in the capacity of a director, advisory director, trustee, or otherwise.
b) The names of affected corporations for which the person serves as an executive officer.
c) The name of affected partnerships, limited partnerships, proprietorships, or other business associations of which the person is a partner, joint venture or owner.
d) The amount of any compensation received for services related to (a), (b), (c), including any benefits, direct or indirect (reported by range of amounts), and benefits received for intellectual property rights (e.g., patents, copyrights, and royalties from such rights).
e) Affected business entities in which the person holds a controlling interest or is the principal shareholder.
f) Whether the person is employed by any affected business entities described in (a) through (e) above that have any relationship to Texas A&M University or any of its components, and a brief description of such relationship.

Maria R. Gutierrez 7-25-07

Signature of Investigator
(Original signature only – a "per" signature is not acceptable)

Date

Texas College and University List

Sul Ross State University
P.O. Box C-114
Alpine, Texas 79832

Texas A&M University - Corpus Christi
6300 Ocean Dr.
Corpus Christi TX, 78412-5503

Texas A&M International University
Office of Enrollment Management & School Relations
5201 University Blvd-Student Center 126
Laredo, TX 78041

Texas A&M University-Kingsville
700 University Blvd. MSC 114
Kingsville, TX 78363

University of Houston, Downtown
One Main Street
Houston, TX 77002

University of Texas at Brownsville
80 Fort Brown
Brownsville, TX 78520

The University of Texas at El Paso
500 West University Avenue
El Paso, Texas 79968

The University of Texas at San Antonio.
6900 N. Loop 1604 West
San Antonio, TX 78249

University of Texas of the Permian Basin
4901 East University Blvd.
Odessa, TX 79762

University of Texas Pan American
1201 W. University Drive
Edinburg, TX 78541

Description of Conceptual Inventory of Natural Selection Survey

The overall objective of this study is to investigate and determine if Hispanic and Non-Hispanic university students differ in their misconceptions of natural selection and, if so, could cultural factors contribute to the differences in their misconceptions? Specifically, I will explore and identify which misconceptions of natural selection exist and are more prevalent within the Hispanic/Latino student population who are enrolled in Hispanic-Serving Institutions in Texas. In addition, I will investigate the cultural factors that significantly impact and are linked in the formation of these misconceptions. The hypothesis for this study is that: "cultural background and cultural factors such as linguistics, cultural norms, and religion contribute to misconceptions of natural selection. If this is true, then Hispanic/Latino students will answer the survey notably different than Non-Hispanic students."

The survey that will be disseminated aims at understanding how college students in nonmajor biology courses conceptualize the process of natural selection and the results reported by Anderson et al (2002) have revealed that most student-thinking is not in line with suitable biological theory and that most students attribute trait changes to a notion that is need-driven through adaptation. In addition, students do not accept the roles of variation of traits within a population; however, they do tend to believe that traits are gradual changes and occur in all members of a population (Anderson et al, 2002).

The survey's answer format includes fill in the blank and multiple-choice items. All answers will be provided on the questionnaire itself. Pencils will be provided to the participants for survey completion.

E-mail Write-up to Initially Contact Professors:

Dear Professor:

My name is María R. Gutiérrez. I am a Ph.D. Candidate at Texas A&M University, in the College of Agriculture and Life Sciences, Department of Ecosystem Science and Management. I'm currently working under the direction and supervision of Dr. Cruz C. Torres (CCTorres@ag.tamu.edu). My proposed research project is to survey university nonbiology major students who are attending a four-year university and are enrolled in a general, introductory, or first semester biology course this fall semester. The scope of my study is in the area of evolution and natural selection. Therefore, I am writing not only to provide background information about my proposed project but also to request your permission and assistance in implementing the survey that will be part of my Ph.D. dissertation.

In addition to the general U.S. Census demographic information, my research project involves implementing a questionnaire written and validated by Anderson, D.L., Fisher, K.M. & Norman, G.J. (2002) to determine students' knowledge of evolution and natural selection. The multiple-choice survey will take no longer than 15-20 minutes to complete. My intent is to administer the questionnaire, targeting students attending Hispanic-Serving Institutions within the state of Texas during the 2007 Fall Semester. Of course, this is contingent upon permission being granted and your willingness to allow me 15-20 minutes of class time either the first day of class or within the first week of classes; as I'm attempting to collect my data before any lectures on evolution and natural selection are conducted.

My proposed project is currently being reviewed by the Texas A&M Institutional Review Board (IRB) office. Upon IRB approval and your willingness to allow me to disseminate my survey, I will contact your IRB office and inquire as to what type of procedures I must follow in order to comply with your institution's Office of Research Compliance.

Once permission is granted to administer the questionnaire, I will contact you to obtain the date, time, and location of your classes. If I'm unable to personally administer the surveys (due to scheduling conflicts) I will seek the assistance of someone locally to assist me in administering the surveys. However, since I do not wish to disrupt your classroom by having someone you may not be familiar with conduct the survey; please inform me if you have a person of preference whom you would recommend to assist me. I plan to personally compensate anyone who assists me administer the surveys with a $20.00 gratuity for their assistance. I also plan to have the surveys delivered and returned to me by Federal Express with all fees paid. In any event, no cost to you or your institution will be incurred by allowing me to administer the research questionnaires.

I request that you please inform me as to your decision to grant me permission to administer my research questionnaire and survey to your students. Also, please let me know if you have additional questions, concerns, or need additional information. I can be contacted via cell phone (210-279-4024) and/or via e-mail at mrgutierrez@ag.tamu.edu.

I would like to thank you in advance for your time and consideration. I look forward to hearing from you soon.

Sincerely,

María R. Gutiérrez
Ph.D. Candidate

Script for Telephone Solicitation

Maria R. Gutierrez = MRG

MRG: Hello Dr._______, my name is Maria R. Gutierrez and I'm a Ph.D. Candidate at Texas A&M University at College Station in the College of Agriculture and Life Sciences, Department of Ecosystem Science and Management. I'm working under the direction and guidance of Dr. Cruz C. Torres and I'm conducting my dissertation research on Hispanic-Serving Institutions within the state of Texas and I'm surveying undergraduate nonbiology majors on evolution and natural selection. I came across your name from your department's website and I'm calling to provide you with background information regarding my project in hopes that you will grant me permission and assistance to implement a survey as part of my dissertation research. Would you be interested in finding out more about my project?

If professor is interested in learning more:

MRG: My dissertation research project involves administering a questionnaire that was written and validated by Anderson, D.L., Fisher, K.M. & Norman, G.J. (2002) to determine students' knowledge of evolution and natural selection. The multiple-choice survey will take no longer than 15-20 minutes to complete since it contains the general U.S. Census demographic information and the 13 multiple-choice questions. My intent is to administer the questionnaire, targeting students attending Hispanic-Serving Institutions within the state of Texas during the Fall 2007 Semester. Of course, this is contingent upon permission being granted and your willingness to allow me 15-20 minutes of class time either the first day of class or within the first week of classes; as I'm attempting to collect my data before any lectures on evolution and natural selection are conducted.

My proposed project is currently being reviewed by the Texas A&M Institutional Review Board (IRB) office. Upon your willingness to allow me to disseminate my survey, I will contact your IRB office and inquire as to what type of procedures I must follow in order to comply with your institution's Office of Research Compliance.

Once permission is granted to administer the questionnaire, I will contact you to obtain the date, time, and location of your classes. If I'm unable to personally administer the surveys (due to scheduling conflicts) I will seek the assistance of someone locally to assist me in administering the surveys. However, since I do not wish to disrupt your classroom by having someone you may not be familiar with conduct the survey; please inform me if you have a person of preference whom you would like to assist me. I plan to personally compensate anyone who assists me administer the surveys with a $20.00 gratuity for their assistance. If I am unable to personally administer the questionnaires, I will have them delivered to you and returned to me by Federal Express with all fees paid. In any event, no cost to you or your institution will be incurred by allowing me to administer the research questionnaires.

Would you like to schedule a survey date and time for the Fall 2007 Semester?

Exchange of information and scheduling will follow.

If professor is not interested in participating:

MRG: I can understand your reservations thus; I would like to thank you for your time. If you were to change your mind, my name is Maria R. Gutierrez and my e-mail address is mrgutierrez@ag.tamu.edu. Once again, than you for your consideration and have a nice day. Goodbye.

Script Preceding Questionnaire

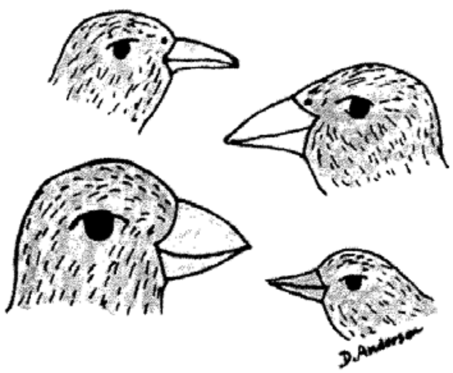
Hello, my name is Maria R. Gutierrez and I am a Ph.D. Candidate at Texas A&M University at College Station, in the College of Agriculture and Life Sciences, Department of Ecosystem Science and Management. I am currently working under the direction and guidance of Dr. Cruz C. Torres and I am conducting my research on Hispanic-Serving Institutions university students on knowledge of evolution and natural selection. Dr. _________ has granted me permission to administer this survey that will take approximately 15-20 minutes to complete. The information you provide will be strictly confidential and your final course grade will not be affected by participating or not participating in this survey.

Please read the questionnaire carefully and thoroughly and mark your responses where indicated. At the end of the survey, my contact information is provided in case you should ever have any questions regarding my research project.

I would like to thank you in advance for your time and cooperation. You may begin.

Conceptual Inventory of Natural Selection Survey

Part One: Galapagos Finches



Scientists have long believed that the 14 species of finches on the Galapagos Islands evolved from a single species of finch that migrated to the islands one to five million years ago (Lack, 1940). Recent DNA analyses support the conclusion that all of the Galapagos finches evolved from the warbler finch (Grant, Grant & Petren, 2001; Petren, Grant & Grant, 1999). Different species live on different islands. For example, the medium ground finch and the cactus finch live on one island. The large cactus finch occupies another island. One of the major changes in the finches is in their beak sizes and shapes as shown in this figure.

Choose the one answer that best reflects how an evolutionary biologist would answer.

1. What would happen if a breeding pair of finches was placed on an island under ideal conditions with no predators and unlimited food so that all individuals survived? Given enough time, the finch population would
   a. stay small because birds only have enough babies to replace themselves.
   b. double and then stay relatively stable.
   c. increase dramatically.
   d. grow slowly and then level off.

2. Finches on the Galapagos Islands require food to eat and water to drink.
   a. When food and water are scarce, some birds may be unable to obtain what they need to survive.
   b. When food and water are limited, the finches will find other food sources, so there is always enough.
   c. When food and water are scarce, the finches all eat and drink less so that all birds survive.
   d. There is always plenty of food and water on the Galapagos Islands to meet the finches' needs.

3. Once a population of finches has lived on a particular island with for many years, the population
   a. continues to grow rapidly.
   b. remains relatively stable, with some fluctuations.
   c. dramatically increases and decreases each year.
   d. will decrease steadily.

4. In the finch population, what are the primary changes that occur gradually over time?
   a. The traits of each finch within a population gradually change.
   b. The proportions of finches having different traits within a population change.
   c. Successful behaviors learned by finches are passed on to offspring.
   d. Mutations occur to meet the needs of the finches as the environment changes.

5. Depending on their beak size and shape, some finches get nectar from flowers, some eat grubs from bark, some eat small seeds, and some eat large nuts. Which statement best describes the interactions among the finches and the food supply?
   a. Most of the finches on an island cooperate to find food and share what they find.
   b. Many of the finches on an island fight with one another and the physically strongest ones win.
   c. There is more than enough food to meet all the finches' needs so they don't need to compete for food.
   d. Finches compete primarily with closely related finches that eat the same kinds of food, and some may die from lack of food.

6. How did the different beak types first arise in the Galapagos finches? The changes in the finches' beak
   a. size and shape occurred because of their need to be able to eat different kinds of food to survive.
   b. occurred by chance, and when there was a good match between beak structure and available food, those birds had more offspring.
   c. occurred because the environment induced the desired genetic changes.
   d. changed a little bit in size and shape with each successive generation, some getting larger and some getting smaller.

7 What type of variation in finches is passed to the offspring?
   a. Any behaviors that were learned during a finch's lifetime.
   b. Only characteristics that were beneficial during a finch's lifetime.
   c. All characteristics that were genetically determined.
   d. Any characteristics that were positively influenced by the environment during a finch's lifetime.

8 What caused populations of birds having different beak shapes and sizes to become distinct species distributed on the various islands?
   a. The finches were quite variable, and those whose features were best suited to the available food supply on each island reproduced most successfully.
   b. All finches are essentially alike and there are not really fourteen different species.
   c. Different foods are available on different islands and for that reason, individual finches on each island gradually developed the beaks they needed.
   d. Different lines of finches developed different beak types because they needed them in order to obtain the available food.

9. A typical natural population of finches consists of hundreds of finches. Which statement best describes the finches of a single species in an isolated population?
   a. The finches share all of the same characteristics and are identical to each other.
   b. The finches share all of the essential characteristics of the species; the minor variations they display don't affect survival.
   c. The finches are all identical on the inside, but have many differences in appearance.
   d. The finches share many essential characteristics, but also vary in many features.

10. Fitness is a term often used by biologists to explain the evolutionary success of certain organisms. Which feature would a biologist consider to be most important in determining which finches were the "most fit"?
   a. Large body size and ability to fly quickly away from predators.
   b. Excellent ability to compete for food.
   c. High number of offspring that survived to reproductive age.
   d. High number of matings with many different females.

Part Two: Demographic Information

1. Next we would like to ask you some questions that will help us get to know you better. Please answer all questions where indicated:

a. What is your major? ______________________

b. What is your academic classification?

1 Freshman
2 Sophomore
3 Junior
4 Senior
5 Other (Please specify.) ______________________

c. What is your age? ______________________

d. What is your sex?

1 Male
2 Female

e. Which of the following ethnicities best describes you?

1 Mexican (born in Mexico)
2 Mexican-American (born in the United States)
3 Anglo-American
4 Other Please Specify. ______________________

2. Religious Preference:

a. Please mark the number that illustrates your religious preference? (Please indicate one.)

1 Catholic
2 Protestant (Specify) ______________________
3 Non-Christian (Specify) ______________________

b. How often do you attend religious services?

1 Never	4 Several times a year	7 Nearly every week
2 Less than once a year	5 About once a month	8 Every week
3 About once or twice a year	6 2-3 times a month	9 Several times a week

c. In the past 30 days, did you attend a religious service, other than a wedding or funeral?

1 Yes
2 No

3. Political Orientation:

a. Do you consider yourself an active environmentalist, sympathetic to environmental causes but not active, neutral, or unsympathetic to environmental causes?

1 Active
2 Sympathetic
3 Neutral
4 Unsympathetic
5 Don't know

b. Generally speaking, do you usually think of yourself as a…?
1 Republican
2 Democrat
3 Independent
4 Other (Please specify.)________________________________

c. Did you get a chance to vote in the last election?
1 Yes
2 No

d. How important is a candidate's position on environmental issues in influencing the way you vote?
1 Very important
2 Somewhat important
3 Not very important

4. Below are some questions about yourself. Please answer where indicated:

a. What is **your** hometown? ________________________________
(Please specify with **City** and **State**)

b. Please select **one** of the following that best describes **you.**
1 You were born in Mexico or other country.
2 You were born in USA; either parent born in Mexico or other country.
3 You were born in USA, both parents born in USA, and all grandparents born in Mexico or other country.
4 You and your parents were born in USA and at least one grandparent born in Mexico or other country with remainder born in the USA.
5 You and your parents born in the USA and all grandparents born in the USA.

5. Education:

a. What is the **highest grade completed** in either elementary or high school for which your **mother** and **father** received credit? (Please Specify grade.) **Mother** ____________ **Father** ____________

b. For each parent, please mark whether they have attended / received a…

	Mother		Father	
	Yes	No	Yes	No
1. High school diploma?	1	2	1	2
2. Technical school?	1	2	1	2
3. College, but no degree?	1	2	1	2
4. College degree?	1	2	1	2
5. Graduate degree?	1	2	1	2

6. Income:

a. Are you employed?

1 Yes
2 No

b. Below is a list of income categories. First, please select the income category (by circling the number) that is closest to **your annual income in US dollars**. Then, please select the income category that is closest to your **parent's combined annual income in US dollars**.

Your Annual Income		Parent's Combined Annual Income	
1	Under $1,000	1	Under $1,000
2	$ 1,000 to 2,999	2	$ 1,000 to 2,999
3	$ 3,000 to 3,999	3	$ 3,000 to 3,999
4	$ 4,000 to 4,999	4	$ 4,000 to 4,999
5	$ 5,000 to 5,999	5	$ 5,000 to 5,999
6	$ 6,000 to 6,999	6	$ 6,000 to 6,999
7	$ 7,000 to 7,999	7	$ 7,000 to 7,999
8	$ 8,000 to 9,999	8	$ 8,000 to 9,999
9	$10,000 to 14,999	9	$10,000 to 14,999
10	$15,000 to 19,999	10	$15,000 to 19,999
11	$20,000 to 24,999	11	$20,000 to 24,999
12	$25,000 to 34,999	12	$25,000 to 34,999
13	$35,000 to 39,999	13	$35,000 to 39,999
14	$40,000 to 49,999	14	$40,000 to 49,999
15	$50,000 or 59,999	15	$50,000 or 59,999
16	$60,000 to 74,999	16	$60,000 to 74,999
17	$75,000 to 89,999	17	$75,000 to 89,999
18	$90,000 to 109,999	18	$90,000 to 109,999
19	$110,000 or over	19	$110,000 or over

Human Participant Protections Education for Research T

Completion Certificate

This is to certify that

Maria R. Gutierrez

has completed the **Human Participants Protection Education for Research Teams** online course, sponsored by the National Institutes of Health (NIH), on 11/18/2003.

This course included the following:

- key historical events and current issues that impact guidelines and legislation on human participant protection in research.
- ethical principles and guidelines that should assist in resolving the ethical issues inherent in the conduct of research with human participants.
- the use of key ethical principles and federal regulations to protect human participants at various stages in the research process.
- a description of guidelines for the protection of special populations in research.
- a definition of informed consent and components necessary for a valid consent.
- a description of the role of the IRB in the research process.
- the roles, responsibilities, and interactions of federal agencies, institutions, and researchers in conducting research with human participants.

National Institutes of Health
http://www.nih.gov

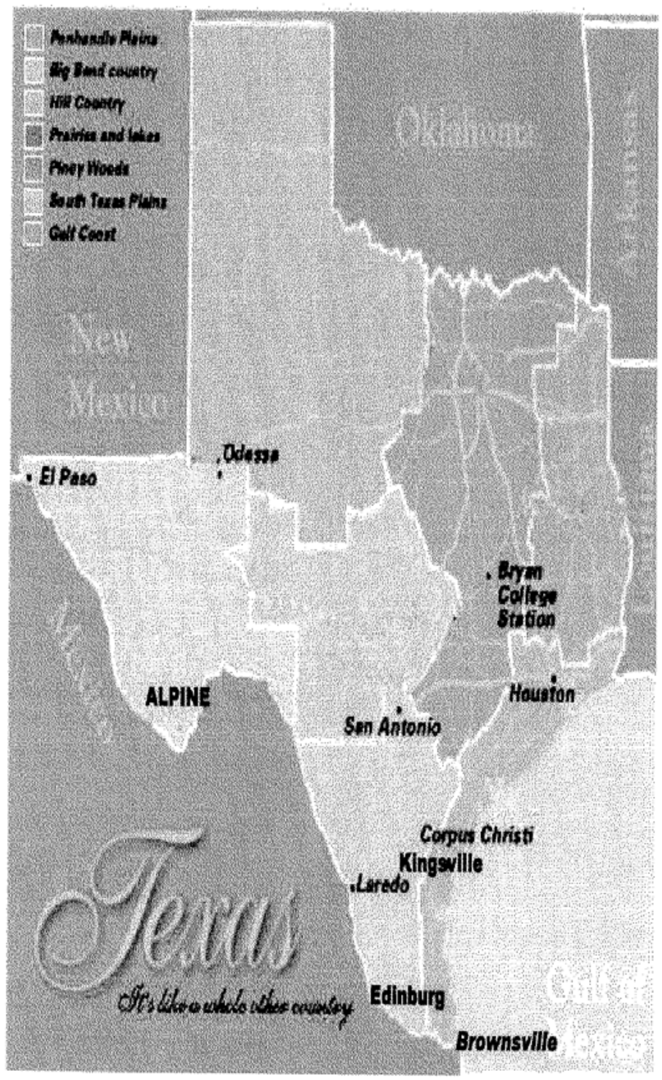
Office of the
Vice President for Research
Texas A&M University

Certificate of Completion

Dear Maria R. Gutierrez,

This certificate has been given to you because you have completed the Human Subject Research module and successfully answered all of the quiz questions for the year 2003.

VPR Office
Texas A&M University


Panhandle Plains
Big Bend country
Hill Country
Prairies and lakes
Piney Woods
South Texas Plains
Gulf Coast
Oklahoma
New Mexico
Odessa
El Paso
Bryan College Station
ALPINE
Houston
San Antonio
Corpus Christi
Kingsville
Laredo
Texas
It's like a whole other country
Edinburg
Brownsville
Gulf of Mexico

APPENDIX B

STUDENT RECRUITMENT REVISIONS SUBMITTED TO THE IRB OFFICE
(Replaces page 18)

STUDY INFORMATIONAL SHEET

Cultural Factors Effects on Latino Knowledge of Evolution and Natural Selection

You have been asked to participate in a research study that aims at understanding how college students in nonmajor biology courses conceptualize the process of natural selection and how cultural factors play a role in the students' notion of evolution by means of natural selection. You have been selected as a possible participant because the college and/or university you currently attend is a Hispanic-Serving Institution within the state of Texas and because you are currently enrolled in an introductory or general biology course for nonmajors. You also have been selected as a possible participant because your professor has granted permission to the investigator to disseminate her questionnaire during your class time. All of your classmates are being given the same opportunity to participate in this study on a voluntary basis. A total of 800 people have been asked to participate in this study. The purpose of this study is to gain an understanding of how college students enrolled in a nonmajor biology course conceptualize the process of evolution by means of natural selection. In addition, this study is evaluating if cultural factors play a role in how natural selection is conceptualized.

If you agree to be in this study, you will be asked to complete a questionnaire. This study does not require the use of any video or audiotaping. This study will take approximately 15-20 minute to complete. The risks associated with this study are minimal. The benefits of your participation include the opportunity for the investigator to make a contribution to the literature since little research has been conducted in the area of cultural factors and natural selection. In addition, the results of this study could facilitate an opportunity for a qualitative improvement of the educational system in regard to how evolution is taught in schools throughout the U.S. The findings could be a driving force in continuing to improve curricula; and thus benefit students throughout the educational continuum. This ultimately could provide students with the opportunity to benefit from ecology education and thus, provide students with the opportunity to apply and synthesize what they learn in addition to exploring careers in the sciences. You will not receive any compensation for participating in this study. This study is confidential because you will not be asked to write your name on the questionnaire itself. Therefore, you will never appear on any research document, and no single individual's answer will ever be reported. Thus, group findings will be reported. In addition, the records of this study will be kept private. No identifiers linking you to the study will be included in any sort of report that might be published. Research records will be stored securely and only the investigator (Maria R. Gutierrez) will have access to the records.

Your decision whether of not to participate will not affect your current or future relations with Texas A&M University at College Station, Texas A&M International, Texas A&M Kingsville, Texas A&M Corpus Christi, Sul Ross State University, University of Houston, Downtown, University of Texas at Brownsville, The University of Texas at El Paso, The University of Texas at San Antonio, University of Texas of the Permian Basin, University of Texas Pan American. If you decide to participate, you are free to refuse to answer any of the questions that may make you uncomfortable. You can also withdraw at any time with out your relations with the university, job, benefits, etc., being affected. You can contact

Maria R. Gutierrez	Dr. Cruz C. Torres
Graduate Student	Associate Professor
1007 E. 27th St.	Dept. of Recreation, Park & Tourism Sciences
Bryan, TX 77803	Texas A&M University
210-279-4014 (Cell #)	979-845-8522
mrgutierrez@ag.tamu.edu	CCTorres@ag.tamu.edu

with any questions about this study.

This research study has been reviewed by the Institutional Review Board - Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects' rights, you can contact the Institutional Review Board through Ms. Melissa McIlhaney, IRB Program Coordinator, Office of Research Compliance, (979)458-4067, mcilhaney@tamu.edu.

You have read the above information. You have asked questions and have received answers to your satisfaction. You have been given a copy of this consent document for you records.

Signature of Investigator:____________________________________ Date: ________________________

APPENDIX C

IRB APPROVAL NOTIFICATION

From:	"Office IRB" <irb@tamu.edu>	Wednesday - August 15, 2007 8:48 AM
To:	"GUTIERREZ MARIA" <MRGUTIERREZ@AG.TAMU.EDU>, "Office IRB" <irb@tamu.edu>	
Subject:	IRB Announcement	
Attachments:	TEXT.htm (91 bytes)	[View] [Open] [Save As]
	815200784802AM31682892102.htm (14127 bytes)	[View] [Open] [Save As]
	Mime.822 (18695 bytes)	[View] [Open] [Save As]

The attached file is a notice regarding the continuing compliance of your research project

TEXAS A&M UNIVERSITY
VICE PRESIDENT FOR RESEARCH - OFFICE OF RESEARCH COMPLIANCE

1186 TAMU
College Station, TX 77843-1186
1500 Research Parkway, Suite B-150

979.458.1467
FAX 979.862.3176
http://researchcompliance.tamu.edu

Institutional Review Board

DATE: 13-Aug-2007

MEMORANDUM

TO: GUTIERREZ, MARIA

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Initial Review

Protocol Number:	2007-0447
Title:	Cultural Factors Effects on Latino Knowledge of Evolution and Natural Selection
Review Category:	Exempt from IRB Review

The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

This determination was based on the following Code of Federal Regulations:

(http://wwww.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

45 CFR 46.101(b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation

Provisions:

This electronic document provides notification of the review results by the Institutional Review Board.

APPENDIX D

IRB TITLE APPROVAL NOTIFICATION

TEXAS A&M UNIVERSITY
DIVISION OF RESEARCH AND GRADUATE STUDIES - OFFICE OF RESEARCH COMPLIANCE
1186 TAMU, General Services Complex 979.458.1467
College Station, TX 77843-1186 FAX 979.862.3176
750 Agronomy Road, #3500 Http://researchcompliance.tamu.edu

Human Subjects Protection Program Institutional Review Board

DATE: 26-Oct-2009

MEMORANDUM

TO: GUTIERREZ, MARIA

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Amendment

Protocol Number: 2007-0447

Title: Cultural Factors Effects on Latino Knowledge of Evolution and Natural Selection

Review Category: Exempt from IRB Review

It has been determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

This determination was based on the following Code of Federal Regulations:
(http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

45 CFR 46.101(b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Provisions: Title of study changed to "Conceptual Knowledge of Evolution and Natural Selection: How Culture Affects Knowledge Acquisition."

This electronic document provides notification of the review results by the Institutional Review Board.

APPENDIX E

IRB APPROVAL PROTOCOL NUMBERS

University	IRB Protocol Number	Geographical Location
Texas A&M College Station	2007-0447	College Station, TX
Texas A&M Corpus Christi	2007-044708	Corpus Christi, TX
Texas A&M-Kingsville	2007-0447E	Kingsville, TX
Texas A&M International	2007-044708E	Laredo, TX
University of Texas at San Antonio	07-211E	San Antonio, TX
University of Texas at Brownsville	07-048E	Brownsville, TX
University of Texas-Pan American	07-048E	Edinburg, TX
University of Texas of the Permian Basin	07-0408	Odessa, TX
Sul Ross State University	07-0447E	Alpine, TX

APPENDIX F

SUPPLEMENTAL READING RESOURCES

List of Evolutionary Theory Readings to Improve Conceptual Understanding Source: Anderson, D.L., 2003, p. 218.		
Reading # and Topic	**Section A**	**Section B**
#1 Biotic Potential	Weiner (1994). *The Best of the Finch* (pp. 100-102) Describes rapid finch reproduction after abundant rain	Audesirk & Audesirk (1996). *Biology: Life on Earth*, 5th ed. (pp.793-794) Describes experimental growth curves of eagles and bacteria with data tables and graphs
#2 Stable Populations	Jones (2000). *Darwin's Ghost* (pp. 59-62) Describes a population of swifts studied for over 200 years	Brum, McKane & Karp (1989) Biology: Exploring Life, 2nd Ed. (pp. 991-994)Describes carrying capacity of sheep in Tasmania with graph
#3 Limited survival/natural resources	*The Beak of the Finch* (Weiner(1994). pp.70-76) Describes how many finch chicks starved in a drought year	Campbell (1996). *Biology* 4th Ed. (pp.1109-1110) Describes limited factors and limited survival with graphs of seed production and beetle density.
#4 Variation	*The Beak of the Finch* (pp. 37-40, 46-48, 287) Weiner (1994). Describes variation in finch beaks and Darwin's study of variation in barnacles	Blamire (1994) *Exploring Life: The Principles of Biology* (p.335) and Minkoff & Baker (2001). *Biology Today: An Issue Approach*, 2nd Ed. (pp223-224) Describes human variation in response to environmental stress.
#5 Variation Inherited	Weiner (1994). *The Beak of the Finch* (pp. 66-68, 90) Describes finch traits that are inherited	Solomon, Berg & Martin (2001) *Biology*, 6th Ed. (pp. 398,400-401). Describes genetic polymorphism and geographic variation with table and one graph
#6 Origin of variation	Weiner (1994). *The Beak of the Finch* (pp. 214, 216-217)253-255) Describes Darwin's desire to understand the origin of variation, then goes into how variation finches and insects	Blamire (1994) *Exploring Life: The Principles of Biology* (pp. 338-339).Describes how mutation and recombination take place with two diagrams
#7 Differential survival/ change in population	Weiner (1994). *The Beak of the Finch* (pp. 89-96) Describes experimental study of how colored spots in guppies are affected by both predators and mating	Starr (2000). *Biology: Concepts and Applications*, 5th Ed. (p. 253) and Johnson (2000). *The Living World*, 3rd Ed. (p. 265) Describes stabilizing, directional and disruptive selection with two graphs
#8 Origin of species	Weiner (1994). *The Beak of the Finch* (pp. 142-143, 207-208, 231-235) Describes speciation in African cichlids, Hawaiian fruit flies, and apple flies	Mader (2001). *Biology*, 7th Ed. (pp. 310-311), Describes reproductive isolating mechanisms and modes of speciation

VITA

Name:	María del Refugio Gutiérrez
Address:	Horticulture/Forest Science Building Room #305 2138 TAMU College Station, Texas 77843-2138
Email Address:	mrgutierrez@ag.tamu.edu
Education:	B.A., Spanish, Southwest Texas State University, San Marcos, Texas, 1989
	B.A., Environmental Management and Resource Studies, Southwest Texas State University, San Marcos, Texas, 1991
	M.A.G., Environmental Management and Resource Studies, Southwest Texas State University, San Marcos, Texas, 1999
	Ph.D. Rangeland Ecology and Management Texas A&M University, College Station, Texas, 2009
	Dissertation Title: *Conceptual Knowledge of Evolution and Natural Selection: How Culture Affects Knowledge*