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Effects of an Educational Experience Incorporating an Inventory of Factors Potentially Influencing Students' Acceptance of Biological Evolution

ABSTRACT

This investigation provides an extensive review of scientific, religious, and otherwise non-scientific factors that may influence student acceptance of biological evolution. We also measure the extent to which students' levels of acceptance changed following an educational experience designed to address an inclusive inventory of factors identified as potentially affecting student acceptance of evolution (n=81, pre-test/post-test; n=37, one-year longitudinal). Acceptance of evolution was measured using the MATE instrument (Rutledge and Warden, 1999; Rutledge and Sadler, 2007) among participants enrolled in a secondary-level academic program during the summer prior to their final year of high school and as they transitioned to the post-secondary level. Student acceptance of evolution was measured to be significantly higher than initial levels both immediately following and over one year after the educational experience. Results reported herein carry implications for future quantitative and qualitative research as well as for cross-disciplinary instruction plans related to evolutionary science and non-scientific factors which may influence students' understanding of evolution.

INTRODUCTION

Evolution, defined narrowly, is the scientific principle that the diversity of life on Earth has arisen via descent with modification from a common ancestry.[1] In the broader

[1] This definition of *evolution* is derived from that used by Scott (2004, p. 23). This definition is consistent with Bell (1996, p. 9) and with the definition used by Alters and Alters (2001, p. 10), which was originally found in Futuyma (2000, p. 3), a document endorsed by the following scientific societies: American Society of Naturalists, American Behavior Society, American Institute of Biological Sciences, Ecological Society of America, Genetics Society of America, Paleontological Society, Society for Molecular Biology and Evolution, Society for the Study of Evolution, and the Society of Systematic Biologists.

sense, evolution can refer to cumulative change in the natural world over time (Scott, 2004, p. 23). Under both of these definitions, evolution has been accepted among the scientific community as a set of factual phenomena, explained and understood via a well supported body of theoretical knowledge, and deemed by scientists and science educators alike as a central and unifying principle in biology and other sciences (Sager, 2008, Wiles, 2010).

Confoundingly, however, there remains an apparent disconnect between the scientific community and much of the general public regarding the understanding and acceptance of evolution. Widespread rejection of evolution among members of the non-scientist public has been lamented by a host of scientists and science educators. Alters and Nelson (2002) reported that science educators and researchers consider the public understanding of evolution to be ‘woefully lacking’ (p. 1891). In 1998, Randy Moore, then editor of the *American Biology Teacher*, described the state of public understanding and rife rejection of evolution as ‘by far the biggest failure of science education from top to bottom’ (Christensen, 1998, p. D3), and the situation has apparently not appreciably improved (Branch and Scott, 2008; Miller, Scott, and Okamoto, 2006).

REVIEW OF FACTORS POTENTIALLY INFLUENCING STUDENT ACCEPTANCE OF BIOLOGICAL EVOLUTION

A number of scholars have deconstructed the notion of acceptance and considered its value as an educational goal pertaining to evolution (Ingram and Nelson, 2006; Sinatra, Southerland, McConaughy and Demastes, 2003; Southerland, Sinatra, and Matthews, 2001; Smith and Seigel, 2004). According to Sinatra, et al. (2003), acceptance “refer[s] to a learner’s personal assessment of the validity of a construct” based on a "systematic evaluation of the evidence" (p. 512). And after much discussion, Southerland, et al. (2001) concluded that teaching toward acceptance of evolution is an ethically defensible educational goal as long as it is not *required* of students. Ingram and Nelson (2006) asserted that student understanding of evolution is more important than student acceptance of evolution, and we certainly agree. However, they concluded from their results as well as a thorough review of prior research, 'a more favorable attitude toward evolution leads to higher achievement' (p. 9), and rejection of evolution has 'serious consequences for learning biology' (p. 9). Hence, and as so much attention has been given to acceptance of evolution in prior research and public discussion, it is clearly a matter of interest to the science education community.

Many studies have provided valuable information regarding what may influence student understanding and acceptance of evolution, which practises may be more effective for teaching evolution, and what might influence teachers' decisions about what or whether to teach about evolution. Evolution education is rapidly growing as a field of inquiry, and this trend is expected to continue into the near future (Wiles, 2011, In press). The burgeoning swell of valuable information is encouraging, as perceptions of an overall paucity of research related to the teaching and learning of evolution have been noted and lamented for some time (Alters and Nelson, 2002; Cummins, Demastes, and Hafner, 1994; Woods and Scharmann, 2001).

Evolution education has been a topic of popular debate in North America since the issue blazed onto the stage of public awareness amid the media frenzy surrounding the infamous 'Scopes Monkey Trial' (*Scopes v. State*, 1925), and questions regarding the teaching and learning of evolution have been of interest to the education research community at least since the early post-Scopes era work of Dudycha (1934). During the rest of the 20th century and into the new millennium, there have been waves of research on evolution education, perhaps having been provoked by several other well-publicized legal battles over the teaching of evolution in public schools. Courts in the U.S. have seen such litigation when attempts have been made to stifle the teaching of evolution in public schools or to have it ‘balanced’ with explanations of life’s history rooted in religion. It is clear that much of the public, as well as student, rejection of evolution stems from perceived conflict with religious teachings. In a study conducted with 518 high school students from the American Mid-West, Woods and Scharmann (2001) found that theological factors (i.e., ‘the Bible, God, religion, and church’ [Summary and Discussion, para. 4]) were most frequently identified by their participants as important in shaping the students’ attitudes about evolutionary theory.

The most well-known religious doctrine that has occasioned tension with the science of evolution is that of creationism. The (U.S.) National Academy of Sciences (NAS) broadly defines a creationist as ‘someone who rejects natural scientific explanations of the known universe’ in favor of explanations involving creation ‘by a supernatural entity’ (National Academy of Sciences, 2008, p. 37). Scott (2004) has presented an assortment of variations of creationism along a continuum of belief structures from least accepting to most accepting of evolutionary science, and there are those who accept the scientific description of evolution while still maintaining a religious belief in a Creator not at all in conflict with science, which does not examine the existence of God or other supernatural constructs. It is only those along the far creationist pole of Scott’s continuum who are at odds with the overwhelming scientific evidence that the universe, Earth, and life have in fact evolved over many millions of years. As such, it is these most extreme creationists who are often the most vehement deniers of evolution and vocal opponents of evolution education.

Religious adherence to creationism, however, is not the only factor that has been discussed in the relevant literature as potentially affecting student acceptance of evolution. In their explanation of why students reject evolution, Alters and Alters (2001) divided such factors into religious and non-religious reasons, although they recognized that some of these reasons are sometimes difficult to pigeonhole as exclusively religious or not. For example, many misconceptions about evolution may not be based on religion in and of themselves, but they may be propagated by creationists in their churches, thus lending them the weight of religious authority. These categories were later modified as *mostly* religious or *mostly* non-religious (Alters, 2005). Noting, as did Alters and Alters, the sometimes indeterminate division between these designations, we will retain their former wording for the structure of our discussion and endeavor to make note of the more important areas of ambiguity as they arise.

We will further subdivide the list of non-religious factors that may influence student acceptance of evolution into those that are scientifically based (e.g., student understanding of the evidence for evolution or of the mechanisms of evolution) and non-scientifically based (e.g., social and emotional factors), again with the caveat that these distinctions may often be nebulous.

Religious Factors

Students may perceive relationships between science and religion in a variety of ways, ranging from regarding them as incompatible or even hostile to each other, to regarding them as completely separate from each other, to regarding them as complementary or even integrated (Asghar, Wiles, and Alters, 2007a; Asghar, Wiles, and Alters, 2007b; Dagher and BouJaoude, 1997; Esbenshade, 1993; Jackson, Doster, Meadows, and Wood, 1995; Meadows, Doster, and Jackson, 2000; Shipman, Brickhouse, Dagher, and Letts, 2002). Many students are able to adopt non-confrontational views similar to that described by Gould (1997), who explained the compatibility of religious faith with acceptance of evolution via the separation of science and religion as 'non-overlapping magisteria' (p. 1622). However, a comparatively small, but far from negligible, number of students find religion and science to be in direct conflict (Shipman et al., 2002), and individuals who find science and religion to be in conflict or in tension may be resistant to learning about evolution (Meadows et al., 2000).

As previously mentioned, Woods and Scharmann (2001) found religious factors to rank at the top of those affecting the attitudes toward evolution held by the high school students they studied. Students may interpret scripture literally (Lawson and Weser, 1990; Lawson and Worsnop, 1992), and adherence to a fundamentalist faith in scripture as both inerrant and literally true is closely linked with rejection of evolution (Alters and Alters, 2001; Miller et al., 2006). When science and a literal interpretation of scripture disagree, creationist students will often side with their understanding of scripture (Alters and Alters, 2001), which 'supersedes any scientific finding or interpretation' (Miller et al., 2006, p. 765). Alters and Alters (2001) discussed this conflict in terms of biblical scholarship, explaining that students may reject evolution based on what they think the biblical explanation may be whether or not they know the actual content of the scripture.

Trani (2004) suggests that a ‘factor which appears to relate to acceptance of evolutionary theory is professed religious convictions that lead individuals to reject the theory of evolution’ (p.420). In their discussion of the implications of a study among university students who were not science majors, although religious convictions were not the focus of the research, Bishop and Anderson (1990) suggested that such metaphysical or religious commitments may affect student acceptance of evolution more profoundly than their level of knowledge of evolutionary theory or of science in general. This is consistent with the findings of other studies among biology majors (Downie and Barron, 2000) and biology teachers (Aguillard, 1999; Osif, 1997).

The religious convictions discussed most often in relation to evolution are, of course, those of creationism. The religious doctrine of Young-Earth Creationism and its so-called ‘creation science’ are at the root of many students’ rejection of evolution (Alters and Alters, 2001; Dutch, 2002). The difficulty with labeling many misconceptions generated by creation science as religious or non-religious lies in the fact that creationists often teach the claims of creation science in their churches, Bible schools, and other religious outlets (Isaak, 2006), which may lead some students to hold to these scientifically untenable notions as fervently as they would believe their religious leaders’ teachings about religious principles. Nonetheless, we will address these misconceptions in the ‘*Scientific Factors*’ sub-section of the ‘*Non-religious Factors*’ section below.

There is one misconception often furthered by the efforts of creationists, however, which warrants discussion within this section. Students who hold this misconception believe that in order to accept evolution, one must reject any faith in God or religion altogether, or, conversely, that any true believer in God must reject evolution. The dichotomy is, of course, a false one, and this is clearly evinced by the diversity of religious beliefs held by individuals who accept evolution. A striking example is afforded by the signers of the Clergy Letter, over 13,000 priests, preachers, ministers, pastors, rabbis, and other religious leaders who affirm the validity of evolutionary theory and its compatibility with their faith (Zimmerman, No date). Furthermore, the leadership bodies of many mainstream religious affiliations have issued position statements in support of the teaching of evolution in schools and indicating that rejection of evolution is not a necessary component of conventional religious faith (Sager, 2008, pp. 97-125).

Changing students' understandings of religious doctrine is not the bailiwick of teachers in public school science classrooms. However, students, perhaps especially high school students, are often epistemological dualists, and teachers are right to help their students develop a generally more flexible mode of scientific thinking. According to Woods and Scharmann (2001), 'transform[ing] their dualistic view of evolutionary theory' (Summary and Discussion, para. 6) appears to be a very important step toward achieving student acceptance of evolution. This assessment is in agreement with, and in part built upon, the work of a number of previous researchers (Nelson, 1986; Perry, 1970; Scharmann and Block, 1992).

Non-religious Factors

Scientific Factors

Overall knowledge of evolutionary theory. Student understanding of evolution has been studied in detail, and usually with regard to specific misconceptions about evolution that students often hold. Such alternative conceptions include Lamarckian ideas of inheritance of acquired traits (Banet and Ayuso, 2003; Brumby, 1984; Dagher and BouJaoude, 1997;

Deadman and Kelly, 1978; Filisky, 1999; Hallden, 1988; Jensen and Finley, 1996; Jimenez-Aleixandre, 1992; Lawson and Thompson, 1988), teleological notions that evolution is somehow driven by the *needs* of organisms (Bishop and Anderson, 1990; Brumby, 1984; Clough and Wood-Robinson, 1985; Jensen and Finley, 1996; Jimenez-Aleixandre, 1992; Zimmerman, 1986), impressions that organisms adapt by means of a conscious choice to do so (Clough and Wood-Robinson, 1985; Hallden, 1988), and the particularly confounding, yet common, misconception that humans evolved from modern apes or monkeys (Dagher and BouJaoude, 1997; Woods and Scharmann, 2001).

Perplexingly, studies assessing the degree to which student understanding of evolution is related to acceptance have returned inconsistent results. Overall understanding of evolutionary theory was found to correlate with acceptance by some (Rutledge and Warden, 1999; Rutledge and Warden, 2000; Trani, 2004). However, Sinatra et al. (2003) found no evidence of a relationship between understanding evolution and its acceptance, which is consistent with other findings (Bishop and Anderson, 1990; Demastes-Southerland, Settlage, and Good, 1995; Lord and Marino, 1993). Ingram and Nelson (2006) similarly concluded that neither acceptance nor understanding of evolution are ‘a prerequisite nor necessary condition of the other’ (p. 10).

Evidence of evolution. Student knowledge of the physical evidence of evolution was found by Woods and Scharmann (2001) to be a factor that shapes students’ attitudes about evolutionary theory. Alters and Alters (2001) discussed several evidence-related misconceptions that cause students to reject evolution, including perceived problems regarding gaps in the fossil record or ‘missing links’; erroneous reports of human and dinosaur tracks within the same geologic strata; unwarranted criticisms of or misunderstandings regarding the dating methods used to determine the age of fossils, rocks, Earth, and/or the universe; and denial of plate tectonics or continental drift. These misconceptions, although ultimately rooted in misunderstanding of science, are often perpetuated, if not entirely fabricated, by creationists (Isaak, 2006). Research has shown that increased acceptance of evolution can be achieved by presenting students with a direct comparison of various naive misconceptions associated with creationism (though without explicitly labeling them as creationist or otherwise religious misconceptions) to explanations which are more consistent with scientific evidence (Alters, 2005; Alters and Nelson, 2002; Ingram and Nelson, 2006; Nelson, 2007; Scharmann, 2005; Verhey, 2005; Wilson, 2005).

Other stumbling blocks regarding the natural history of life that may hinder students' acceptance of evolution involve uncertainties about the origin of life (Alters and Alters, 2001), which science has not fully explained. Some students may see this as a failure of science that necessitates rejection of evolution in favor of a supernatural creator. Along these lines, students may have difficulty accepting evolution because they may think it is mathematically improbable; that it may violate the laws (specifically the second law) of thermodynamics; or that organisms and/or their components are too complex to have evolved naturally, and must therefore have been 'intelligently designed' (Alters and Alters, 2001; Patterson, 1983; Strickberger, 2000). For an extensive list of misconceptions students may hold, many related to evidential issues, see Isaak (2006).

Finally, with regard to evidence, it may be important that students are exposed to many and varied sources of information. According to Pigliucci's assertion, (2002), acceptance of evolution may increase with repetition and with the number of sources and formats of information about evolution and its evidence.

Mechanisms and patterns of evolution. Some researchers have suggested that student acceptance or rejection of evolution may be related to their understanding of the mechanisms by which evolutionary change occurs. Miller et al. (2006) report strong correlations between understanding of modern genetics and acceptance of evolution. Alters and Alters (2001) describe differential student acceptance of ‘horizontal’ evolution (change within a species or ‘kind’) versus ‘vertical’ evolution (evolution of new species associated with evolutionary descent with modification), otherwise known as *microevolution* and *macroevolution* respectively. Misconceptions regarding natural selection and other evolutionary mechanisms, as well as alternative understandings of the interplay between competing theories on the mode and tempo of evolution (e.g., gradualism versus punctuated equilibrium) have also been linked to students’ acceptance or rejection of evolution (Alters and Alters, 2001; Alters and McComas, 1994).

Finally, students’ attitudes toward science and their understanding of the nature of science have been discussed at length by many researchers. It seems that in most cases, a more sophisticated understanding of the nature of science is correlated with acceptance of evolution (Alters and Alters, 2001; Rutledge and Warden, 2000; Trani, 2004), with an exceptional case being found among a population of university-level non-biology majors in which instruction in the nature of science elicited no significant change in acceptance of evolution (Bishop and Anderson, 1990).

Non-scientific Non-religious Factors

Social and emotional factors. Woods and Scharmann (2001) found that the second most important factor (behind religious belief) shaping students' attitudes about evolution is personal relationships (parents, teachers, friends, etc.). They found that students often accept or reject evolution based on an appeal to authority (i.e., church, parents, teachers, etc.), which is consistent with the findings of Demastes, Good, and Peebles (1995). In their stirring account of their own eventual acceptance of evolution, former creationists Stephen Godfrey and Christopher Smith (2005) discuss the importance of their personal relationships with their families, friends, teachers, and leaders in the clergy in terms of shaping their attitudes toward evolution.

Students may also reject evolution for emotional reasons such as fear of or discomfort with perceived implications of evolution. For example, when asked about the cosmological concept that the universe is expanding, an observation central to 'Big Bang' theory and evolution in the broad sense, many Americans expressed fear of unknown change and danger to Earth (Lightman and Miller, 1989). Such concerns were also found among high school students (Lightman, Miller, and Leadbeater, 1987). Brem, Ranney, and Schindel (2003) found that most groups among their study population of college students believed that evolutionary theory might lead to a variety of social or personal consequences. Students who accepted evolution were more likely to hold that evolutionary theory would have no social or personal impact, but students who rejected evolution (including creationists) consistently expressed the belief that evolution would lead to heightened selfishness and racism as well as diminished spirituality, sense of self purpose, and self-determination. Furthermore, students who perceived such potential repercussions of evolutionary theory viewed these consequences as decidedly negative.

Critical thinking, epistemological views, and cognitive dispositions. Critical thinking skills, described by some as ‘logical thinking’ or ‘logical reasoning’ skills, appear to be associated with higher levels of acceptance of evolution. Woods and Scharmann (2001) found a significant correlation between logical thinking skills and evolution acceptance, and they reported that logical reasoning skills accounted for 10% of the common variance in acceptance of evolution among their students. This is consistent with the findings of Lawson and Thompson (1988), Lawson and Weser (1990), and Lawson and Worsnop (1992). According to Alters and Nelson (2002) and Pigliucci (2007), critical thinking is considered to be a key aspect of learning about, understanding, and accepting evolution.

Sinatra, et al. (2003) found that students with more sophisticated epistemological views and more flexible cognitive dispositions were more likely to accept evolution. These researchers measured students’ levels of acceptance of evolution, epistemological beliefs, and cognitive dispositions, reporting that higher levels of epistemological sophistication reflecting an understanding of knowledge as ‘tentative and subject to change’ (p. 521) corresponded to greater acceptance of human evolution. Furthermore, they found that students who exhibited more open-minded cognitive dispositions were also more likely to accept human evolution. They concluded that acceptance of evolution is affected by a student’s willingness to ‘entertain knowledge change intentionally’ (p. 521). This corresponds to Lawson’s (1983) assertion that a student’s cognitive disposition can interfere with subsequent learning.

Demographic factors. Several demographic factors have been explored with respect to student understanding and acceptance of evolution. Researchers have found little to no difference among the levels of acceptance or knowledge of evolution with regard to gender (Grose and Simpson, 1982; Lord and Marino, 1993; Woods and Scharmann, 2001), race (Woods and Scharmann, 2001), and academic major (Grose and Simpson, 1982; Johnson and Peeples, 1987).

Higher academic standing has been associated with higher levels of acceptance of evolution (Dudycha, 1934; Fuerst, 1984; Lord and Marino, 1993). Moreover, a national poll discussed by Brumfiel (2005) suggested that individuals achieving higher levels of education are more likely to accept evolution. Interestingly, this poll revealed that it is only among those individuals with college degrees that slightly more than half (52%) of the respondents accept evolution. Among those with only ‘some college education’ (p. 1062, Figure 1), the proportion of respondents accepting evolution is less than one-third. However, Alters and Nelson (2002) suggest that current educational practices appear to make little, if any, difference with regard to evolutionary misconceptions citing several supporting examples. This seeming paradox may make more sense in the light of epistemological beliefs, which are related to educational level (Schommer, 1993). Essentially, individuals achieving higher levels of education are not necessarily more likely to understand evolution, but are probably more likely to accept evolution as a function of having more sophisticated epistemological views.

Gaps in the Literature and Research Questions

The reviewed literature is ambiguous regarding the effectiveness of courses containing evolutionary content with regard to increasing student acceptance of evolution. Furthermore, although some have reported changes, and others no change, in students’ levels of acceptance of evolution as a result of instruction, there appear to be no reports of the effectiveness of a course or other educational experience designed to address an inventory of suspected factors which may influence student acceptance of evolution. Additionally, much of the relevant research has been conducted in college or university settings. There are few reports monitoring changes in the levels of acceptance of evolution among high school students, and there have apparently been no studies exploring the levels of acceptance of evolution among high school students as they transition to post-secondary education.

This study addresses these gaps and areas of ambiguity in the literature by measuring changes in students' evolution acceptance levels following a concentrated evolution education experience designed around factors identified in the preceding review as potentially influencing students' acceptance of evolution. Herein, we focus on measuring the potential effects of focused instruction in evolutionary science and associated, but not necessarily science-oriented, educational activities. The primary research questions guiding the study were:

To what extent might secondary students' levels of acceptance or rejection of the occurrence of biological evolution change:

(a) immediately following an educational experience, prior to their final year in high school, specifically designed to address an inventory of factors identified as potentially affecting student acceptance of evolution? and

(b) during their final high school year after the aforementioned evolution education experience?

METHODS AND PROCEDURES

Sample

Participants and Location of Research

Data were collected in a secondary level public education setting in Arkansas, a state located in the American mid-south along what is commonly referred to as the ‘Bible Belt’. The topic of evolution is of particular interest in Arkansas, in part due to formal attempts to undermine the teaching of evolution in the state's public schools. These efforts go back as far as the Scopes era, and Arkansas has played an inglorious part in the national debate as state laws undermining evolution education have repeatedly been struck down in the federal courts (*Epperson et al. v. Arkansas,* 1968; *McLean v. Arkansas Board of Education*, 1982). Even given the fates of these laws from decades past, other anti-evolution bills have more recently been introduced in the Arkansas legislature (Arkansas House Bill 2548, 2001; Arkansas House Bill 2607, 2005). Local school districts have also played a role; for example, a warning label was for years affixed to biology textbooks in the state’s Beebe Public School District, where they were finally removed after the American Civil Liberties Union of Arkansas warned the district of imminent legal perils (National Center for Science Education, 2005). Moreover, even in the absence of such formal pressure, there is a generalised climate of hostility to teaching evolution in Arkansas that results in the frequent downplaying or omission of evolution in its public school science classrooms (Wiles, 2006; Wiles, 2008), and the state’s education standards repeatedly earned failing marks on evolution coverage (Gross et al., 2005; Lerner, 2000) though there has been recent improvement (Mead and Mates, 2009).

Participants in this research project were students of the Arkansas Governor’s School (AGS), a high-school-level summer programme of the Arkansas Department of Education. The students of AGS are selected to attend the six-week programme from a pool of applicants from across the state, whether they attend public schools, private schools, or home schools. All AGS students have completed their junior year of high school (Grade 11) and are considered to be ‘rising’ seniors (entering Grade 12). Thus, they are generally between the ages of 16 and 17 when they attend the programme.

Most AGS students have been identified as gifted, and those who take the course on evolution generally exhibit high aptitude and motivation in science. The sample population for this study (n=81) comprised a moderate majority of females (58%) over males (42%). Data provided by the AGS administration indicated that the majority (75%) of the population during the session in which this study was conducted was white, while 14% identified as black and 11% as ‘other’ (see limitations below for further discussion of sample population demographics).

Access and Entry

As most of the participants had not reached the age of majority, informed consent by the students’ parents was required in almost all cases. Consent was freely given by the parents or guardians of all participants who were minors, and all subjects granted their voluntary assent. One 18-year-old student gave consent without the requirement of parental approval. All procedures were conducted under certification issued by the appropriate university Ethics Review Board.

About the Educational Experience

The majority of the scientific and related components of the educational experience were contained within a course on evolutionary science, with supporting components being addressed in other AGS courses, seminars, and by semi-weekly guest speakers. AGS is an ideal setting for incorporating the range of factors identified during via review of the literature as potentially affecting student acceptance of evolution, largely due to: the opportunities afforded by daily extracurricular seminars and semi-weekly guest speakers; the core curriculum which all students experienced; and the inclusion of a course on evolution taken by all AGS students concentrating on studies in the natural sciences. The course on evolutionary science was specifically designed to address scientific and related factors that may influence student acceptance of evolution, and the core curriculum of AGS and presentations of guest speakers addressed other factors that are associated with acceptance of evolution that may not be best introduced in a science course.

Extracurricular Seminars and Semi-weekly Guest Speakers

The daily AGS schedule includes two extracurricular seminars, and the weekly schedule includes two opportunities for students to attend presentations by nationally and internationally recognized guest speakers. With regard to this study, two of the seminars and two of the guest speakers' presentations were of particular importance concerning evolution acceptance factors identified in the literature.

The false dichotomy between science and religion. In order to address students' potential misconception that acceptance of evolution necessitates rejection of religious faith, a factor which may arguably not be within the proper scope of a science course, participants were encouraged to attend an extracurricular seminar on the question of the compatibility of evolution with religious faith. Although attendance was voluntary, 100% of the participants attended this seminar session which addressed the various views of individuals representing a variety of religious traditions as they related to evolution and their personal faith. All religious faiths known to be represented by the students in attendance (i.e., Catholic, Protestant and evangelical Christians, Jews, Muslims, Hindus, Buddhists, etc.) were addressed. Scott's (2004) evolution/creationism continuum was used to demonstrate a range of views of individuals who accept evolution to varying degrees within their frameworks of faith. Also, students were allowed to search the list of priests, ministers, pastors, and other religious leaders signatory to the Clergy Letter, all of whom affirm the validity of evolutionary theory (Zimmerman, No date), for clergy members who represented leadership within the students' particular denominations.

Students' dichotomous views of evolution versus religion were also challenged by one of the speakers in the semi-weekly forum, a prominent local theologian, who presented a message and led discussions addressing a variety of faith traditions. His presentation and discussion sessions affirmed the idea that there need be no conflict between acceptance of evolution and faith in the divine, and he called for reconciliation of any perceived tension between science and religion.

The perceived problem of evolution and racism. The literature regarding emotional factors influencing how students think about evolution includes a discussion of possible negative implications of students' perceptions of an association between evolutionary science and increased racism (Brem, Ranney, and Schindel, 2003). In an effort to address this issue, participants were asked to attend a presentation on evolution and race which included a screening of a documentary film entitled *Race—The Power of an Illusion: The Difference Between Us*. With appearances by notable evolutionary biologists such as Joseph Graves, Stephen Jay Gould, and Richard Lewontin, the film authoritatively deplored the eugenics movement and 'racist science', revealed that the biological differences between groups of humans often categorized into separate 'races' are scientifically superficial at best and largely insignificant outside of any culturally derived meanings; demonstrated that evolutionary science emphasizes that the human population is overwhelmingly interrelated; and dispelled the misconception that evolutionary science supports racist ideology (California Newsreel, 2003). All research participants attended the presentation, and a majority participated in the discussion that followed.

Additional attention to misconceptions rooted in physics. Another visiting scholar, an accomplished physicist, delivered a presentation at one of the semi-weekly guest speaker sessions. During the following discussion period, participants engaged the speaker with questions related to evolution. The visiting physicist attempted to dispel misconceptions pertaining to the laws of thermodynamics, Intelligent Design, 'Big Bang' theory, and the age of the universe. He assured students that there is nothing to be found within modern physics that would contradict evolution. Rather, he explained, the science of physics supports evolution impressively.

AGS Core Curriculum

Students attending AGS spend the majority of the academic day in classes pertaining to their primary area of study, which was natural science for our participants. However, whether they primarily study the natural sciences, drama, social science, or any of the other seven areas of focus (referred to as their 'Area I' study), all AGS students are additionally enrolled in two core courses called 'Area II' and 'Area III', both of which address factors which may influence their acceptance of evolution.

Area II is a course on epistemology. Among the aims of the Area II curriculum are helping students to develop logical thinking skills, to develop an ability to weigh the validity of theories, and to understand new ways of thinking. According to the Area II course description, it is hoped that students 'will have an appreciation for well-formed and solidly-supported ideas even if they differ from their own' (Arkansas Governor's School, 2007). The Area II course touched on at least three factors associated with acceptance of evolution: critical thinking, epistemological disposition, and progression beyond cognitive dualism (for a detailed description of the course, its purpose, and its objectives, see http://www.hendrix.edu/ags/ags.aspx?id=11184, Section on Area II). This last factor is also broached in Area III, which is a course on personal and social development. Within this context, Area III 'fosters the development of both the personal and social awareness the students will need as their knowledge expands and they encounter diverse worldviews' (Arkansas Governor's School, 2007), and calls students to value individuals who are different from themselves and ideas differing from their own.

Course on Evolutionary Science

All participants in this research project attended AGS with a concentration in the natural sciences. As part of this curriculum, these students were enrolled in a course designed to address scientific and related factors identified in the literature as potentially affecting student acceptance of evolution. The course was multidisciplinary in nature and included instruction on the nature of science; the history of evolutionary theory; a survey of methods used in determining the chronology of cosmological, geological, and biological history; evidence of evolution drawn from the Earth and space sciences and from the biological sciences; evolutionary mechanisms; current theories regarding the pre-biotic Earth and the origin of the first organisms; and practical applications of evolutionary science such as those in the fields of medicine and agriculture. Efforts were made to encourage critical thinking, and students were challenged directly to compare preconceptions associated with creationism (though without explicitly referring to such alternative conceptions as creationist or religiously based ideas) with explanations that are more consistent with scientific evidence, as suggested by Alters and Nelson (2002) and by Nelson (2007). Also, in keeping with Pigliucci's (2002) assertion that acceptance of evolution may increase with the number of sources and formats of information about evolution and its evidence, a variety of delivery methods were employed and guest experts were invited throughout the course.

Instrument for Determining Students' Levels of Acceptance of Evolution

There are several extant measures of acceptance of evolution, such as the Measure of Acceptance of the Theory of Evolution (MATE) instrument (Rutledge and Warden, 1999); a process for measuring acceptance of evolution described by Sinatra et al. (2003); and the Evolution Attitudes Survey developed by Alters and employed with modification by Ingram and Nelson (2006). In selecting an instrument appropriate for measuring acceptance of evolution among the participant population, it was important to consider their changing academic level over the course of the research. Because the participants were recruited as high school students but would also be surveyed as they matriculated to various universities, it was necessary to select an instrument validated for measurements of evolution acceptance among both secondary and post-secondary students.

Although the MATE instrument was originally developed for use with high school biology teachers, it has subsequently been validated and employed for measuring evolution acceptance among populations of university students (Rutledge and Sadler, 2007) and high school students (Donnelly, Kazempour, and Amirshokoohi, 2007). Furthermore, the MATE has been recommended as a tool for measuring the effectiveness of instructional strategies with regard to changes in student acceptance of evolution

(Alters and Nelson, 2002; Rutledge and Sadler, 2007). Hence, the MATE instrument was adopted as the primary tool for measuring acceptance of evolution and changes therein.

The MATE instrument consists of 20 statements related to various aspects of evolutionary theory, its validity, and misconceptions commonly held by individuals who reject evolution. Participants indicate their level of agreement or disagreement with these statements on a 5-point Likert scale. Output is in the form of a score between 20 and 100, which indicates a participant's level of acceptance of evolution. Published score ranges for relative categories of evolution acceptance are listed in Table 1.

Reliability and Validity

The validity and reliability of the MATE instrument have been repeatedly measured and reported (Donnelly et al., 2007; Rutledge and Sadler, 2007; Rutledge and Warden, 1999). In all cases and with all population types studied, the MATE instrument has been shown to be a valid and reliable instrument for measuring acceptance of evolution. Evaluation of the MATE instrument has returned high scores with regard to both test-retest reliability and internal consistency reliability (Rutledge and Sadler, 2007; Rutledge and Warden, 1999). Additionally, the MATE instrument was compared to a similar instrument developed by Alters, and measurements of evolution acceptance returned through implementation of both instruments were positively and highly correlated (Ingram and Nelson, 2006). That these instruments, which were independently designed to measure the same construct, produce such similar results supports the validity of the MATE. Finally, the MATE instrument was reviewed by a panel of evolutionary scientists and science education researchers and was determined to have a high level of content validity and to be appropriate for use with the participant population.

Administration of the MATE Instrument

The MATE instrument was administered prior to the AGS educational experience, at the end of the AGS experience, and one year after the AGS experience as participants were embarking on their post-secondary education. Participants were informed that participation was entirely voluntary, and there were no consequences for non-participation. Because participants were assured anonymity, pre- and post-treatment surveys were linked according to participants' self-assigned 'codewords'. Participants were instructed to construct a codeword, which could contain letters, numbers, or other symbols found on a computer keyboard, that they would be sure to remember but would not identify the participant (e.g., they were told not to use their name or nickname as their codeword). Participants marked their surveys with their codeword but not with their names or other identifying information. The pre- and immediate post-treatment surveys were completed in a classroom setting, and the distal longitudinal survey was administered using internet-based survey software.

Data Analyses

A dependent t-test (repeated measures) was conducted to examine differences in the participants' levels of acceptance of evolution represented by MATE scores measured prior to treatment and immediately after the treatment course on evolution (n=81). This design reflects a standard one-group pretest-posttest design as described by Campbell and Stanley (1966) and listed by Isaac and Michael (1997) as one of eight 'commonly used designs' in education research (p. 70). Among the subset of participants who responded to the survey one year after the AGS experience as they entered into post-secondary education (n = 37), a one-way repeated measures ANOVA was conducted to analyse evolution acceptance longitudinally. Differences between groups representing different categories of relative acceptance of evolution were also explored. Additionally, independent t-tests were conducted to compare the previous MATE scores of the subsets of the population that did or did not participate in the third measurement taken one year after the AGS experience.

Methodological Assumptions and Limitations

Parameters of this study pertaining to limitations and validity include items related to the participant population, the educational experience, and the instrumentation.

Because most AGS students have been identified as gifted, and because the participants exhibited high aptitude and motivation for study in the natural sciences, the sample is probably not representative of high school students in general. For example, according to Thomas (2008), gifted students may be more likely than the general population of high schoolers to have progressed beyond epistemological dualism. However, it is reasonable to assume that the sample is similar in most respects to students in typical advanced placement, honours, or accelerated science courses at the secondary level and/or in transition to the post-secondary level.

The sample was taken from only one institution, albeit one whose students comprise individuals selected from disparate communities across the state in which it is situated. As a result of the state's geography and of the institution's student selection process, although many participants were from rural communities with relatively low racial and cultural diversity, the participant population was more diverse than many of the state's public school classrooms may be.

According to the United States Census Bureau, Arkansas's population is 80.6% white (including 3.2% persons of Hispanic or Latino origin); 15.8% black or African American; and the remaining 3.6% are from other groups including American Indians or Alaskan Natives (0.9%), Asians (1.2%), Native Hawaiian and Other Pacific Islander (0.1%), and persons reporting two or more races (1.5%). However, there are vast differences across the state with regard to how the overall diversity is distributed. For example, the population of Philips County in the southeastern portion of the state is 61.5% black and 36.5% white (other groups are each 1% or less), while Newton County in the Northwestern quadrant of the state is 97.3% white and no other group besides those reporting two or more races comprises even 1% of the population (United States Census Bureau, 2009). Wealth is also non-homogenously distributed across the state, as there are large discrepancies in median income and percentages of populations in poverty from one county to the next with a general trend from wealthier counties to the north and west to more disadvantaged counties to the south and east (Casey Foundation, 2009).

Among the acknowleged weaknesses of this study is that data on these demographic factors were not collected from participants via our research surveys, so acceptance of evolution could not therefore be examined against these potential factors. We deemed this to be a necessary concession, however, as associating such personal information could have been perceived by participants as a potential threat to their anonymity, especially if they were representatives of a small minority group. However, the population can be described within certain parameters, as some demographics were available from the AGS administration. Students who attended the session during which we collected data identified racially as 'white' (~75%), 'black' (~14%), or 'other'

(~11%). Hence, the study population was somewhat more diverse than Arkansas's general population, particularly with regard to those who identified as neither black nor white. Data indicating family income was also not collected, but AGS records do indicate that students attending the session included residents of the state's wealthiest counties as well as the most economically challenged counties. Furthermore, as AGS is fully funded by the Arkansas Department of Education, students attend at no personal cost. Although the exact range of status cannot be reported with accuracy, it is reasonable to expect that students from across the socioeconomic spectrum were represented in this study.

Also, as we did not collect information from students regarding their religious affiliations on our surveys, and as the AGS administration does not record such information about students, we cannot report on the exact religious make up of the study population. However, data are available on the religious landscape of the general population of Arkansas, of which the vast majority identify as Christian (86%) and predominately protestant (78% protestant, 7% Roman Catholic, other Christian denominations represent < 1% of the population). Among protestants, Baptists are the largest group (39% of the total population) followed by Methodists (9%), Pentecostals (6%), members of the Church of Christ (6%), members of the Assemblies of God (3%), and 15% of the population of Arkansas identify as 'Other Protestant'. About 14% of the population identifies as non-religious, and fewer than 1% are Muslims, Jews, or adherents to other religions. (Kosmin, Mayer, and Keysar, 2001; Association of Religion Data Archives, 2000). Again noting that neither we nor the AGS administration can give exact details on the religious make up of the participant population, based on classroom interactions and student comments, denominations included among student requests for weekend transportation to worship services, and the overall context of Arkansas, it is reasonable to characterize the particpants as predominately Christian (including Catholics, Protestants, and Evangelicals), but there were also representatives of Islam, Judaism, Buddhism, and Hinduism, as well as students who vocally identified as atheists and agnostics. As there were multiple Muslims, Jews, Buddhists, and at least one Hindu student among the participant population, and as these religions each account for less than 1% of the overall population of Arkansans, it is reasonable to assert that the religious make up of the participant population was at least somewhat more diverse than the state's general population.

The level of diversity among this population and that the participants were gifted students limits the generalizability of this study to many other populations. Additionally, as measured according to the methods described below, while a substantial number of the participants rejected evolution initially, a higher percentage of this population accepted evolution than the general U.S. population (Miller, et al., 2006). However, this population is likely to be similar in these respects to accelerated or advanced placement science classrooms, particularly in urban settings or other centres of diversity, or in early post-secondary courses.

Due to the structure of the curriculum employed by the institution at which this research was conducted, and due to ethical issues particular to research with human subjects who are minors, it was impossible to establish a comparable control group. These constraints further limited control over variables not related to the educational experience, and it is thus acknowledged that the participants' acceptance of evolution may be influenced by factors beyond those addressed. Only the dependent variable, acceptance of evolution, was measured using a previously validated quantitative instrument. Whereas the educational experience was designed to address an inventory of factors that may influence student acceptance of evolution, it is assumed that measured changes in students' acceptance levels were attributable, at least to some degree, to the educational experience. Also, the instrument used to measure acceptance of evolution was slightly modified to be more inclusive of religious students who were not Christians.

In determining the effects of the educational experience (though the assumption that students' levels of acceptance of evolution is measurable and quantifiable has surely been validated by the substantial amount of research centred on measuring this variable), this study nonetheless further assumes that the instrument employed can be reliably used to discern changes in acceptance levels (as its developers and others have asserted).

RESULTS

In the following section, the findings of this investigation are presented in corresponding order to the research questions set forth above.

Pre- and Post-treatment Measures of Students' Acceptance of Evolution

Prior to the educational experience, participants' acceptance of evolution was measured by the MATE instrument as described above. Recall that the MATE instrument returns a whole-number score between 20 and 100, and that higher scores indicate higher levels of acceptance of evolution. Score bands defining categories of acceptance levels are listed in Table 1.

[*Insert Table 1 about here.*]

The mean pre-course MATE score across participants was 72.89 (n=81; S.D.=15.88), which corresponds to the 'moderate acceptance' band. However, the MATE scores obtained from individual participants revealed a wide range of acceptance levels. Pre-test scores spanned almost the entire MATE scale from a low score of 36 to a high of 98. According to category bands, 14% of the participants' scores indicated 'very low acceptance', 10% 'low acceptance', 33% 'moderate acceptance', 21% 'high acceptance,' and 22% 'very high acceptance'.

The mean post-test MATE score was 85.88 (n=81; S.D.=13.19) , indicating an average gain over pre-test scores of about 13 points (12.98; S.D.=10.39), which is equivalent to 16.25%, or just over one sixth, of the 80-point MATE scale. Limited to participants whose original MATE scores fell within the 'very low acceptance' to 'low acceptance' range, the average gain over pre-test scores was about 21 points (20.79; S.D.=13.25), which is 26.25%, or just over one quarter, of the 80-point MATE scale. A dependent t-test (repeated measures) was conducted to compare the pre-test and post-test scores, and the difference was indeed significant ($t = 11.242$, $p < .001$).

Post-test scores returned extreme values similar to those of the pre-test measurement. However, although the least-accepting participant maintained his or her initial score of 36, on the other end of the scale, more than 10% of the participants scored 100, the maximum value of acceptance that the MATE instrument can return. By category band, 1% of the participants scored in the 'very low acceptance' range, 5% 'low acceptance', 18% 'moderate acceptance', 25% 'high acceptance', and 51% 'very high acceptance'. A comparison of pre-test and post-test scores by category band is provided in Figure 1. Average gain in MATE score by category band is reported in Table 2.

<u>*Insert Figure 1 and Table 2 about here.*</u>

Longitudinal Measurements of Acceptance of Evolution

Of the 81 original participants, 37 (about 46%) responded to the survey administered one year after their AGS experience. Difficulties related to the method of contact, rather than self-selection based on differential acceptance or attitudes toward evolution, were most likely the primary factor in attrition rates. For the students in the participant population, the timeframe of the follow-up survey was during a transitional period as they had graduated from high school and were entering various colleges or universities. Contact was initiated by e-mail, and more than 25% of the outgoing e-mails returned error messages. Many of the contact e-mails left by the students were connected to the high schools that they no longer attended. Additionally, it is likely that the recruitment messages were quarantined by several would-be participants' junk-e-mail filters. However, comparisons between those participants who responded to the follow-up survey and those who did not were conducted by means of t-tests comparing their scores before and after the educational experience and gains between measurements. There were no significant differences in any of these fields between responders and non-responders to the follow-up survey.

For those participants who responded to the follow-up survey, a repeated measures one-way ANOVA revealed that there were significant differences in their MATE scores between the three times of measurement ($F = 47.35$, $p < .001$). Fisher's LSD (least significant difference) comparisons revealed that the pre-AGS MATE scores ($M = 71.24$; $S.D.=17.58$; $n=37$) differed significantly from immediate post-AGS MATE scores ($M = 83.00$; $S.D.=15.08$, $n=37$) and from the follow-up MATE scores ($M = 83.92$; $S.D.=13.71$; $n=37$). However, there was no significant difference between the immediate post-AGS and the one-year follow-up MATE scores. Longitudinal comparisons of mean scores on the MATE instrument are shown with quartiles and extreme values in Figure 2.

Insert Figure 2 about here.

Conclusions and Discussion

A review of the prior literature pertaining to evolution education (see above) revealed ambiguities regarding the effectiveness of courses containing evolutionary content toward increasing student acceptance of evolution. For example, Wilson (2005) and Ingram and Nelson (2006) reported increased acceptance of evolution among university students as a result of instruction. However, although Wilson (2005) does invite interested readers to contact him for the complete details of his results, the gains in student acceptance of evolution he reported were apparently claimed based upon interpretation of the results of only one survey question and a few representative student quotes. And the change in acceptance of evolution measured by Ingram and Nelson (2006) was quite small. On the other hand, neither Bishop and Anderson (1990) nor Lawson and Worsnop (1992) found evidence of change in student acceptance of evolution after instruction on evolutionary theory.

Moreover, although some researchers had reported changes, and others no change, in students' levels of acceptance of evolution as a result of instruction, most reports focused only on one or a few potential factors of influence. This study narrowed these gaps in the literature by measuring changes in students' evolution acceptance levels after an educational experience designed around an extensive inventory of factors identified as potentially influencing students' acceptance of evolution.

The results of the pre and post measurements using the MATE instrument (Rutledge and Sadler, 2007; Rutledge and Warden, 1999) indicate a substantial increase in students' levels of acceptance of evolution. This increase appears to be of greater magnitude than that reported by Ingram and Nelson (2006). Furthermore, when Ingram and Nelson contrasted the small increase in acceptance among their students to the lack of change among participants in studies by Bishop and Anderson (1990) and Lawson and Worsnop (1992), they cited the longer period of instruction over an academic semester as a likely explanation for the increase in acceptance of evolution among their subjects. This is interesting indeed, as the participants in the present study were engaged for only a few weeks during a summer programme, much less time than a university semester. Additionally, the largest changes among the participants in the study by Ingram and Nelson (2006) were seen among students who were initially undecided, whereas the greatest shifts in evolution acceptance among participants in the present study were exhibited by those students who initially rejected evolution (Table 2). But of course, contrasting our results with those of Ingram and Nelson (2006) should be considered with caution as it involves comparing drastically different study populations. Their study focused on upper-division, university-level biology majors whereas our participants were gifted high school students who had yet to matriculate to the post-secondary level.

The longitudinal element of our study was an important and novel aspect of this research. None of the prior research indicating changes in student acceptance of evolution assessed whether such changes were lasting ones, nor did studies indicating no change in student acceptance of evolution as an immediate result of instruction endeavor to determine whether changes in student acceptance of evolution may have manifested among students after a longer period of time. Our distal analyses of measurements taken just over one year after the participants' AGS experience suggest that gains in acceptance of evolution were maintained during their final high school year. Increased acceptance of evolution was seen across all categories in both near and longitudinal measurements, as illustrated in Table 2 and Figures 1 and 2. Interestingly, although the least accepting student did not appear to have become more accepting of evolution immediately after the educational experience (represented by the 'outlier' mark in Figure 2), this participant apparently increased his/her acceptance by ten MATE scale points within the next year.

Implications and Recommendations

Within the scope of the investigations described herein, it can be said that there was a significant change in participants' evolution acceptance levels following a focused academic experience designed to incorporate an inventory of factors which were suspected to influence student acceptance of evolution. Importantly, the greatest gains in acceptance of evolution were seen among those students who initially rejected evolution. This type of effect for students with low and very low acceptance of evolution, most of whom advanced to at least moderate acceptance, are likely the most important to achieve. By at least temporarily overcoming their initial rejection of evolution, these students may well have reached positions of deferred judgment sufficient to achieve the goal of greater understanding of the concept necessary for informed assessment of the evidence as suggested by Sinatra, et al. (2003).

The results presented herein indicate only that increased acceptance of evolution was apparent after exposure to an educational experience addressing an extensive inventory of factors identified as potentially influencing student acceptance of evolution.

They do not indicate *which* factors were responsible for the changes observed. We regret, for example, that we are not able to report on the degree to which possible gains in student understanding of evolution may have mitigated their gains in acceptance. Likewise, future reports illuminating the relative importance of confounding variables such as students' levels of cognitive development and understandings of the nature of science would be extremely valuable. To that end, qualitative information should be sought via further dialogue with students who are resistant to evolution and students who have been identified as potentially becoming more accepting of evolution. Conversations with such students may give teachers at all levels more insight into what methods may work and whether their efforts may impact these students, even if the effects may not be immediately evident. Also, further exploration of the relative influence various factors may have on student acceptance of evolution should be explored by means of a standardized instrument administered to a much larger sample across student populations in varying geographic locations, institution types, academic majors, and academic levels.

Finally, we acknowledge that many of the factors that were addressed within the overall AGS experience may not be appropriate for inclusion in science classes (e.g., the diversity of religious responses to evolution or its potential compatibility with a variety of faith traditions). However, many of the non-religious non-scientific factors (e.g., critical thinking skills, cognitive dispositions, and epistemological views) may well be developed in science classrooms. Furthermore, all of the potential factors listed herein can certainly be part of teaching and learning within the broader context of a school system or educational programme, and this may carry implications for efforts at cross-disciplinary planning and instruction.

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Table 1

Relative categories of acceptance of evolution according to MATE score

Relative Acceptance Category	MATE Score
Very High Acceptance	89-100
High Acceptance	77-88
Moderate Acceptance	65-76
Low Acceptance	53-64
Very Low Acceptance	20-52

Reproduced from Rutledge and Sadler (2007).

Table 2

Average gain over pre-treatment MATE scores as measured by post-treatment re-administration of the MATE instrument

Pre-treatment Acceptance Category	Average Gain on Post-treatment MATE Score		
	Mean	SD	N
Very High Acceptance	4.83	2.87	18
High Acceptance	9.94	5.92	17
Moderate Acceptance	14.85	9.16	27
Low Acceptance	16.75	11.36	8
Very Low Acceptance	23.73	14.25	11

Figure 1.

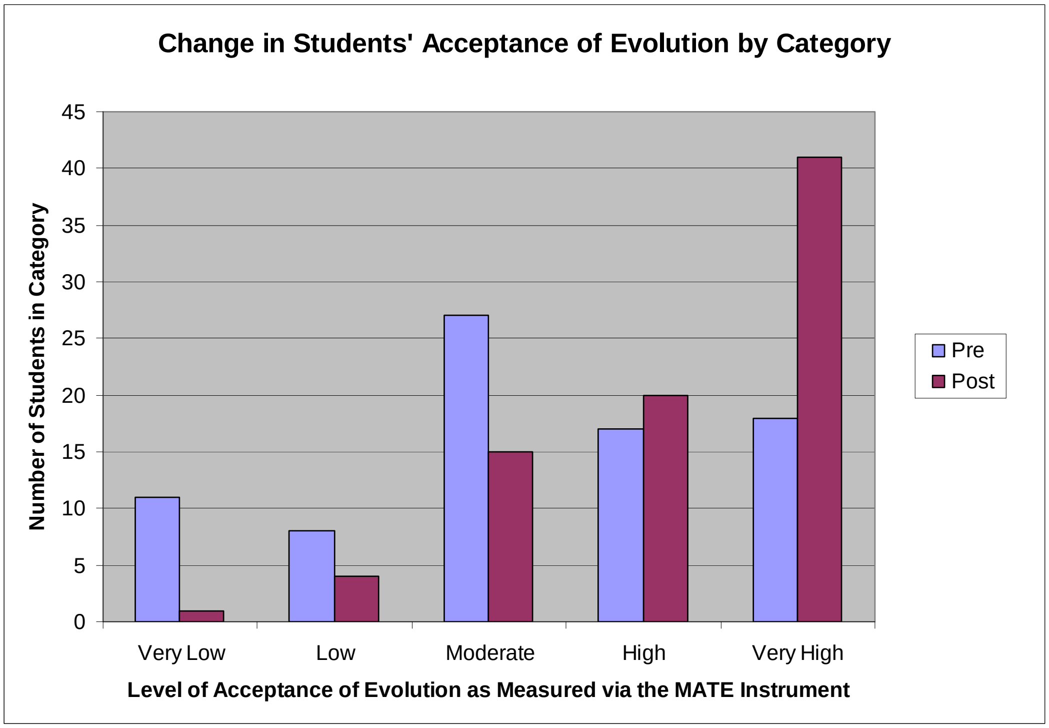
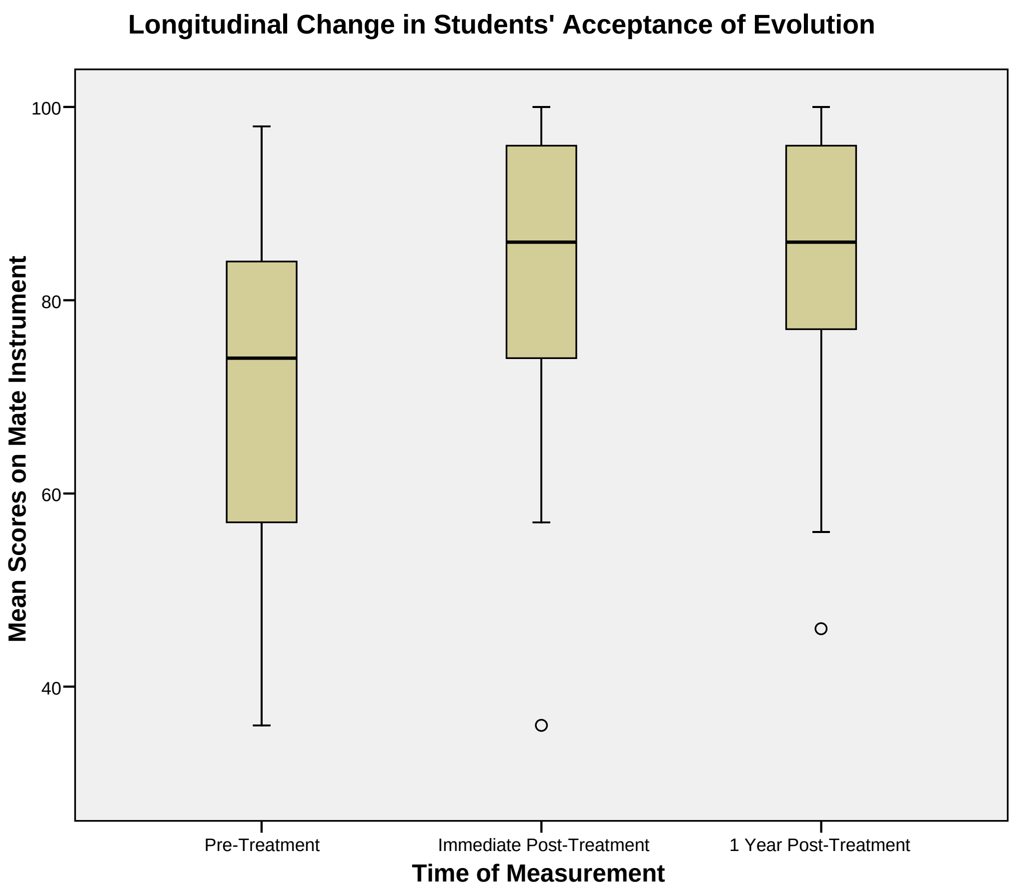

Change in Students' Acceptance of Evolution by Category
Number of Students in Category
45
40
35
30
25
20
15
10
5
0
Very Low
Low
Moderate
High
Very High
Level of Acceptance of Evolution as Measured via the MATE Instrument
Pre
Post

Figure 2



Boxplots represent means, quartiles, and extreme values. Circles are outliers.