

ACCEPTANCE OF THE THEORY OF EVOLUTION
AND TRIGGER WORD AVOIDANCE

by

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DEDICATION

There is an objective reality, and the process of science is the best method thus far that humans have used to discover the true nature of that objective reality. This research project is dedicated to all the people out there that let evidence and reason guide their perceptions of this objective reality.

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ABSTRACT

The purpose of this study was to determine if the word evolution and/or its derivatives act as a “trigger” that reduces acceptance and/or understanding of evolution. Acceptance of evolutionary theory in the United States remains lower than levels seen in other countries, and lower than other equally well supported science. One of the primary goals of teaching evolution should be that of increasing levels of acceptance in addition to understanding. A factor that has been demonstrated to lower levels of acceptance is the exposure to “trigger” words related to other controversial science. The impact of the word evolution and its derivatives on acceptance levels of evolutionary science has not been widely studied. These words were avoided in most class materials and lectures with a group of 7th grade biology students in Montana over the course of a five-week unit on evolutionary theory. Other content specific words like *adaptation* were used in its place. Students took an anonymous Likert-scale survey and misconception probe pre- and post-treatment, with responses paired through the use of student-generated coding. Data was analyzed by quantifying the Likert-scale data and then performing normalized gain, correlational, and paired *t*-tests analyses. The results of the study were that students in the control group that were exposed to the word evolution and its derivatives from the beginning of the content unit showed increased levels of acceptance and understanding compared to the treatment group.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

The teaching of evolution in the U.S. has a long and fraught history (Kitzmiller v. Dover, 2005; Scopes v. State of Tennessee, 1927). The theory of evolution by natural processes is the “unifying” principle and foundation of modern biology (National Science Teachers Association, 2023, para. 1). According to the American Association for the Advancement of Science (2006) evolution is “one of the most robust” scientific theories in existence. It is supported by evidence from a diversity of fields including astronomy, physics, biochemistry, geochronology, geology, genetics, archaeology, and anthropology (National Science Teachers Association, 2023). Despite the foundational nature of the theory of evolution and the overwhelming evidence supporting the fact of evolution, there exists a massive discrepancy between how scientists and the U.S. public accept evolution (Pew Research Center, 2015). How evolution is perceived and taught by U.S. science teachers may have a role in this large scientist versus public gap in attitudes.

The theory of evolution is not consistently or universally taught by all U.S. biology teachers. Nearly 40% of middle school and 9% of high school biology teachers do not cover any evolutionary processes in their curriculum, while 55% of middle school and 22% of high school teachers specifically avoid only the topic of human evolution (Branch et al., 2021). This means that each year out of the estimated 50.7 million students enrolled in U.S. public schools (National Center for Education Statistics, 2021), millions never receive *any* exposure to the theory of evolution by the time they graduate high school. Of the teachers that do cover evolutionary

theory at all, nearly 30% of middle school and 22% of high school teachers spend less than six total class hours on the subject annually (Branch et al., 2021), leaving millions more students with only a minimal education on the foundational concept of all biology. Examining *why* teachers avoid the subject can also illuminate the source of the public and scientist discrepancies in acceptance of evolution.

Science teachers' personal religious views and messaging to students may play a role in the public's negative attitudes towards evolution. Creationism is religious in nature and should not be taught in the science classroom as a valid alternative to the theory of evolution (Edwards v. Aguillard, 1987). The term *Intelligent Design* was originally coined to try to subvert bans on teaching creationism in public classrooms as a valid scientific theory yet was found to be religious in nature as well (Kitzmiller v. Dover, 2005). Despite the religious undertones, creationism and Intelligent Design are still presented to U.S. public school students as a valid alternative to the theory of evolution by their science teachers. Nineteen percent of middle school and 14% of high school biology teachers emphasize creationist ideas as a valid alternative, and 16% of middle school and 14% of high school biology teachers emphasize that substantial percentages of *scientists* view Creationism and/or Intelligent Design as valid alternatives to evolutionary theory (Branch et al., 2021). In reality, just 2-3% of *all* U.S. scientists hold religious views as an alternative to evolutionary theory (Masci, 2019; Pew Research Center, 2009). Students view their teachers as authoritative and knowledgeable on the subjects they teach, so these religious views held and shared as valid science by such a significant portion of U.S. biology teachers creates uncertainty in the minds of students as to the validity of the theory of evolution, contributing to the U.S. public's negative attitudes towards evolution.

My own personal experiences have supported the dire state of evolution education and acceptance in the U.S. I have no personal memory of learning about the theory of evolution throughout my secondary public education. Assuming my memory is correct, either (a) it was taught so poorly or minimally that I do not recall it or (b) it was not taught to me at all. Out of the six total undergraduate Secondary Broadfield Science teachers in my final Methods class [at Montana State University] I was the only one who planned on teaching the theory of evolution in my upcoming career. The other preservice teachers were uncomfortable with the notion of teaching “controversial” topics and of potential student, parent, and/or community conflicts. I have experienced these anxieties regarding conflicts from other in-service teachers, with many reporting similar attitudes of “worries about community backlash” as a reason to avoid teaching evolution (Hawley & Sinatra, 2018, p. 381). One of the preservice teachers in the class initially thought it was illegal to teach in the U.S. This incorrect notion was quickly corrected, yet that student maintained an attitude of discomfort like the other four. In my professional career I have also experienced antithetical attitudes and views towards teaching evolution. A middle school non-science colleague of mine also thought that teaching evolution was illegal in the U.S. and was surprised to learn the opposite. In an online discussion forum for biology teachers, I was a participant in a discussion with a biology teacher from Louisiana who proudly proclaimed that though they did teach the theory of evolution, they consistently informed their students that they were only teaching it because it was a state content standard and that they themselves did not accept it as true. These experiences have all served to strengthen my desire to teach the theory of evolution and to find a way to teach it that helps close the gap between scientist and public acceptance of it.

As my own views on teaching evolution have grown over the years, so have my own personal goals for student outcomes. Not only do I want my students to understand the core ideas of the theory of evolution, but I also want them to walk away *accepting* it as fact. I find the distinction between understanding and acceptance extremely important. For example, a person can *understand* the core ideas and principles of Hinduism, yet not *accept* it as a true or valid explanation for events taking place on Earth today and/or in the past. A person can *understand* the arguments of “flat-Earthers,” yet not *accept* their arguments as valid or true. Therefore, my primary goal in teaching evolution and the rationale for this action research are to help students both understand and accept evolution. By reducing initial perceived conflicts with students regarding their preconceptions of the theory, I predicted there would be an increased level of acceptance. This research may also provide support for other teachers who avoid teaching evolution. If a teacher is empowered to teach evolution and has evidence that this strategy can increase understanding and acceptance with a reduction in conflicts, then perhaps they will add or increase evolution curriculum to their own classrooms.

This action research project was implemented on the entire 7th grade class at Belgrade Middle School in Belgrade, Montana. The city of Belgrade has a population of 10,460, a median household income of \$59,146 that is below the national average, and a median value of owner-occupied homes at \$243,000 (U.S. Census Bureau, 2020). The percentage of persons with a bachelor's degree or higher is 33.6%, which is just slightly less than the national figure of 36% (U.S. Census Bureau, 2020). The number of households with a computer is 86% (U.S. Census Bureau, 2020), while the national figure is 89% (Ryan, 2018). The ethnic background of this community is 94.4% Caucasian/White and 4.7% Hispanic/Latino, compared to nationally 76.3%

and 18.5% respectively (U.S. Census Bureau, 2020). The bulk of the city of Belgrade lies within state legislative districts 67 and 68, with more rural portions of the school district encompassing districts 64 and 69 (Montana State Library, 2013). In the 2020 general election, districts 67 and 68 combined voted by a margin of 62.91% for the Republican state house candidate and 34.34% for the Democratic state house candidate (Gallatin County, Montana, 2020). There are 18 churches of various denominations in or very near the city limits of Belgrade (Google Maps, 2022), which equals 1 church for every 581 residents. Compared to the estimated U.S. national average of 1 church for every 941 residents (Hartford Institute, n.d.). Belgrade has an above average incidence of churches per capita compared to the national average, suggesting it is above average in terms of religiosity. These community demographic factors will make this action research project of particular interest due to a known correlation between conservative politics, religion, and denial of scientific concepts that are strongly supported by evidence (Barnes et al., 2021; Dunk et al., 2019; Funk & Hefferon, 2019; Levin et al., 2022).

Focus Questions

The primary research question for this study was: Does avoiding the use of the word *evolution* during an instructional unit on evolution increase student levels of acceptance of the theory of evolution?

My sub-questions include the following:

1. Is there a correlation between student understanding and acceptance of the theory of evolution?
2. Which aspects of the theory of evolution have the greatest change in acceptance levels?

3. How will the acceptance levels of students initially indicating a disagreement towards evolution change?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Introduction

Over the last four decades, the U.S. adult non-scientist acceptance of the theory of evolution as an explanation for the development of life on Earth has remained exceptionally low compared to U.S. adult scientists (Brenan, 2019; Masci, 2019). While knowledge/understanding of evolution has been shown to have both a positive and negative correlation with higher evolution acceptance levels (Dunk et al., 2019; Mead et al., 2017), increased religiosity is regularly strongly correlated with lower levels of acceptance (Barnes et al., 2021). Many cognitive effects related to a person's *preconceptions* have also been shown to influence attitudes and opinions towards many social, political, and scientific issues. The discrepancy between scientist and non-scientist attitudes towards evolution highlights that it is not immune from these cognitive influences. This study will seek to assess whether *avoiding triggering* a person's cognitive resistance based on their preconceptions increases their overall acceptance levels of the theory of evolution.

Belief Versus Acceptance

Differentiating between *belief* and *acceptance* has caused debate among researchers studying the teaching of evolution. The words *belief* and *acceptance* have different definitions yet are often used interchangeably by scientists and the public. *Belief* is defined as a strong feeling or confidence that something exists or is true, while *acceptance* is the act of agreeing

with something and approving of it (Hornby et al., 2000). Some researchers have argued that these two words are equivalent. Alters (1997) points out that there are many instances of scientists using the words *believe* or *belief* and that students do not understand the subtle differences between the words *belief* and *acceptance*. Wiles (2014) points out that there are now far more researchers and education-focused organizations that differentiate between the two (National Academy of Sciences, 2008). Smith and Siegel (2016) analyzed the words *belief* and *acceptance* through a philosophically based lens. They conclude that while both belief and acceptance are mental states, belief is an involuntary disposition or attitude, while acceptance is a voluntary decision (Smith & Siegel, 2016). This interpretation would mean that if one believes in the theory of evolution, their opinion on the matter is not based on any evidence, while accepting it indicates that the person has considered the evidence and reasoning and has decided it is true. Other researchers have argued that the use of the word *belief* in science causes confusion among the public between knowledge and belief constructs and muddies the waters regarding scientific knowledge and religious belief (Sinatra et al., 2003; Southerland et al., 2001). Southerland et al. (2001) also found that the use of the word *belief* in relation to scientific theories like evolution suggested to students that they should disregard their religious beliefs in favor of believing in evolution without scrutiny of the evidence. Therefore, to avoid general or religious confusion among participants, in this study the term *acceptance* will be adopted and used over *belief* to mean “a learner’s personal assessment of the validity of the construct” (Sinatra et al., 2003, p. 512), the construct being the theory of evolution.

Acceptance of Evolution in the U.S.

Although there is near consensus about the validity of evolution among U.S. scientists, the public's attitude towards evolution remains drastically lower. For example, 97% percent of scientists agree that humans and other living things have evolved over time, and 87% of scientists say this is due to natural processes alone (Pew Research Center, 2009). A more recent survey of scientists affiliated with the AAAS indicated 98% support that humans and other living things have evolved over time (Figure 1; Masci, 2019). Contrastly, just 61% of U.S. adults agree with the statement that humans and other living things have evolved over time and only 32% agree that this is due to natural processes (Figure 1; Pew Research Center, 2009).

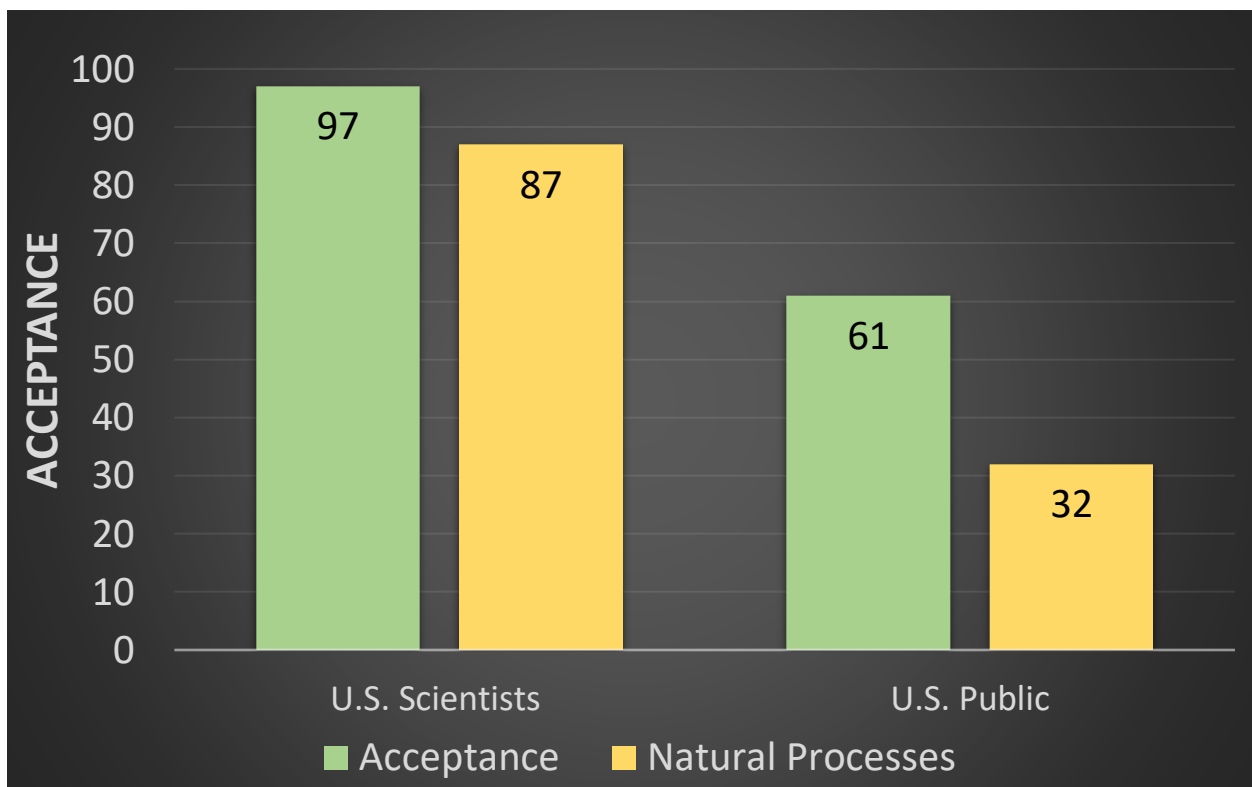


Figure 1. Acceptance levels between adult U.S. scientists and the public that humans and other living things have evolved and whether that is due to natural processes.

Other more recent surveys of U.S. adults have supported this low level of acceptance (Pew Research Center, 2015). When asked whether they accepted evolution as an explanation for the development of humans over millions of years without intervention of God, just 22% of U.S. adults agreed (Brenan, 2019). Considering the strong and objective evidence in support of the theory of evolution (National Science Teachers Association, 2023), the large discrepancy between the scientist and general population's acceptance of the theory of evolution indicates that there is something influencing the public's acceptance levels.

Factors Influencing Acceptance of Evolution

Two major factors that impact whether a person accepts or rejects the theory of evolution and to what degree are knowledge/understanding of the theory of evolution and religiosity. While some studies have found no correlation between knowledge/understanding of evolution and acceptance (Mead et al., 2017; Sinatra et al., 2003), others have found a positive correlation (Dunk et al., 2017; Lark et al., 2018; Weisberg et al., 2018). Weisberg et al. (2018) found that even when accounting for religiosity, age, and politics, greater knowledge/understanding of the theory of evolution was the strongest predictor of a higher level of acceptance. Around 70% of the U.S. public identify as somewhat to strongly religious (Brenan, 2019; Smith, 2021). There is a strong connection between higher levels of religiosity and lower levels of acceptance of the theory of evolution (Barnes et al., 2021; Dunk et al., 2019). In contrast to the U.S., a study of over 9,000 university students in Europe found that 55% of participants indicated minimal to no religious influences in their lives and 81% indicated acceptance or high acceptance levels of the theory of evolution (Kuschmierz et al., 2021). Interestingly, the cohort in this study also had a very low knowledge/understanding of evolutionary principles, with over 74% scoring in the low

to very low knowledge range (Kuschmierz et al., 2021). This may indicate an attitude acceptance of evolutionary science as they do any other science, regardless of understanding. In a qualitative study of high school students in Arkansas, Wiles (2014) found the factors influencing student acceptance of evolution to be complicated and unique to individuals. Each student interviewed reported a mix of prior knowledge, family history, religiosity, community influences, level of interest in evolution, and psychological factors influencing their level of acceptance (Wiles, 2014). In their work, however, patterns did emerge. The most common pattern was that of increased religiosity having an inverse effect on level of acceptance (Wiles, 2014). This link between religiosity and acceptance has been found by numerous other studies (Dunk et al., 2017). Over half of the participants in Wiles' (2014) study reported human evolution as the most difficult scientific topic to accept, as it most directly contradicts their religious beliefs than other scientific theories. A student's preconceived perception of conflict between religion and evolution has also been shown to be a greater factor in reducing acceptance of evolution than just religiosity or lack of knowledge/understanding (Barnes et al., 2021).

Other factors influencing a person's acceptance of the theory of evolution are more complex cognitive traits. Many students in Wiles' (2014) study reported various forms of guilt or negative emotions for going against their near ubiquitous evolution-rejecting families and/or communities as a barrier to greater acceptance of evolution. Openness to experiences, or open-mindedness, was another cognitive factor at work in predicting levels of acceptance. A lower openness to experience was found to be strongly correlated with lower levels of acceptance of evolution, and higher levels of religiosity (Hawley et al., 2010). What is the psychological foundation of these reported cognitive factors influencing a person's acceptance of the theory of

evolution? Are these cognitive influences at work in other areas of science and societal issues? If religious beliefs are such a barrier to being open-minded to and accepting evolution as true, perhaps a way around this inhibition is if the learner *does not know* they are learning about evolution.

Cognitive Traits and Acceptance Inhibition

A person's preconceptions about a topic or an issue has a well-documented and predictable effect on their attitudes and opinions about said topics. A small but interesting study at the Muddy Charles pub in Cambridge, MA offers a glimpse into how these preconceptions influence a person's opinions and attitudes. Over the course of several weeks, participants were offered samples of Sam Adams beer that were either (a) plain beer, or (b) beer that had a small amount of balsamic vinegar added (Ariely, 2009). Some participants were told about the controversial additive prior to tasting, some were not told at all, and others were told just after sampling but, importantly, before officially recording their opinions of the flavor (Ariely, 2009; Lee et al., 2006). The results of this study showed that knowledge of the additive ahead of time caused an overall more negative opinion of the experimental beverage compared to the plain Sam Adams control beverage. Participants that (a) had no knowledge of the additive and (b) were informed of the additive just after sampling reported a more positive opinion of the experimental beverage than they did the control sample, the plain beer (Lee et al., 2006). This study demonstrates how being informed of something preconceived to be undesirable beforehand can have a negative effect on acceptance. The cognitive effects at work in this study are also at work in people's attitudes and opinions about the validity or truth of other much larger scale societal and scientific factors.

Motivated reasoning is the primary cognitive trait that causes illogical outcomes in people's attitudes and opinions about controversial topics. Kunda (1990) defines motivated reasoning as a process of psychological gymnastics that people go through to arrive at the conclusion they want to, rather than one that the objective evidence should lead to. Other related factors under the umbrella of motivated reasoning are confirmation bias, the backfire effect, and belief polarization. Confirmation bias is defined as the inclination of a person to process information by seeking out, or interpreting, information that is consistent with what they already believe (Casad, 2019). The backfire effect occurs when evidence-based information is presented in relation to a misconception or misinformation, and the target audience reports believing or adhering to the original misconception misinformation even more (Lewandowsky et al., 2012). Belief polarization is when people receive the same information yet update their belief constructs or worldviews in opposite directions based on prior beliefs and/or worldviews (Lewandowsky et al., 2012). All four of these cognitive effects have been documented in multitudes of studies regarding contentious social and political issues.

Participants in a study surrounding acceptance or rejection of the death penalty found that people became more rigid in their views after receiving contradictory evidence (Lord et al., 1979). Religious and nonreligious U.S. adults exposed to a fake report that countered the Biblical account of creation caused the religious to increase their level of belief and the nonreligious to become more skeptical (Batson, 1975). U.S. political conservatives and liberals exposed to two reports about weapons of mass destruction (WMD's) in Iraq exhibited these cognitive effects. The first report stated that WMD's had been found after the U.S. invasion of Iraq in 2003, while the second issued a correction stating there were in fact no WMD's. Conservatives became more

convinced of their presence while liberals' perceptions shifted in the opposite direction (Nyhan & Reifler, 2010). These examples all have an objective truth to them regarding the evidence that was presented, yet participants reacted in dramatically different ways depending on their social and political preconceptions. The same effects hold true for scientific aspects of society as well.

A large-scale scientific issue that exhibits (a) a large discrepancy in attitudes between scientists and the public (Pew Research Center, 2009), and (b) has all the hallmarks of motivated reasoning, confirmation bias, the backfire effect, and belief polarization is that of climate change. A survey of the authors of 4,014 published research papers on the effects of climate change that took a position on the subject found that there was 97% consensus among climate scientists that climate change is anthropogenic (Cook et al., 2016). Meanwhile, just 49% of all U.S. adults agree that a great deal of the effects of climate change are human caused (Funk & Hefferon, 2019). When broken down by political ideology, just 14% of conservative Republicans and 84% of liberal Democrats thought that human caused activity was contributing a great deal to climate change (Funk & Hefferon, 2019). Dixon et al. (2017) showed that while consensus messaging had little to no effect on climate change acceptance rates between conservatives and liberals, targeted messaging emphasizing free market solutions to climate change led to a higher level of acceptance among conservatives. Another study found that education on health impacts due to climate change had a belief polarization effect dependent on political party (Hart & Nisbet, 2012). A study by Villar and Krosnick (2010) found that the term *climate change* was rated as a more serious problem than *global warming*. The evidence regarding climate change is overwhelmingly and objectively in support of an anthropogenic explanation, and these studies all support the claim that subconscious cognitive effects were at work in determining participants'

attitudes towards climate change. This cognitive phenomenon seems to be at work in relation to the theory of evolution.

Negative preconceptions may be an inhibiting factor to acceptance when students are learning about the theory of evolution. A study by Vaughn and Robbins (2017) that consisted of preservice teachers enrolled in an introductory biology course at a midwestern Jesuit university included a small yet tantalizing data point to support this claim. The study involved respondent's answers on a Likert-scale question that read, "The word evolution causes me to feel distaste" (Vaughn & Robbins, 2017, p. 11). On two separate pre-treatment Likert scale surveys given in two different years, participants averaged responses to this statement on a five-point scale (5=strongly agree) were 2.50 and 2.72, and after instruction those same groups averaged 2.35 and 2.20 respectively (Vaughn & Robbins, 2017). I interpreted this data to mean that the respondents still had some level of distaste for the word evolution, otherwise they would have selected answers more in the lower value range of disagreement. Other studies involving evolution acceptance have purposely avoided specific words to avoid triggering an emotional response in participants, thereby influencing the results (Lark et al., 2018). If a person is thinking of an objective scientific theory in such emotional terms, then it is predicted that they are using various aspects of motivated reasoning to arrive at the conclusions that align with their preconceptions.

Conclusion

Clearly there is a case to be made for researching whether motivated reasoning and psychological triggers experienced during instruction are inhibiting student acceptance of the theory of evolution as a valid explanatory theory of life on Earth. Psychological factors involved

in accepting objective reality have already been identified in other large-scale issues such as climate change (Dixon et al., 2017; Hart & Nisbet, 2012) to small-scale issues such as the taste of beer (Lee et al., 2006). Preconceptions and motivated reasoning around religiosity (Barnes et al., 2019; Dunk et al., 2019) and social pressures (Wiles, 2014) have also been identified as inhibiting factors to accepting the theory of evolution as true. Considering the theory of evolution is the unifying principle of all of biology (National Science Teachers Association, 2023), the dismally low levels of acceptance of the theory of evolution of U.S. non-scientist adults compared to scientists (Brenan, 2019; Masci, 2019; Pew Research Center, 2009) is a failure of our educational system. In a democracy where an educated public capable of making decisions based on evidence is important to the functioning of society, understanding how to work around people's subconscious biases and psychological triggers has implications far beyond just the acceptance of the theory of evolution.

CHAPTER THREE

METHODOLOGY

Demographics

The purpose of this study was to determine if student acceptance of the theory of evolution is affected by explicit knowledge of being taught about it during an instructional unit. The primary research question was: Does avoiding the use of the word *evolution* during an instructional unit increase student levels of acceptance of the theory of evolution? A research sub-question was: Is there a correlation between student understanding and acceptance of the theory of evolution? All participants were students enrolled in seventh grade Life Science as a core science class at Belgrade Middle School located in Belgrade, Montana. One hundred students participated in this study ($N=100$) out of a total of 119 enrolled at the time of the post-treatment data collection (Belgrade School District, 2023). This discrepancy is due to students being absent during the pre- or post-treatment data gathering days, new enrollments since pre-treatment data collection, or unenrollments before post-treatment data collection. The research methodology for this project received and exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Participants in this study were grouped by class period into the treatment and control groups in a non-random way. Factors that were used to determine which class periods were in which group were prior academic achievement, class size, and time of day. Prior academic achievement was determined by calculating the percent of students that achieved a level 3.0 on all prior scored academic standards of the year in a standards-based grading system, where a 3.0

is considered at-standard (Table 1). Scoring a 3.0 is comparable to scoring 95-100% on the same summative assessments that were given in prior academic years that used the A-F grading model.

Table 1. Class period, enrolled number of students, and academic achievement (Belgrade Middle School, 2023; NGSS Lead States, 2013).

Class period	Enrolled class size	Percent (%) of students that achieved level 3.0 on MS-LS1-6 standard	Percent (%) of students that achieved level 3.0 on MS-LS1-1 standard	Percent (%) of students that achieved level 3.0 on MS-LS1-3 standard	Percent (%) of students that achieved level 3.0 on MS-LS1-5 standard	Average of percent of students scoring level 3.0
1	14	50.0	85.7	85.7	50.0	67.9
2	17	46.7	50.0	94.1	37.5	57.1
3	23	43.5	62.5	86.4	30.0	55.6
4	24	59.1	65.2	95.8	45.8	66.5
6	22	56.5	70.8	95.6	65.0	72.0
7	21	50.0	60.9	90.5	55.0	64.1

Research Design and Grouping

The research design of this study is classified as a group comparison, correlational, and quasiexperimental (Mertler, 2020). The study gathered quantitative survey data classifying it as survey research (Mertler, 2020). This study qualifies as a group comparison study since it is taking all of the participants and splitting them into a treatment and control group. These two groups were exposed to different conditions and were analyzed to determine if there was any cause-and-effect relationship from the treatment (Mertler, 2020). The research sub-question asked whether there was a link between understanding and acceptance of evolution (Table 3).

These two variables were statistically analyzed to determine whether there was any relationship, classifying this study as correlational (Mertler, 2020).

The participants in this study were not truly randomized in their assignment to the treatment or control groups since they were assigned to specific class periods. However, measures were taken to try and ensure group similarity. Prior summative assessments were used to generate an average academic performance level for each class period (Mertler, 2020; Table 1). Two types of matching were used as well to make the groups as similar as possible: a) number of participants enrolled in each class, and b) time of day that the class meets (Mertler, 2020; Table 1). Using these prior summative assessments and matching techniques qualify this action research as quasiexperimental (Mertler, 2020).

Class periods two, four, and seven were designated as the treatment group and one, three and six the control. This grouping resulted in a treatment and control group with very similar characteristics. The total number of participants in each group and the group-averaged academic ability were both within 5% of each other (Table 2). The control group consisted of 51% ($n=51$) of the total participants ($N=100$), and the treatment group 49% ($n=49$) (Table 2). Averaged academic abilities were the average of students scoring a level 3.0 from Table 1 across all three class periods for each group (Table 2). The time of day each period met was also fairly divided. Class periods six and seven both met after the lunch hour and were split between groups.

Table 2. Group class period assignment, size, and averaged academic abilities.

Group	Class periods	Size ($n=$)	Averaged academic abilities
Control	1, 3, 6	51	65.2
Treatment	2, 4, 7	49	62.5

Treatment

The overall treatment method for this study was the avoidance of the word *evolution* verbally and in writing during the participants instructional unit on evolutionary theory and its principles. Other relevant vocabulary and their derivations such as *adaptation*, *natural/artificial selection*, *change over time*, *selective pressure*, and *mutations* were all used freely and widely with both groups to accurately convey the principles of evolution. An example of how the word *evolution* was avoided in writing was in a notes presentation. The control group's notes were titled "Evolution Notes," whereas the treatment groups were titled "Adaptation Notes." I was able to avoid exposing the treatment group to the word *evolution* and its derivatives for the first 15 class days of a 29-class day instructional unit except for one activity assigned on day 13. This activity had the word "Evolution" as part of the title of the online simulation page. Towards the end of the unit, the word evolution became unavoidable in certain instructional materials, and the treatment group was exposed to the word *evolution* and/or its derivatives as often as the control group. On day 16 the treatment group was explicitly informed that they had been learning about the theory of evolution and its principles for the past 15 days. After this explicit revelation, I reviewed the principles they had been taught about such as adaptation natural selection through the explicit lens of evolution. This way, they could analyze and connect their thoughts and feelings towards the principles they had learned and the true nature of those principles being the theory of evolution.

Data Collection and Analysis Strategies

Data Collection Methods

Choosing the correct data collection strategies that align with the type of research being done is important. The data collected in this study was collected using methods the participants were familiar with in the form of Google Forms. Data was collected using quantitative methods with a Likert-Scale Survey, a Misconception Probe, and an Awareness Survey (Table 3). The pre-treatment Likert-Scale Survey and Misconception Probe was given over two days from January 30th to February 1st, 2023. On the first day, all students present took the survey in class. Students that were present on February 1st but absent on January 30th all attended a morning meeting in my classroom during our homeroom “advisory” period. This ensured anonymity for the absent students to submit their surveys in a large group. Had they taken it as small groups of students during each class period, their answers may not have remained anonymous enough since Google Forms collects a timestamp on submissions. The post-treatment survey and probe was given April 28th through May 1st, 2023. The same procedure for absent students was followed with the post-treatment survey and misconception probe.

Table 3. Data collection instruments and alignment to research questions.

Data Collection Instruments	Primary Research Question: Does avoiding the use of the word <i>evolution</i> during an instructional unit on evolution increase student levels of acceptance of the theory of evolution?	Sub-Question 1: Is there a correlation between student understanding and acceptance of the theory of evolution?	Sub-Question 2: Which aspects of the theory of evolution have the greatest change in acceptance levels?	Sub-Question 3: How will the acceptance levels of students initially indicating a disagreement towards evolution change?
Likert-Scale Survey	X	X	X	X
Misconception Probe		X		
Awareness Survey	X			

Likert-Scale Survey. The primary data collection method was a pre- and post-treatment Likert-Scale Survey given in a Google Form (Appendix B) to answer the primary research question: Does avoiding the use of the word *evolution* during an instructional unit increase student levels of acceptance of the theory of evolution? Likert-scale surveys are widely used in research when measuring participant attitudes and feelings towards a topic (Horst & Pyburn, 2018; Mertler, 2020). Participants' responses on the pre- and post-treatment surveys were completely anonymous to me. My own personal experience with students is that they are unlikely to openly disagree with their science teachers on scientific subjects. Though complete anonymity has been shown to compromise the accuracy of self-reported data on surveys (Lelkes et al., 2012), the study was only approved if complete anonymity was maintained.

The survey had 12 declarative statements, most of which were derivations of statements found on other well-established and widely used surveys that gauge participants' attitudes toward evolution (Romine et al., 2018; Rutledge & Warden, 1999; Smith et al., 2016). Each statement was followed by four response choices: *Completely agree*, *somewhat agree*, *somewhat disagree*, and *completely disagree*. A neutral option was intentionally left out which forced participants to take a position on each statement (Gracyalny, 2017). Nine statements were worded so that a response in agreement indicated acceptance of evolution and three were worded so that a response in disagreement indicated acceptance of evolution.

All participants were required to use headphones to listen to an audio recording of the statements and answer choices so that reading ability was not a limiting factor in comprehension of the survey. This ensured that all students that have a lower reading ability had the surveys read to them and served as another control variable in the data collection portion of this study.

On the day that participants took the pre-treatment Likert-Scale Survey, they used a free online random password generator. This password was treated as a secret code that was unique to each participant. Participants were explicitly instructed to keep the code secret, and to write it down on a provided piece of paper and seal it in a provided envelope after entering it in the Google Form. Participants were instructed to put the sealed envelopes in their school lockers to be used at a future date. The students also emailed themselves their secret codes in case the envelope was lost. On the day of the post-treatment Likert Scale Survey, which was identical to the pre-treatment survey, participants were instructed to retrieve their secret codes and enter them on this post-treatment survey. This was done so that specific participant's attitudes would be paired and could be directly compared and analyzed between pre- and post-treatment.

Misconception Probe. Students frequently hold many misconceptions about the theory of evolution (Ferguson et al., 2022; Johnston et al., 2022; Yates & Marek, 2014). The Misconception Probe is an 11-question multiple-choice assessment that focused on common misconceptions surrounding evolutionary theory that were covered during the instructional unit (Appendix C). Probes are “intrinsically interesting questions that reveal what *all* students are thinking, uncovering initial ideas and misconceptions about core concepts and familiar phenomena that students bring to their learning” (Keeley, n.d., para. 1). This probe was given pre- and post-treatment to answer the secondary research question of, Is there a correlation between student understanding and acceptance of the theory of evolution? Responses on this probe were also paired. The pre- and post-Misconception Probe was attached to the same Google Forms as the pre- and post-treatment Likert-Scale Survey.

Awareness Survey. On day 16 of the treatment period, the treatment group was given an anonymous one-question survey that asked how aware they were that they had in fact been learning about evolution for the previous three weeks (Appendix D). These responses were not paired in any way to the Likert-Scale Survey or Misconception Probe. It was simply given to students in the treatment group class periods on this one day. This survey was given so that I could gauge the level of awareness students had throughout the treatment period as to the true nature of the content being taught. Since my study was testing whether knowledge of learning about evolution affected acceptance, I thought it relevant to gather a snapshot as to their level of awareness.

Analysis Strategies

Likert-Scale Survey. The Likert-Scale Survey had a mix of positively and negatively worded statements intended to help validate the data for reliability. The first analysis step was to go through the Likert-Scale Survey data and eliminate participants with invalid responses. Invalid responses were responses where a participant selected a single answer choice for all statements. This technique of throwing out specific participant's data is a way to validate entire data sets like these to be more accurate and reliable by eliminating participants that may not have cared about the survey as they were taking it (Horst & Pyburn, 2018). After the post-treatment data was collected, no participants responses had to be thrown out.

The Likert-Scale Survey's positively worded statement response choices were assigned numerical values where *completely agree* = 4 and *completely disagree* = 1. On the negatively worded statements, the assigned numbers were inverted so that *completely agree* = 1 and *completely disagree* = 4. Assigning numerical values on Likert-scale surveys has been used in other evolution attitude research surveys (Ferguson & Jensen, 2021; Lark et al., 2018; Vaughn & Robbins, 2017). Other widely used measures of the acceptance of evolution surveys such as the MATE and GAENE also employ the technique of quantifying Likert-scale responses (Rutledge & Warden, 1999; Smith et al., 2016). Ordinal Likert-type statement responses can be quantified if a set scale is constructed, all statements follow that same scale, and all questions address the same overall concept (Bowen & Bartley, 2014). Since this Likert-Scale Survey meets these criteria, quantifying participant's answers in this manner is justified.

The quantified responses were summed to generate an overall Acceptance of Evolution Score, or Acceptance Score, with a higher total value indicating a stronger level of acceptance, and a lower total value indicating a weaker level of acceptance. The maximum and minimum

Acceptance Scores were 48 and 12 respectively. By constructing this scale and generating this score, the nonparametric ordinal Likert-scale data was considered interval data and could be analyzed in a parametric manner such as “averaging, standard deviations [and] t-tests...” (Bowen & Bartley, 2014, p. 86).

Three parametric tests were done with the validated data. The first parametric test done on the Likert-Scale Survey data was to calculate a pre- and post-treatment average Acceptance Scores for the control and treatment groups. The average pre-Acceptance Score was subtracted from the average post-Acceptance Score to generate an average Change in Acceptance Score for each group. The next parametric test done was a normalized gain analysis. Normalized gain was originally described by Hake (1998) as a generalized method of determining how effective a treatment is at causing a change in participants knowledge of a subject. In the case of this study, the normalized gain measured how effective the treatment was in causing a change in acceptance, with a higher level of acceptance the goal for both groups. Participants paired pre- and post-Acceptance Scores were used in this analysis. Normalized gain is an appropriate analysis technique here because it is a standardized percentage-based measure that compares how much the factor of Acceptance of Evolution changed from pre- to post-treatment relative to how much it *could* have changed (McKagan et al., 2017).

The last parametric test that was done on the Likert-Scale Survey data were one-tailed paired *t*-tests. Participants paired pre- and post-Acceptance Scores were used in this analysis. A paired *t*-test is an appropriate analysis technique for this research design since each participants data is linked from pre- to post-treatment, and it is the same group of individuals being pre- and post-surveyed and tested (Mertler, 2020). The *t*-test was done to determine if any changes in

participant attitudes pre- to post-treatment were due to random chance or treatment (Bowen & Bartley, 2014; Knapp, 2017). A one-tailed *t*-test was chosen as the more powerful test over a two-tailed *t*-test. A one-tailed *t*-test is more powerful only if the researcher has hypothesized the correct direction of the experimental variables change (Salkind, 2007). In the case of this study, it was hypothesized from prior personal experience and surveys that participant attitudes in both the control and treatment groups would change in the direction of a higher level of acceptance, making the one-tailed *t*-test an appropriate choice. The alpha value of $p < 0.05$ was used as the threshold of significance for the results. A *p*-value above 0.05 indicates there was a greater than 5% chance the results were due to random chance and not the treatment and are thus not considered significant or reliable (Makarovs, 2020; Mertler, 2020).

Specific questions and groups of questions on the Likert-Scale Survey were analyzed for any changes in acceptance levels. Since this study did not include any qualitative data, analyzing these specific questions based on topic was the next best option to understand participant thinking about different aspects of evolution. The first specific question analyzed was the first question, which stated, “The theory of evolution is completely true” (Appendix B). This single question was analyzed because regardless of student comprehension of the other statements on the survey, this one question was direct and to the point about their attitudes towards the theory of evolution.

Another subset of Likert-Scale Survey questions analyzed were those that dealt specifically with human versus non-human evolution. This was done in place of a qualitative analysis to assess whether the treatment had any effect on acceptance of human vs non-human evolution. Questions three and four of the Likert-Scale Survey dealt specifically with non-human

evolution, and questions five and eight dealt specifically with human evolution (Appendix B). The two human and two non-human questions were respectively summed and analyzed pre- to post-treatment using normalized gain (Hake, 1998) and *t*-tests of significance (Makarovs, 2020; Mertler, 2020).

Misconception Probe. These scores were summed to generate an overall Understanding Score pre- and post-treatment. The summed Understanding Scores were averaged for each group. Normalized gain was calculated using these average Understanding Scores (Hake, 1998). From these pre-to post-treatment scores, an individual and group average Change in Understanding Score was generated by subtracting the pre-Understanding score from the post-Understanding Score. The paired response Change in Understanding and Change in Acceptance Scores were analyzed using a correlational test to determine if there was any relationship between the two variables. A Pearson's correlation coefficient *r*-value was calculated, where a positive value would indicate that an increase in understanding was correlated to an increase in acceptance, and a negative value would indicate that an increase in understanding was correlated to a decrease in acceptance. This correlational analysis to determine the degree that two variables relate to one other is often employed in situations like this (Makarovs, 2020; Mertler, 2020). The individual pre- and post-Understanding Scores were also analyzed using a one-tailed *t*-test to determine the significance of the data and likelihood of being due to chance or not.

Awareness Survey. The Awareness Survey results were simply summed and represented as a percentage of the total students present on the day the survey was given. No other analysis was done with this data since it was not paired to any specific participants.

CHAPTER FOUR

DATA ANALYSIS

Results

The results of the study consistently showed that the word evolution was not a trigger word that hindered acceptance or understanding. Participants in both groups increased their acceptance and understanding levels, but the control group consistently increased more than the treatment group in both acceptance and understanding. There was a weak correlation between understanding and acceptance in both groups, with the control group being a slightly stronger correlation.

Acceptance Levels

Pre-Treatment Acceptance Levels.The results of this research study show that students in both the control and treatment groups came into the unit on evolution with attitudes accepting of the theory of evolution (Figure 2). On the first question of the pre-treatment Likert-Scale Survey which was given well in advance of the evolution unit, participants were asked to rank their attitudes towards the statement “The theory of evolution is completely true” (Appendix B). In the control group 31.4% ($n=16$) chose *completely agree* and another 52.9% ($n=27$) chose *somewhat agree*. In contrast, 14.3% ($n=7$) of the treatment group chose *completely agree* and 71.4% ($n=35$) chose *somewhat agree* (Figure 2).

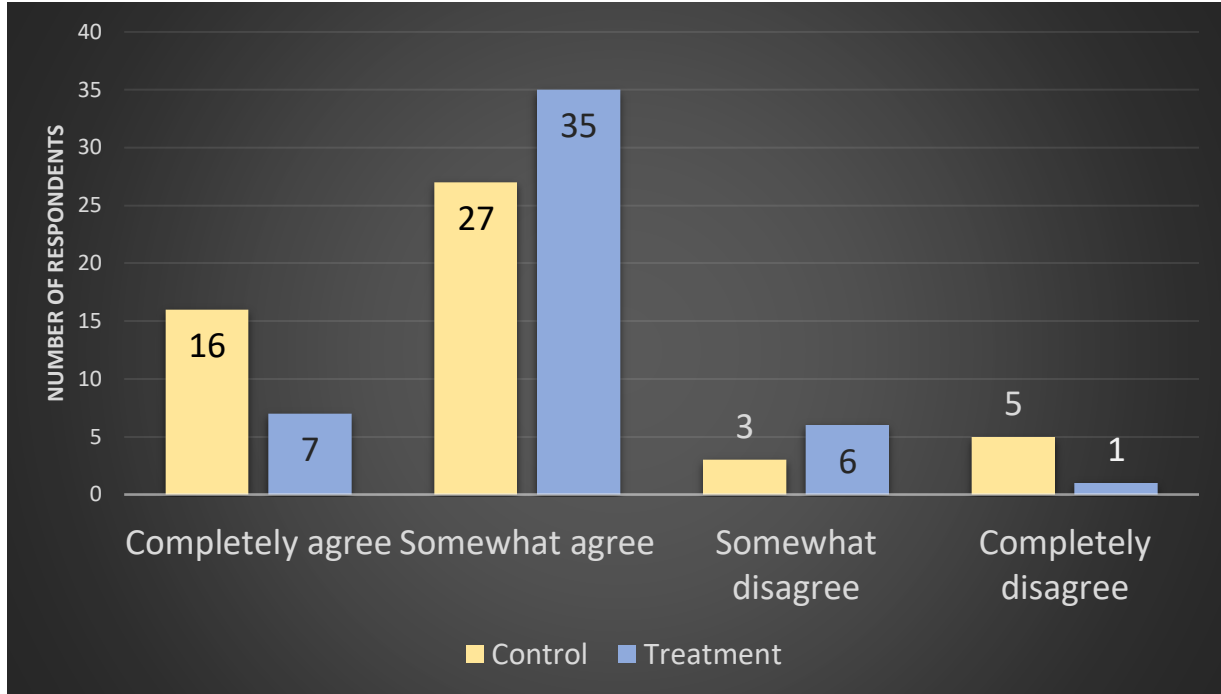


Figure 2. Participant pre-treatment responses to question one on the Likert-Scale Survey, “The theory of evolution is completely true.”

Post-Treatment Acceptance Levels. Both groups showed an increase in acceptance levels after treatment. The highest and lowest Acceptance Scores possible for an individual were 48 and 12 respectively. The control group had an average pre-treatment Acceptance Score of 36.12, and the treatment group 37.39 (Figure 3). Relative to the maximum Acceptance score of 48, the control group as a whole was 75.25% accepting before treatment, and the treatment group was 77.89% accepting. Both groups had an average post-treatment Acceptance Score of 39.29 (Figure 3) which was 81.85% accepting. The control group had an 8.7% increase in acceptance and the treatment group had a 5.1% increase in acceptance. The normalized gain for the control group’s average Acceptance Score was $g = 0.267$, and for the treatment group was $g = 0.179$. Both gains are classified as a low gain (Hake, 1998).

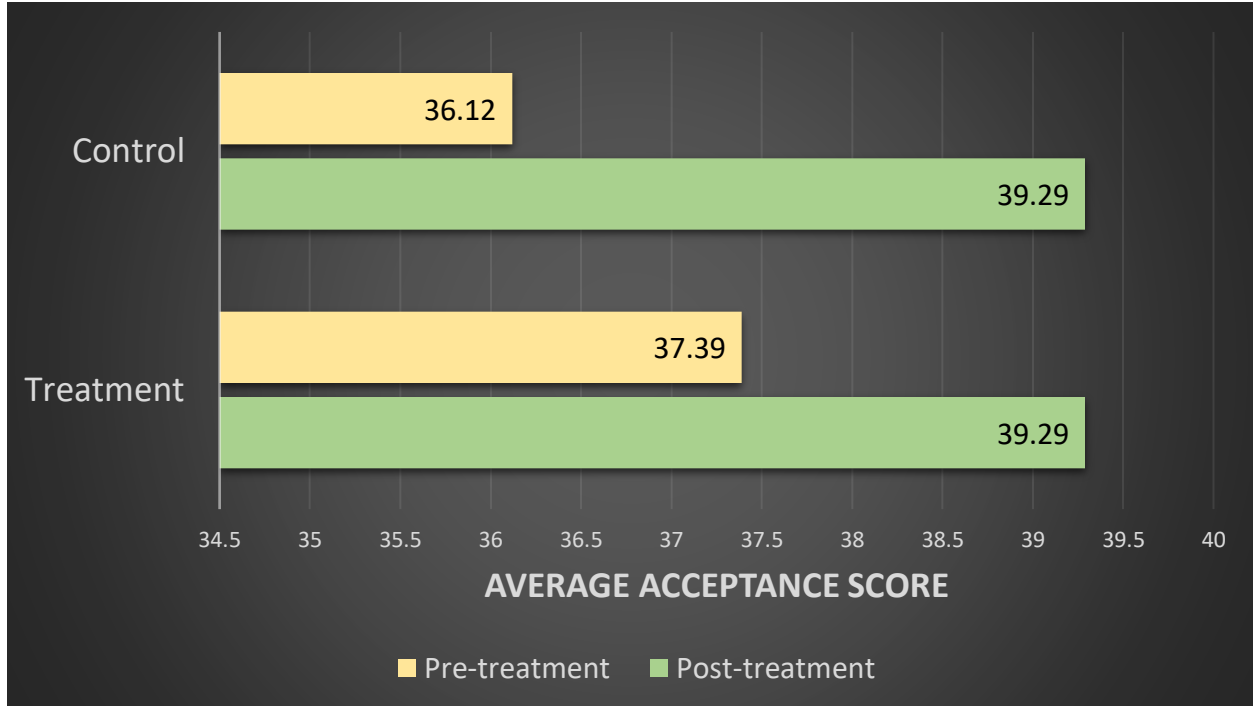


Figure 3. Average Acceptance Scores pre- to post-treatment.

A one-tailed paired t -test was performed on the pre- to post-treatment Acceptance Scores. The p -value for the control group was $p = 0.0000338$ and for the treatment group $p = 0.0059$. For both values, $p < 0.05$, meaning the change in acceptance levels from pre- to post-treatment for both groups were highly unlikely due to random chance (Makarovs, 2020; Mertler, 2020).

The number of students post-treatment that indicated complete agreement with the statement, “The theory of evolution is completely true,” was substantial. In the control group, the number of participants that selected *completely agree* to this statement increased 81.3% ($n=13$) from pre-treatment levels (Figure 4), and the number in the treatment group increased 257.2% ($n=18$) from pre-treatment levels (Figure 5). The control group had a medium normalized gain on this specific question of $g = 0.499$ and a p -value of $p = 0.0001$. The treatment group had a medium normalized gain on this specific question of $g = 0.440$ and a p -value of $p = 0.000006$.

Both groups had a decrease in the number of participants disagreeing with this statement from pre-treatment levels. The control group had a 100% ($n=5$) decrease in *completely disagree* responses, and a 33.3% ($n=1$) decrease in *somewhat disagree* responses (Figure 4). The treatment group did not have a decrease in the number of participants selecting *completely disagree* but did see a 33.3% decrease in the number of participants selecting *somewhat disagree* (Figure 5).

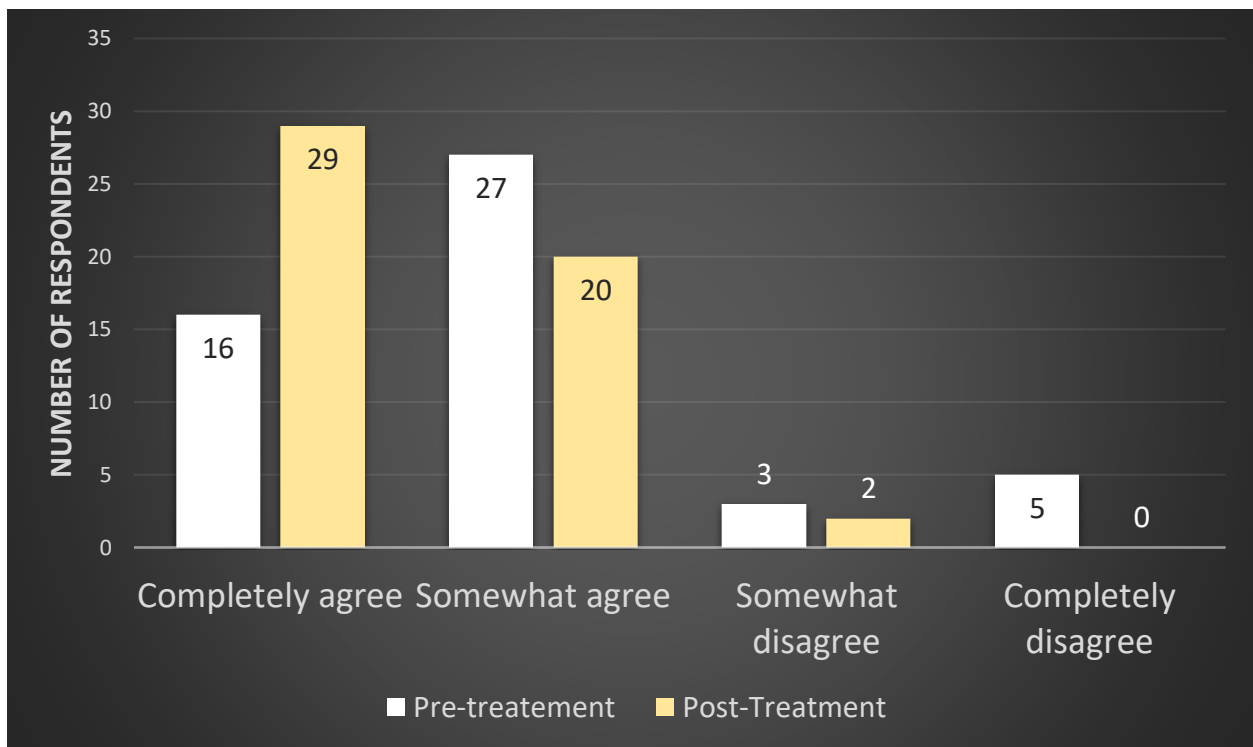


Figure 4. Control group participant responses to question one of the Likert Scale Survey “The theory of evolution is completely true” pre- to post-treatment (Appendix B).

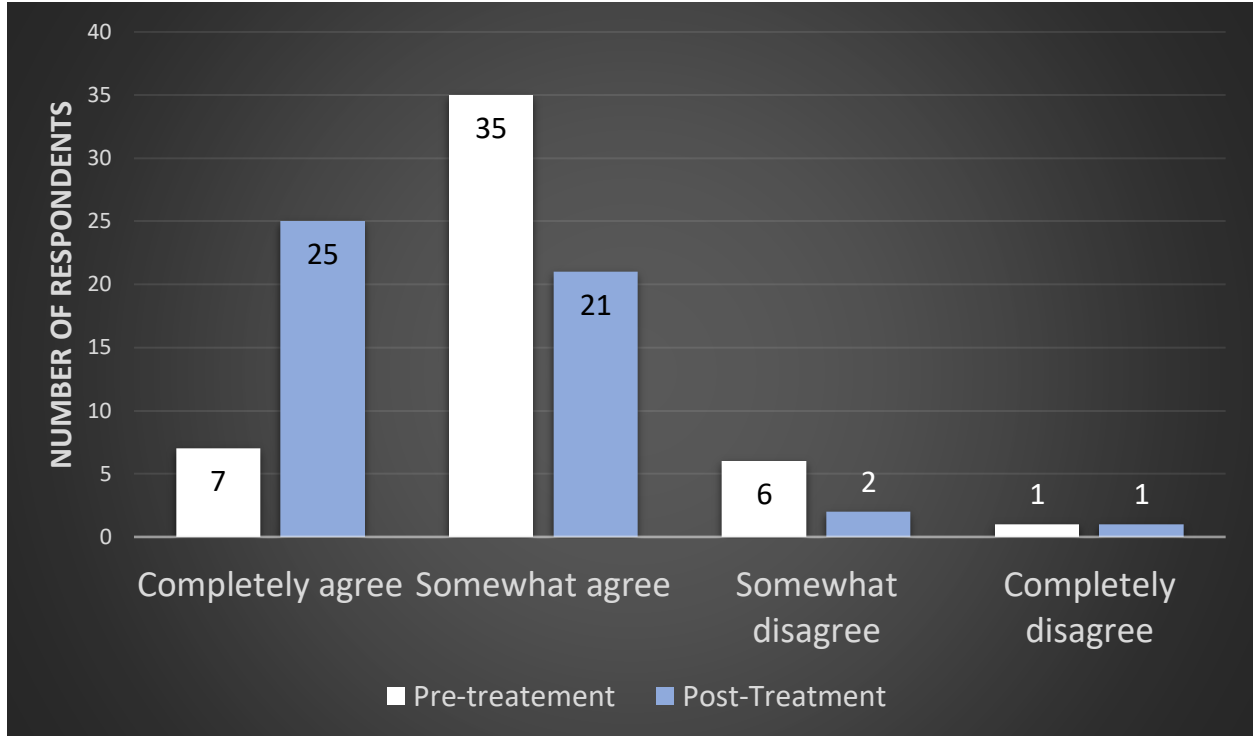


Figure 5. Treatment group participant responses to question one of the Likert Scale Survey “The theory of evolution is completely true” pre- to post-treatment (Appendix B).

In the control group, 15.7% ($n=8$) of the participants responded in complete or somewhat disagreement with the statement “The theory of evolution is completely true” on the pre-treatment survey. All of them ($n=8$) increased their acceptance levels for this specific question on the post-treatment survey (Table 4) and had a medium normalized gain of $g = 0.67$ with a highly significant one-tailed t-test p-value of $p = 0.0001$. Only one participant identified as “Wackyfrog94” maintained an attitude of disagreement, moving from *completely disagree* to *somewhat disagree* pre- to post-treatment. The other post-treatment participant, “hugebone81,” that selected *somewhat disagree* decreased their acceptance level on this specific question, moving down from *completely agree* pre-treatment (Table 4). The overall Acceptance score of “hugebone81” also decreased from 41 to 31.

In the treatment group, 14.3% ($n=7$) of the participants responded in complete or somewhat *disagreement* with the statement “The theory of evolution is completely true” on the pre-treatment survey. Two participants did not change their responses to this question post-treatment (Table 5). One identified as “Wh!tePuppy91” selected *somewhat disagree* pre- and post-treatment, and the other identified as “lumpysilk35” selected *completely disagree* pre- and post-treatment. Of the remaining five that selected *somewhat disagree* pre-treatment, four selected *somewhat agree*, and one *completely agree* on the post-treatment survey (Table 5). One respondent in the treatment group moved *down* from *somewhat agree* to *somewhat disagree* pre- to post-treatment. This sub-group had a medium normalized gain of $g = 0.40$ with a one-tailed t-test p-value of $p = 0.008$ (Hake, 1998).

Table 4. Control group participants selecting pre-treatment disagreement responses and their post treatment responses to question one on the Likert-Scale Survey (Appendix B).

Identifier code	Pre-treatment	Post-treatment
Damplead61	Somewhat disagree	Somewhat agree
Jollycave91	Somewhat disagree	Somewhat agree
Bumpybe@r98	Somewhat disagree	Completely agree
WildSqu@re83	Completely disagree	Somewhat agree
Mistypet15	Completely disagree	Completely agree
Redglass91	Completely disagree	Somewhat agree
Bestbean79	Completely disagree	Somewhat agree
Wackyfrog94	Completely disagree	Somewhat disagree

Table 5. Treatment group participants selecting pre-treatment disagreement responses and their post treatment responses to question one on the Likert-Scale Survey (Appendix B).

Identifier code	Pre-treatment	Post-treatment
Freshlook97	Somewhat disagree	Somewhat agree
Longolive94	Somewhat disagree	Somewhat agree
T!nyGoose55	Somewhat disagree	Somewhat agree
T!nyTwist67	Somewhat disagree	Completely agree
Busyshoe84	Somewhat disagree	Somewhat agree
Wh!tePuppy91	Somewhat disagree	Somewhat disagree
Lumpysilk35	Completely disagree	Completely disagree

Human and Non-Human Acceptance Levels. The participants of this study showed an overall gain in acceptance levels for both human and non-human evolution. Statement five on the Likert-Scale Survey stated, “Humans have evolved and still are evolving” was summed with statement eight to generate a human evolution acceptance score, and statements three and four were summed to generate a non-human evolution acceptance score (Appendix B). The control group had a pre- to post-treatment normalized gain of $g = 0.266$ in acceptance for human evolution and a gain of $g = 0.385$ for non-human evolution. This human evolution acceptance gain is a low gain, and the non-human evolution gain is a medium-low gain (Hake, 1998). The treatment group had a very low pre- to post-treatment normalized gain of $g = 0.073$ in acceptance for human evolution and a low gain of $g = 0.329$ for non-human evolution (Hake, 1998).

A one-tailed t -test of significance was performed on all four of these subset analyses. The control group’s gain in human evolution acceptance had a p -value of $p = 0.0084$ and a non-human p -value of $p = 0.0045$. Both p -values are well below the threshold of $p < 0.05$, making these changes unlikely to be due to random chance. The treatment group’s gain in human

evolution acceptance had an insignificant p-value of $p = 0.273$ and a non-human p-value of $p = 0.099$. Both p-values are above the threshold of $p < 0.05$, making these changes too likely to be due to random chance to be considered significant.

Participants that responded in disagreement to statement five, “Humans have evolved and are still evolving” on the pre-treatment survey had a mix of response changes from pre-to post treatment. Fourteen percent of participants ($n=7$) in the control group selected *somewhat disagree* or *completely disagree* pre-treatment. This sub-group of participants had a medium normalized gain in acceptance of $g = 0.412$ with a significance of $p = 0.024$. Two participants moved up to *completely agree* and one to *somewhat agree* post-treatment (Table 6). On the same pre-treatment question, 6% of participants in the treatment group ($n=3$) selected *somewhat agree* and zero select *completely disagree*. This sub-group had a weak normalized gain in acceptance of $g = 0.170$ with an insignificant result of $p = 0.371$. These participant’s post-treatment responses were mixed (Table 7).

Table 6. Control group pre-treatment participants in disagreement with statement five on the Likert-Scale Survey and their post-treatment responses (Appendix B).

Identifier code	Pre-treatment	Post-treatment
Fancylynx80	Somewhat disagree	Completely agree
Redglass91	Somewhat disagree	Somewhat disagree
=irstSun65	Completely disagree	Somewhat disagree
Bestbean79	Completely disagree	Completely disagree
BumpyBe@nr98	Completely disagree	Completely agree
L!ghtShip98	Completely disagree	Somewhat agree
Wackyfrog94	Completely disagree	Completely disagree

Table 7. Treatment group pre-treatment participants in disagreement with statement five on the Likert-Scale Survey and their post-treatment responses (Appendix B).

Identifier code	Pre-treatment	Post-treatment
Giantstone53	Somewhat disagree	Completely agree
Lumpygiraffe55	Somewhat disagree	Somewhat disagree
Lumpysilk35	Somewhat disagree	Completely disagree

Some participants decreased in acceptance of human evolution from pre- to post-treatment from an attitude of agreement to disagreement. The control group had two participants select *completely agree* to statement five pre-treatment and both selected *somewhat disagree* post-treatment. The treatment group had four participants select responses in agreement pre-treatment that then selected responses in disagreement post-treatment (Table 8).

Table 8. Treatment group pre-treatment participants in agreement with statement five on the Likert-Scale Survey and their post-treatment disagreement responses (Appendix B).

Identifier code	Pre-treatment	Post-treatment
Jollysprings32	Somewhat agree	Somewhat disagree
Longolive94	Completely agree	Somewhat disagree
Ultralynx54	Completely agree	Completely disagree
\$uperBulb59	Somewhat agree	Completely disagree

Misconception Probe

The results of the Misconception Probe were that both groups showed an increase in content knowledge. The control group had an average pre-treatment Understanding Score of 6.04 and a post-treatment average score of 6.53, which is a pre-treatment understanding level of 54.9% and 59.4% post-treatment. This was a 8.11% gain in average Understanding Score. The treatment group had an average pre-treatment Understanding Score of 5.86 and a post-treatment

average score of 6.22, which is a pre-treatment understanding level of 53.3% and 56.5% post-treatment (Figure 6). This was a 6.14% gain in average Understanding Score. The control and treatment groups both had very low normalized gains of $g = 0.099$ and $g = 0.070$ respectively (Hake, 1998). A one-tailed paired t -test was performed on the pre- to post-treatment Understanding Scores for both groups. The control group had a p -value of $p = 0.028$ and the treatment group had a value of $p = 0.120$. Since the control group had a p -value where $p < 0.05$, this result is statistically significant in that the outcome only had a 2.8% chance of being due to random chance. In contrast, the treatment group had a p -value where $p > 0.05$, meaning there was a 12% chance of the result being due to random chance, and is not considered significant (Makarovs, 2020; Mertler, 2020).

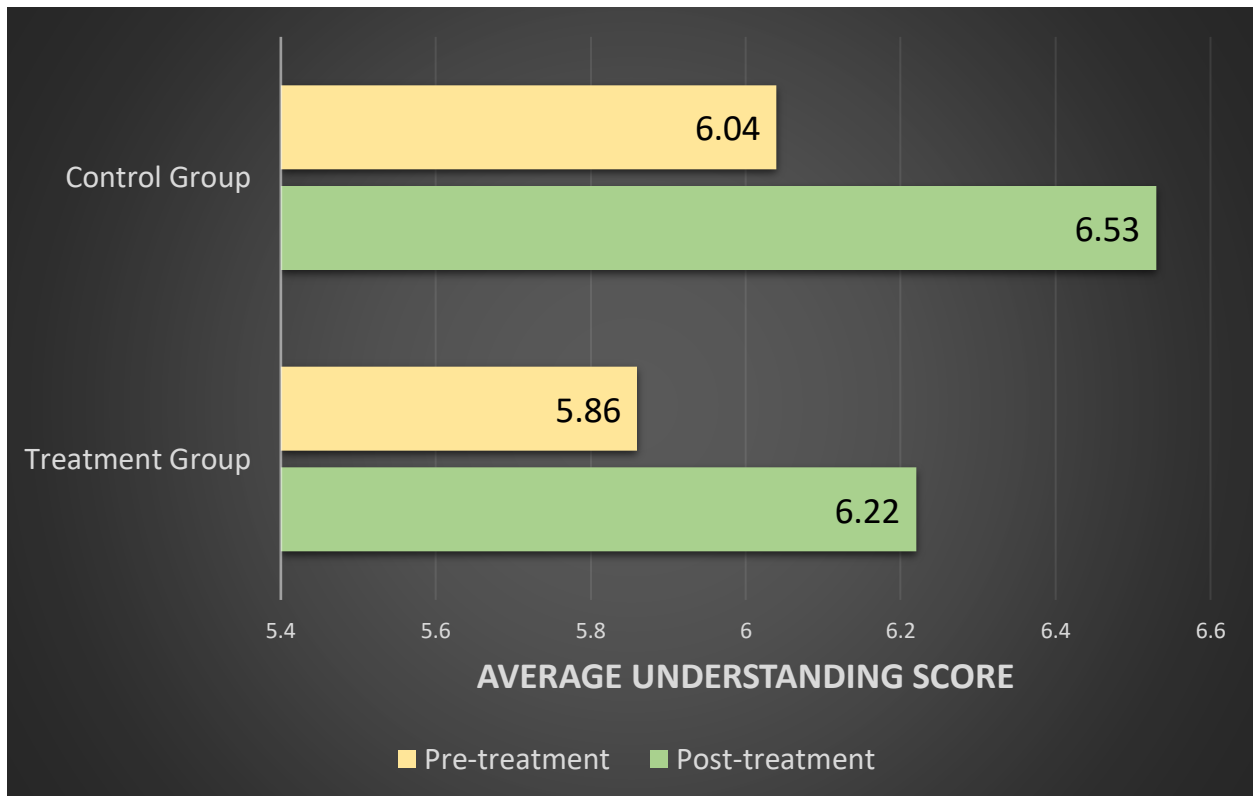


Figure 6. Average Understanding Scores pre- to post-treatment.

After the treatment period, some of the questions on the Misconception Probe were thrown out due to the lack of teaching done on those specific topics. Questions two, six, nine, and eleven were all discarded for a better analysis of content knowledge gains on topics that were heavily covered during the treatment period (Appendix C). This reduced the total possible maximum Understanding Score to seven. Using this Modified Understanding Score (MUS), the control group had an average pre-treatment score of 3.65 and a post-treatment score of 4.25, which is a pre-treatment understanding level of 52.1% and 60.7% post-treatment (Figure 6). This was a 16.4% gain in average Understanding Score. The treatment group had a pre-treatment MUS of 3.76 and a post-treatment score of 3.92, which is a pre-treatment understanding level of 53.7% and 56.0% post-treatment (Figure 7). This was a 4.3% gain in average Understanding Score. The control group had a low MUS normalized gain of $g = 0.179$, and the treatment group had a very low gain of $g = 0.049$ (Hake, 1998). The gains of the control and treatment group's MUS's were insignificant with respective one-tailed paired t -test values of $p = 0.062$ and $p = 0.138$ (Makarovs, 2020; Mertler, 2020).

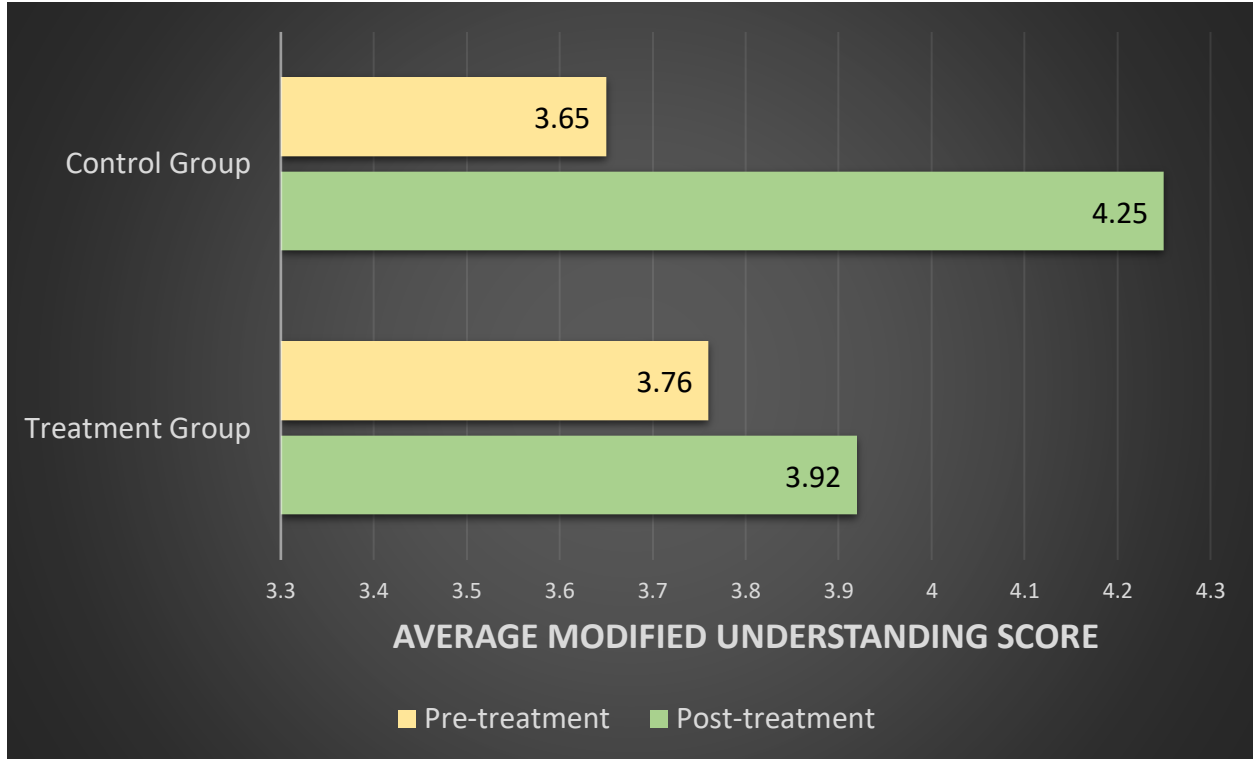


Figure 7. Average Modified Understanding Scores pre- to post-treatment.

Understanding Versus Acceptance

A correlational analysis was done on the Change in Understanding versus the Change in Acceptance scores for each group. The control group had a weakly positive correlation coefficient of $r = 0.369$ with a significance of $p = 0.0077$ (Figure 8; Makarovs, 2020; Mertler, 2020). The treatment group also had a weakly positive correlation coefficient of $r = 0.227$ with a significance of $p = 0.117$ (Figure 9; Makarovs, 2020; Mertler, 2020).

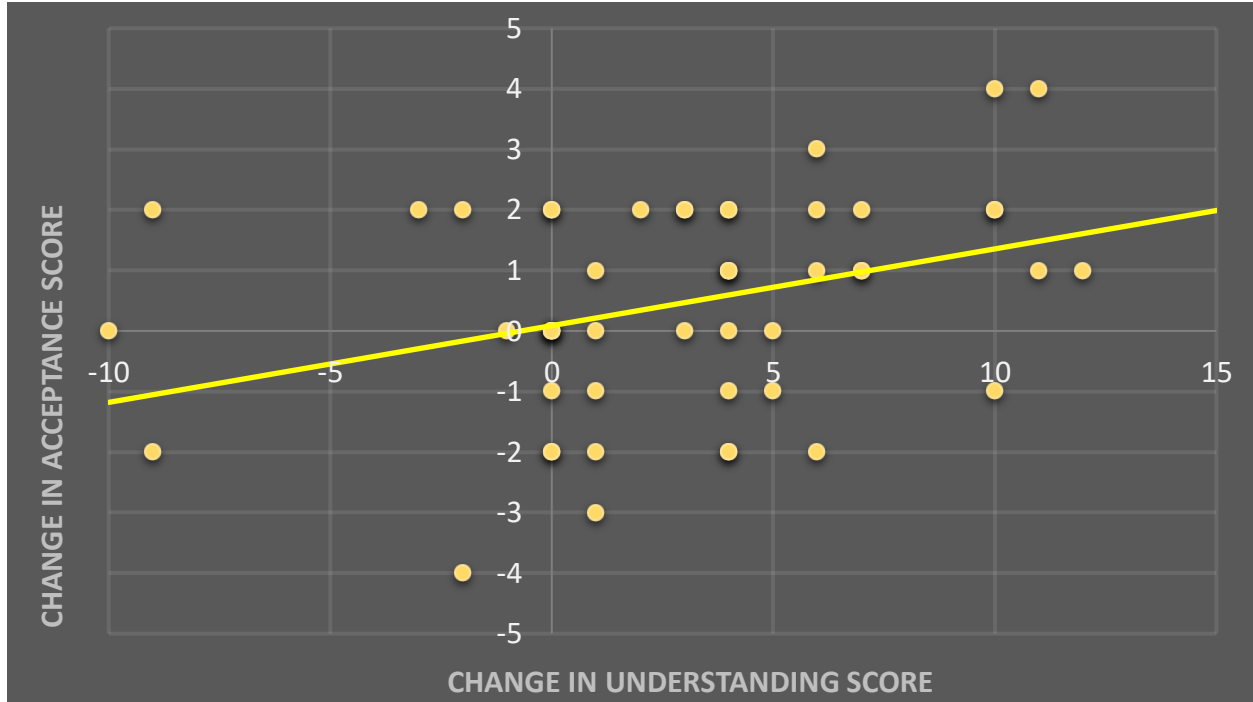


Figure 8. Control group correlation between Change in Understanding Score versus Change in Acceptance Score ($r = 0.369$).



Figure 9. Treatment group correlation between Change in Understanding Score versus Change in Acceptance Score ($r = 0.227$).

A separate correlational analysis was done using the Change in Modified Understanding Score results versus the Change in Acceptance Scores in place of the full Understanding Score results. The results of this analysis were a weak correlation in the control and treatment groups. The control group had a correlation of $r = 0.263$ with an insignificant result of $p = 0.062$ and in the treatment group $r = 0.215$ with an insignificant result of $p = 0.139$ (Makarovs, 2020; Mertler, 2020).

The results of participants Summative 3.0 Assessment showed that the control group ended the evolution unit with a greater understanding (Appendix E). The number of students scoring a 3.0 on the summative assessment was 59.6% ($n=34$) for the control group and 45.2% ($n=28$) for the treatment group. The summative assessment was also analyzed based on a more traditional percentage-based method. The control group ($n=57$) had an average score of 78.0% correct and the treatment group ($n=62$) 71.5% correct (Belgrade School District, 2023).

Awareness Survey

The results of the awareness survey were that 38.8% ($n=19$) of participants had “no idea” they had been learning about the fundamental concepts of evolution, 40.8% ($n=20$) “sort of knew”, and 20.4% ($n=10$) “totally knew” (Figure 10).

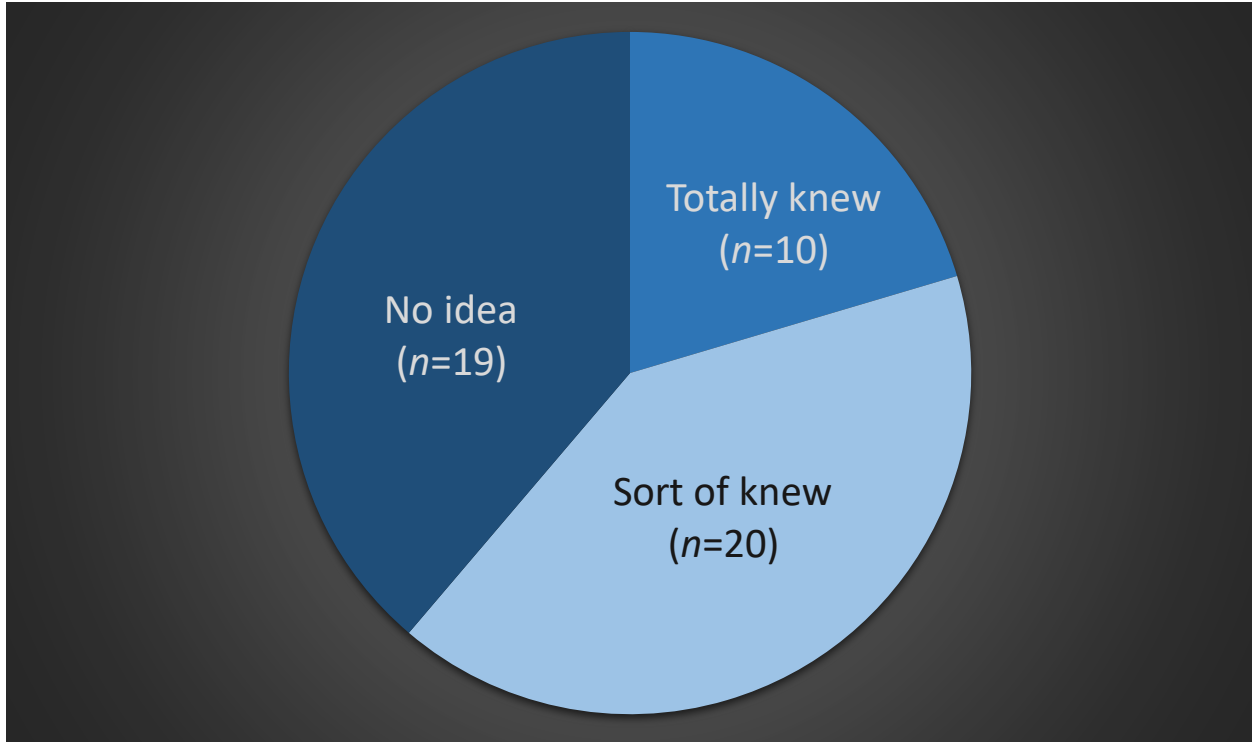


Figure 10. Treatment group responses to Awareness Survey (Appendix D).

CHAPTER FIVE

CLAIM EVIDENCE AND REASONING

Claims From the StudyEvolution as a Trigger Word and Acceptance

Being informed of education of evolution and/or exposed to the word *evolution* and/or its derivatives in an educational unit on the topic has a *greater* effect on the acceptance of evolution than *not* being informed and/or exposed. The word evolution and/or its derivatives does *not* act as a trigger word that reduces acceptance levels. The control group was informed they were learning about evolution and were exposed to the word evolution and/or its derivatives widely and freely from the beginning of the content unit while the treatment group was taught the same content without the use of the word evolution and/or its derivatives.

In every analysis of data in this study, the control group increased their acceptance levels *more* than the treatment group. Both groups had a small increase in Acceptance Scores, with the control group increasing by 8.7% while the treatment group increased by 5.1% from pre- to - post-treatment. One-tailed paired *t*-tests on these gains both indicated that they were highly significant results due to the treatment and very unlikely to have been due to random chance. The changes in average Acceptance Score for the control group had a less than 0.01% probability of being due to random chance while the treatment group had a less than 1% probability of being due to random chance. The small increases in overall acceptance measured are likely since students came into the unit already very accepting of evolution.

The results of acceptance level gains on single Likert-Scale Survey questions and groups of questions also support the control group's increase in acceptance levels being slightly more than the treatment group. Question one of the Likert-Scale Survey stated, "The theory of evolution is completely true". This question was specifically analyzed because of its lack of ambiguity and easy comprehension. While both groups had a medium gain in acceptance levels on this question, the control group had a slightly greater gain of $g = 0.499$ while the treatment group's gain was $g = 0.440$. The gains in the control group had less than a 0.1% probability of being due to random chance, and the treatment group's gains had a less than a 1% probability of being due to random chance. On an analysis of a subset of questions asking respondents specifically about human vs. non-human evolution, the control group showed a higher gain in acceptance levels to both human and non-human evolution. However, *t*-test analyses of these gains were mixed in their significance. The human and non-human evolution acceptance gains for the control group were significant with a less than 1% probability of being due to random chance, while the treatment groups gain on these subsets of questions were insignificant in that their *p*-values were greater than 0.05. The treatment groups small gain in human evolution acceptance levels had a 27% probability of being due to random chance, and the non-human gain had a 9.9% probability of being due to random chance.

Specific analyses of certain sub-groups of participants also showed greater acceptance level gains in the control group versus the treatment group. Of the participants that selected an answer in disagreement with question one of the pre-treatment Likert Scale-Survey, the control sub-group had a slightly greater gain than the treatment group. Both sub-group gains were highly significant with a less than 1% probability of being due to random chance.

The results of this study suggest that open and honest dialogue with students is preferable to trying to shield them from difficult or controversial topics at first. The higher gains in the control group along with the statistically insignificant results of some of the treatment group analyses suggest that students in the treatment group may not have been able to connect the concepts they had learned about for three weeks prior to being informed to being about evolution the whole time. By avoiding the word evolution in the treatment group for the first half of the unit, students may not have been able to make the connection that the processes of adaptation and natural selection *were* core principles of evolution itself. Meanwhile, students in the control group were likely to have been making this connection, as the true nature of these core principles was not hidden from them from the very beginning.

Understanding Versus Acceptance

Research on acceptance levels of evolution commonly shows that exposure to education on the topic increases participant acceptance levels (Donnelly et al., 2008; Dunk et al., 2017; Ferguson & Jensen, 2021; Lark et al., 2018; Vaugh & Robbins, 2017; Weisberg et al., 2018; Wiles, 2014). The results of this study were in line with these general trends in evolution acceptance levels after education on the topic with both groups showing increased understanding and acceptance.

The overall results of the sub-question: Is there a correlation between student understanding and acceptance of the theory of evolution? were that the control group had a slightly stronger correlation ($r=0.369$) between understanding and acceptance (Figure 8) than the treatment group ($r=0.227$) (Figure 9). The correlation of the control group was significant ($p=0.0077$) while the treatment group's results were not significant ($p = 0.117$). The control

group's results only had a 0.7% probability of being due to random chance while the treatment group's results had an 11.7% probability of being due to random chance. The correlational analysis of the Change in MUS versus Change in Acceptance was also a weak relationship with both the control and treatment groups results being insignificant.

Even with confirmation to the treatment group that they were learning about evolution part way through the unit, and frequent reminders that lessons and activities they had already done were all a part of evolutionary concepts, it seems that students in this group were not making the connection to what they had already learned being about evolution.

Value of the Study and Consideration for Future Research

The overall results of this study support previous findings regarding acceptance and understanding. Overall, participants increased their levels of acceptance after education on the subject which is in line with numerous other studies (Barnes et al., 2021; Dunk et al., 2017; Lark et al. 2018; Vaughn & Robbins, 2017; Wiles, 2014). This study also found a weak but positive correlation between understanding and acceptance in the control group (Figure 8) which is in line with some other research into the subject (Dunk et al., 2017; Lark et al., 2018; Weisberg et al., 2018). The treatment group also showed an increase in understanding, but the results were insignificant compared to the control groups highly significant results.

The results of this study also suggest that openness and honesty are the better choice when it comes to teaching about evolution. Scientific literacy, of evolution in particular, is emphasized by the National Science Teachers Association (para. 1, 2023) as necessary to be "well informed citizens and prepared for college and STEM careers." This position is also held by other large science education organizations (American Association for the Advancement of

Science, 2006). By every metric in this study, openly informing students that they are learning about evolution is better. Students in the control group that were informed upfront about the nature of the topic they were learning performed better on both content-oriented assessments, the Misconception Probe and the Summative 3.0 Assessment. The control group also consistently increased their acceptance by small but significant levels.

While this study demonstrated that the word *evolution* and/or its derivatives did not act as a trigger word to students, I do not think this means it is definitive evidence that these methods will necessarily be the same for all students nationally. Considering that the participants in this study came into the unit with such initially high levels of acceptance (Figure 2), it would be interesting to replicate this research on students in other demographic areas that have lower initial acceptance levels. It would also be interesting to modify this study so that participants could be surveyed in such a way that they were answering Likert-type questions about the basic principles of evolution without knowing it was evolution. I am imagining future research where all participants are given a survey that asks about the principles of evolution without mentioning that word and/or its derivatives. Then, one group receives instruction with explicit use of the word *evolution* while the other avoids it. All participants are then surveyed again about their acceptance levels to those basic principles.

This hypothetical future research does present problems. One is that, as demonstrated by the understanding results of this study, there is a risk to the participants of not receiving a fair education about evolution. The other is that this study demonstrated that students in the treatment group struggled to connect the initial content taught *without* using the word evolution as actually being the principles of evolution, even with explicit and frequent reminder's part way through

the unit. This point is perfectly exemplified by a particular student in the treatment group that clearly understood the principles of evolution but wrote an answer that indicated they were not connecting those principles to being evolution. Question five asked, “Did evolution happen in this population...?” (Appendix E). This student wrote, ‘No, evolution did not happen in this population, but adaptation did...’ I gave this student correct credit on this question since they were in the group that learned about “adaptations” in place of evolution for the first three weeks of the unit. This student answered all other questions on their summative assessment correctly, demonstrating that their incorrect perception of adaptations and evolution was likely not a fluke, but an effect of the research methods.

The results of this study suggest that sheltering students from what they are learning should be approached with caution, even if the intentions are sound. A better designed study may provide interesting results about whether knowing one is learning about evolution is a trigger, but it seems that learning it one way and then having to unlearn and then re-learn with the open use of the word evolution has negative impacts on student understanding and acceptance.

Impact of Action Research on the Author

The most profound impact this research had on me was that the results were consistently *opposite* to what I had predicted the outcome would be based on research into other “controversial” subjects and how vocabulary and/or knowledge of the controversial topic negatively impacted participants attitudes (Dixon et al., 2017; Hart & Nisbet, 2012; Lee et al., 2006; Villar & Krosnick, 2010). Lark et al. (2018) explicitly stated that some items having to do with human evolution were explicitly avoided so as not to artificially reduce overall acceptance levels. Vaughn and Robbins (2017) results indicated that even after instruction many participants

still found a level of discomfort or “distaste” towards evolution. Based on these factors, I predicted a higher level of acceptance in the treatment group, or at most no significant difference between the treatment and control groups. I find the consistently higher gains in acceptance and understanding of the control group fascinating.

Another impact this research had on me was an emotional one. On the day that I informed the treatment group that they had in fact been learning about evolution for the past three weeks, I felt very uncomfortable and uneasy. I felt like I was admitting to them that I had done something wrong. It felt unethical. In previous years of teaching evolution, I have done something like what I did with my treatment group in this study; I avoided the word evolution at first only to reveal later they had been learning about evolution the entire time. Up until this study, I have never felt those feelings of unease. The difference this year was that *I* was also a subject in this research. I had two different groups of students that I applied two different teaching methods to, and I was able to compare my own feelings in the moment between these two groups.

Another aspect of emotion that came into play during and after this research was the impact of my methods on *previous* years students. If the results of this study are valid, this suggests to me that my efforts to soften the subject of evolution to these students had the opposite effect of what was intended, even though my intention was to increase their acceptance and understanding.

The last impact on me was one that I had never thought about or predicted. Upon initial analysis of the data, I was surprised that 6% ($n=6$) students moved *down* in their acceptance levels from pre- to post-treatment, four of which were in the treatment group (Table 8).

However, as I spent more time thinking about what may have happened with these students, I now find it predictable and unsurprising that some would move down in their acceptance levels. I speculate that these students may not have really known what evolution was at first, and therefore had no reservations or disagreement with it. Once they learned about what it was, and perhaps connected it to being in opposition to their religious beliefs, this may have been the cause of their decreases in acceptance.

Going forward, I will be openly teaching my students that they are learning about evolution from day one of our content unit on the subject. I will not try and hide it from them in any way. I will share these results with other science teachers in our district and that I know personally so that they can perhaps learn from the results of this study and apply it to their own classrooms. I will also take the results of the pre-treatment acceptance levels (Figure 2) to mean that I do not need to emphasize “convincing” my students about the evidence of evolution as much as I have in the past. While I will still focus on teaching multiple lines of past and present evidence of evolution happening, I now feel that I can spend a little more time going further in depth to some of the more difficult *concepts* of evolution than I have in the past. For example, I have never covered the topics of convergent or maladaptive evolution in depth. I felt that maladaptive evolution in particular would be too complicated for students and may have had a backfire effect of them seeing that as evidence that evolution was *not* true. The results of this study tell me that at this age and in my school district, they are open to the idea and generally very accepting, so I can spend more of my time and effort on increasing their literacy of the subject as emphasized by the NSTA and AAAS (American Association for the Advancement of Science, 2006; National Science Teachers Association, 2023).

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

Your protocol was reviewed by the IRB and has been approved.

PI: Wenger, Matthew

Approval Date: 1/25/2023

Title: Acceptance of the Theory of Evolution and Trigger Word Avoidance

Protocol #: 2023-473-EXEMPT

Review Type: Full Committee

Expiration Date: 1/25/2028

APPENDIX B

LIKERT-SCALE SURVEY

Title: Evolution Survey

This survey is anonymous, which means no one will know how you answer these questions except you. The survey is being given for research being done for Montana State University. Participation in this survey is voluntary and you can choose to not answer any questions you do not want to answer. You may stop at any time for any reason without penalty of any kind. This survey will not affect your grade or class standing in any way. By answering these questions and submitting the survey, you give your consent to have your answers anonymously studied.

You may use the following link to have this survey read out loud to you.

(Link to a recording of me reading the survey)

Use the following link to generate a random code. DO NOT share this code with anyone!

www.dinopass.com

Enter JUST your “dinopass” code. DO NOT type anything else in this box.

a. (_____)

After you have entered your “dinopass” code in the box above, write in on your piece of paper, and seal it in your envelope. Do NOT write your name on the envelope. You will need this code at a later date!

a. I have sealed my code in my envelope.

I understand that this survey is completely anonymous.

a. Yes

1. The theory of evolution is completely true.
2. The theory of evolution is just a theory, which means it is just a guess or an idea.

3. Simple organisms such as bacteria have evolved and still are evolving.
4. Complex organisms like plants and animals have evolved and still are evolving.
5. Humans have evolved and still are evolving.
6. When other people say evolution is not true, I want to (or do) tell them they are wrong.
7. The theory of evolution is as strongly supported by evidence as other scientific theories like the theory of gravity.
8. Humans are an animal species that have the same ancestors as the great apes (chimpanzees, gorillas, etc.), and we evolved apart from them over millions of years.
9. Living things that exist today have not changed since the beginning of time.
10. Evolution is the reason there are so many different kinds of living things on Earth.
11. The theory of evolution can't make predictions or be scientifically tested.
12. Many things about biology only make sense if the theory of evolution is true.

APPENDIX C

MISCONCEPTION PROBE

1. Evolution and natural selection are both _____ processes.
 1. random
 2. predictable (non-random)
2. Mammal (including human) eyes are too complicated for evolution to have made naturally.
 1. True
 2. False
3. Humans can affect and change the evolution of organisms.
 1. True
 2. False
4. Organisms mutate, adapt, and evolve because they need to survive.
 1. True
 2. False
5. Natural selection is...
 1. a natural process that always chooses the best “fit” individual organisms to survive and reproduce in an environment.
 2. a natural process that selects organisms randomly to survive and reproduce.
 3. a process that gives organisms with better “fit” traits a higher chance of surviving and reproducing.
6. Natural selection always produces organisms that are perfectly “fit” to their environment.
 1. True
 2. False

7. The fossil record does not support the theory of evolution because we don't have fossils showing every single step for every organism.

1. True

2. False

8. "Survival of the fittest" means that only the strongest, fastest, biggest, and/or healthiest individual organisms will survive and reproduce.

1. True

2. False

9. Bacteria are equally as evolved as plants and animals.

1. True

2. False

10. Evolution of some organisms can be seen happening in a human lifetime.

1. True

2. False

11. Dogs evolved from wolves

1. True

2. False

APPENDIX D

AWARENESS SURVEY

Please choose the answer that best fits you:

How much of an idea did you have that we were learning about evolution for the last three weeks?

1. I had NO idea
2. I SORT OF knew, but wasn't totally sure
3. I TOTALLY knew it was all evolution

APPENDIX E

SUMMATIVE 3.0 ASSESSMENT

Evolution 3.0 Assessment

[Explanation / Read Aloud Link](#)

MS-LS4-4 Science Standard: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

FIRST: In the background information, watch the video and read everything before answering these questions! Scroll ALL the way to the bottom so that you don't miss anything. DO NOT change or write anything except in the blue "Type answer here:" spots.

$$\left(\frac{\text{Part}}{\text{Whole}}\right) \times 100 = \%$$

1. What was the **percent (%) chance of survival** for birds with the following beak depths? Fill in the table below:

Beak depth (mm)	7.3	8.3	9.3	9.8	10.3
% chance of survival					

2. Did larger or smaller beak sizes have a **higher fitness** during the 1977 drought? Explain how you know **using evidence from the graph**.
[Type answer here:](#)
3. What are the **genetic causes** of slightly different beak sizes in ANY population of birds?
[Type answer here:](#)
4. What put **pressure** on this population of birds? Explain **HOW** this put pressure on them.
[Type answer here:](#)
5. Did evolution happen in this population from 1976 to 1978? **Explain** how you know by describing specific evidence from **BOTH** graphs.
[Type answer here:](#)

Keywords you might use in your written answers:

Environment Natural selection Evolution Species Advantage Survival
 Reproduction Random mutation Adaptation Genetic variation Fitness
 Environmental pressure Selective pressure Change

Background Information:

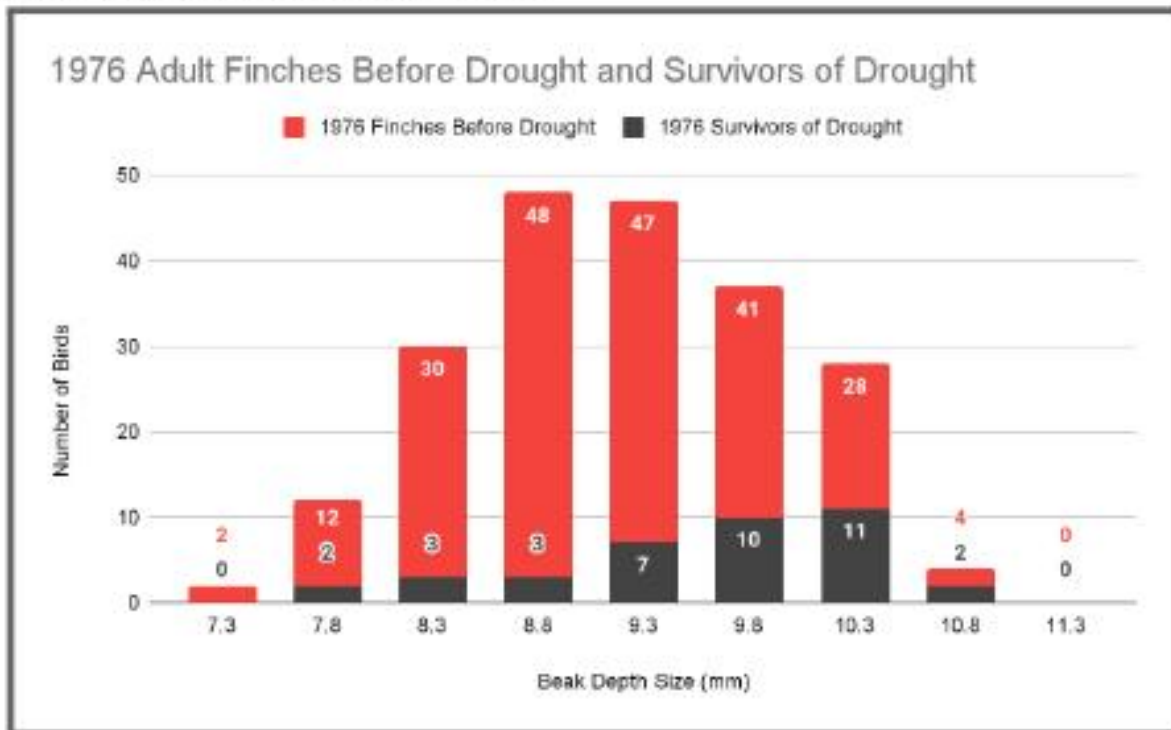
Open [this video link](#) (video will stop on its own at 9:55) and watch the video clip for the Background Information.



The Galapagos Islands are home to a wide variety of Finches. One of them is the "Ground Finch". For 40 years, biologists Peter and Rosemary Grant have been visiting the Galapagos Islands off the coast of South America to study Ground Finches. The method they used for capturing and recording specific birds was by "banding" their legs, each band having a specific code on it. If that bird is captured again later, they know it is the same bird. They measured the beak depth (size) of the finches each year. Below is the same data seen in the video clips. Use the video links above and the graphs below to answer the questions above.

Graph 1

Ground finch beak depth of adult finches in 1976 **before** the 1977 drought, **and** the finches that survived the drought. **Average beak depth in 1976: 8.9 mm.**



Graph 2

Ground Finch drought survivor's **offspring's** beak depth **after** the 1977 drought measured in 1978. **Average beak depth in 1978: 9.6 mm.**

