The Association between Teaching Middle School Science from an Intentionally Christian Worldview and Student Interest in Science

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ABSTRACT

Although Christians comprise the majority of the population in the United States, they make up less than one third of the scientific community. This underrepresentation is attributed to the desire to avoid the secular culture in academia or self-selection due to a perceived incompatibility or belief in negative stereotypes of Christian scientists. Therefore, this study explores the association between teaching middle school science from an intentionally Christian worldview and student interest in science. Using enrollment and demographic data, along with Ohio State Test scores, this quantitative study examined the correlation between how long students received their science education from a Christian worldview at a middle school in Canton, Ohio and their interest in science as measured by their performance on the Ohio State Test in Science. The data fails to reject to null hypothesis of no association between the number of years a student was enrolled and their Science State Test scores. There were no significant correlations between these two variables. Also, there were no significant associations based on gender or grade level. Additionally, there were negative correlations found for some of the science subtopics for Black and Hispanic students, and general education students. However, there were positive associations found for both fifth- and eighth-grade students, mixed-race students, students with 504 Plans and IEPs, and gifted students in select science subtopics. The results of this study were limited by a small sample size, but as a first of its kind study, it indicates that more research is required.

Keywords: science education, Christian worldview, middle school

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CHAPTER I

INTRODUCTION

Introduction

With a global shortage of STEM professionals and the universal desire to increase diversity within the field, Christian scientists are concerningly underrepresented in the STEM fields. Approximately 80% of the United States population self-identifies as religious, but only about 28% of scientists are religious (Ecklund et al., 2016; Rios et al., 2015). This study investigates teaching science from an intentionally Christian worldview to find ways to increase both achievement and consequently interest in science for Christian students. Specifically, this investigation will focus on these differences across a variety of demographic subgroups at a private Christian school in Canton, Ohio.

Although the shortage of Christian scientists has been well-studied, there have been no studies to date that addressed the association between teaching science from an intentionally Christian worldview and student interest in science. This study opens the door to an exciting new field of evaluating the effectiveness of Christian education on student interest. Ultimately, this would allow schools to better prepare a more diverse pool of STEM candidates for future careers.

The choice of this dissertation topic is deeply rooted in an educational background shaped by the integration of scientific learning within a Christian worldview. During undergraduate studies at a Christian college, an interest in science flourished significantly. This transformation was largely attributed to the unique and inspiring perspective provided by the Christian worldview. Christian mentors played a crucial role in this journey, offering unwavering encouragement and support. Despite the challenges

of often feeling marginalized in a field where such beliefs may seem out of place, these mentors were instrumental in fostering a sense of belonging and purpose. This dissertation not only continues these academic pursuits but also stands as a testament to the profound impact of these mentors and the alignment of faith with scientific endeavors.

Statement of the Problem

Christians are severely underrepresented in the scientific community in America (Ecklund et al., 2016; Rios et al., 2015). This creates an issue because not only is the pool of eligible candidates lessened in a world with an increasingly crucial need for STEM professionals, but it also limits the diversity of thought within modern science.

Various research has been conducted to determine that this underrepresentation arises from a combination of reasons, including self-selection, thinking that there is a conflict between science and religion or that Christians simply cannot be good scientists, or a desire to avoid the secular culture of the scientific culture in academia (Ecklund & Park, 2009; Ecklund et al., 2016; Leicht et al., 2021; Rios et al., 2015; Sharp et al., 2022). However, no research has been conducted to determine potential remedies for this underrepresentation of Christians in science.

Purpose Statement

This study aims to determine the association between teaching middle school science from an intentionally Christian worldview and student interest in science in a diverse, inner-city private Christian mission school. The independent variable, the extent of teaching from an intentionally Christian worldview, will be measured by the number of years that a student has attended this particular school. The dependent variable, student

scientific achievement, will be measured by the scores earned on the Ohio State Test in science, with a breakdown for the various scientific disciplines, as measured by the test. The difference in this association is based on subgroups such as grade level, gender, race, and level of support services received (IEP, 504, gifted, general education).

Research Questions

This study aimed to answer two primary research questions.

1. What is the association between teaching middle school science intentionally from a Christian worldview, based on years enrolled at Heritage Christian School, and student interest in science, based on total Science state test scores, and in the following areas: Earth Science, Life Science, Physical Science.
2. What is the difference in this association based on the following variables for the students: grade level, gender, race, and level of support services received (IEP, 504, gifted, general education)?

Methodology

This study used pre-existing secondary quantitative data from two different sources. It considered demographic information including years of enrollment at the school, grade level, gender, race, and level of support services received. Also used were Ohio State Test in science scores, including the results as a whole and a breakdown of Earth Science, Life Science, and Physical Science scores from 2021, 2022, 2023, and 2024.

Data was analyzed using IBM SPSS Statistics version 9.9.0.0 to perform a multivariate analysis of variants (MANOVA) to determine the correlation between the

variables. A Pearson correlation value was used to determine the existence and extent of correlation between the variables.

The primary limiting factor to reliability in this study was the relatively small sample size. This could not be avoided as this school has a small student population, as do many private Christian schools. Each grade at this school has approximately 20 students; the local public school district has approximately 600 students per grade level (Public School Review, n.d.). This threat to reliability was mitigated by including the entire middle school population over multiple years in the sample.

Additionally, internal consistency reliability was improved by the state tests containing multiple items that assess the same content area or cognitive demand. Test-retest reliability was improved by studying multiple years of data for the same student, when available.

External validity was the weakest form of validity for this study since it only included participants from one school. This was minimized due to the diversity of the student population, increasing the likelihood that the conclusions drawn would apply to other private Christian schools as well. Also, validity was increased by comparing differences in mastery of knowledge based on the time students spent at this school as well as their scores on math and English language arts state tests.

Significance of Study

This research will provide a better understanding of the benefit of teaching middle school science from an intentionally Christian worldview on scientific content mastery, as well as determine which subgroups of the population will benefit the most from this method. To date, no research has been published on teaching any level of science from an

intentionally Christian worldview, so this study may open up additional research opportunities to study additional grade levels and other associations between this Christian foundation on science education and student outcomes. By encouraging and enabling more Christians to pursue science, the deficit of STEM professionals will be lessened, and more diverse viewpoints will be introduced to scientific studies.

Assumptions, Limitations, and Delimitations,

The primary assumptions made in this study were that the Ohio State Test scores were accurate representations of student mastery of knowledge, and that this mastery of knowledge accurately represents student interest in science. Another assumption was that this school taught students from a Christian worldview and that the student's previous schools did not teach from a Christian worldview.

This study was limited to middle school students at one particular Ohio inner-city Christian mission school in Ohio. It did not include students of other ages or from other schools.

This study used the entire population of students in grades five through eight at one particular school due to the small population present and available for study. Additionally, although the student population was quite diverse racially and culturally, the vast majority of students' families possessed a lower socioeconomic status. This smaller sample size was the greatest potential weakness of this study. Additionally, there have been no previous research studies performed on the intersection of Christianity and science education.

According to the Ohio Auditor of State (2015), the Ohio Department of Education, now the Ohio Department of Workforce and Education, implemented a

process to develop the Ohio State Tests so that "each question is valid and an appropriate measure of learning standards…[and] to ensure each question is fair and unbiased" (p. 4). Although these measures were taken to develop the Ohio State Tests, no test is perfect; therefore, this study depended on the effectiveness of the Ohio State Tests.

Definition of Terms

Gender - as reported by parent/legal guardian at the time of student enrollment; as a Christian school, only male and female are accepted, but none of the participants openly identified as a gender that does not match their biological sex at birth (Babbitt et al., 2016).

Grade level - grade during the year of state testing, matches the grade level of the test taken.

Level of support services received - additional instructional services that students receive, such as accommodations for a 504 Plan or an Individualized Education Program, or participation in the school's gifted program.

Race - as reported by parent/legal guardian at the time of student enrollment.

Student mastery of knowledge - scaled score on the Ohio State Test.

Years enrolled - number of consecutive years a student was enrolled at Heritage Christian School as of the testing date, partial years rounded to the nearest quarter of a year.

Summary

Since Christians are so underrepresented in scientific fields and diversity of thought is vital to new discoveries, it is important to investigate potential ways to overcome the barriers that Christians face in their scientific studies and careers. This study quantifies the association between teaching science from an intentionally Christian

worldview and student interest in science. Additionally, this association is compared for a variety of demographic subgroups. Using demographic data and scores from the Ohio State Test for all middle school students who were currently enrolled at a private Christian mission school in an urban neighborhood, a MANOVA test was conducted to determine a Pearson correlation value. This value quantifies the relationship between teaching science from an intentionally Christian worldview and scientific knowledge mastery.

CHAPTER II

LITERATURE REVIEW

Religious Diversity of Scientists

In America, Christian scientists are underrepresented in industry and academia. Although the majority of the general population in the United States identifies as religious, that statistic significantly decreases for American scientists. Depending on the source, the portion of the general population that is religious varies from 67 percent to 90 percent, but the portion of scientists that are religious varies from only 25 percent to 30 percent (Ecklund et al., 2016; Rios et al., 2015). It has been theorized that this deviation is caused by a combination of the following: self-selection due to a perceived incompatibility between science and religion, a belief in negative stereotypes, or an avoidance of the secular culture of science (Ecklund & Park, 2009; Ecklund et al., 2016; Leicht et al., 2021; Rios et al., 2015; Sharp et al., 2022).

Self-Selection

One of the reasons that religious individuals may not pursue scientific careers is that they simply choose not to study science or pursue those career opportunities. The two main reasons for this self-selection are theorized to be a perceived conflict between science and religion and a belief in negative stereotypes about religious scientists (Ecklund et al., 2016; Leicht et al., 2021; Rios et al., 2015; Sharp et al., 2022).

Perceived Incompatibility. There is an ongoing debate regarding the perceived conflict between science and religion. Leicht et al. (2021), describe three points of conflict between science and religion. First, belief in religion and belief in science were found to be inversely proportional because they explain the same observations. Second,

religious individuals tend to possess cognitive styles that are strong in intuition, whereas scientific thinking requires more analytical thinking. Finally, social identities shape the idea of what type of person a scientist should be, which often aligns more closely with atheist or nonreligious groups than religious groups.

Ecklund et al. (2016) pointed out that one-third of the general population of America believed there was no overlap between religion and science but believed that sometimes there is an incompatibility between the two based on the particular details of the topic.

However, this perception is largely, but not entirely, dependent upon the subgroup of the perceiver. Those who identify as atheist or nonreligious report a significant incompatibility between science and religion. That belief is perpetuated throughout society and academia, so much so that many religious individuals simply will not pursue scientific studies, and therefore careers, even though they do not hold that same belief of incompatibility (Sharp et al., 2020). Ecklund & Park (2009) found that scientists who either do not attend religious services or who had a religious upbringing believe more strongly that there is a conflict between religion and science. Scientists who perceive others to have a more positive view of religion believe less strongly in this incompatibility. Even though religious conservatives in the general public are typically the ones more opposed to science in society, the conflict between religion and science is more likely to be perceived by religious liberal scientists than religious conservative scientists.

Belief in Negative Stereotypes. Another reason that many religious people do not pursue science is that there is a strong negative stereotype regarding religious scientists.

This is especially true for religious biologists in fields containing topics that are high in public conflicts, like evolution and stem cell research. There is a pervasive stereotype in American culture that religious scientists are less competent and less respected than their atheist or nonreligious peers. This discourages many religious individuals from becoming scientists (Sharp et al., 2020). Rios et al. (2015) showed that when these negative stereotypes were at the forefront of a religious scientist's mind, their performance dropped, especially when they self-identified as highly religious. Although this negative stereotype was shown to be untrue as long as religious scientists were not reminded of it before evaluation, the belief in the negative stereotype alone is problematic. This stereotype threat is theorized to be partially responsible for the self-selection of religious individuals to either avoid scientific pursuits or to underperform in scientific fields, which causes them to discontinue their studies or fail in their scientific careers.

Avoidance of Secular Culture

Sharp et al. (2020) also theorized that another potential cause for the underrepresentation of religious individuals in science is the avoidance of the secular culture of science, which may be hostile towards them. According to one study, 45 percent of academic scientists polled disagreed with the statement that their peers held a positive opinion of religion, compared to 32 percent who had no opinion, and only 23 percent who agreed that their colleagues viewed religion positively (Ecklund & Park, 2009). This means that a religious scientist would likely feel as if they did not belong in academia. Furthermore, as Sharp et al. (2020) theorize, the culture of science is one in which it would not only be a risk for a religious scientist to share their religious beliefs

with others, but also, they would likely endure insults towards their religious beliefs by their colleagues regularly.

Effects of Underrepresentation

As Rios et al. (2015) discuss, the reduction of the desire of religious individuals to pursue science leads to fewer potential candidates for scientific careers. Since most polls still show that most Americans identify as religious, these conditions may contribute to the nationwide shortage of STEM (Science, Technology, Engineering, and Mathematics) professionals.

Relationship between Christianity and Education

Education's Historical Christian Influences

When early colleges were established in America in the seventeenth and eighteenth centuries, their purpose was evangelical: for their students to be strengthened in their faith and spread the gospel to the rest of society. From the mid-seventeenth century until the Civil War, churches founded the majority of colleges. Additionally, the majority of intellectual writing was published by Christian colleges. Since then, rationalization, naturalism, existentialism, and postmodernism have caused the majority of American colleges to become largely secular, eliminating their religious components and ideas from their mission statements (Lawrence, 2007).

Christian Education

According to Liana (2020), there are seven characteristics of effective Christian education: "integration of biblical principles…Godly character training…mastery-based learning…built-in reinforced system of learning…individualized learning…development of critical thinking skills…socialization" (p. 16-18).

Christian schools should not only teach the required academic skills but also motivate students and help them grow in their faith, including creating and refining a worldview (Dernlan, 2013; Liana, 2020). Dernlan (2013) also emphasizes the need for teaching a Christian worldview in the classroom and providing professional development opportunities for teachers to unify academics with faith. Pazmino (2012) emphasizes the importance of balancing academic rigor with forming and growing a student's faith.

Integration of Faith and Learning (IFL)

One method that has become popularized in Christian education is the Integration of Faith and Learning (IFL). Some school policies supporting IFL are weekly Chapel attendance, devotions, lifestyle agreements, classroom decorations, textbook selection, specific class assignments, hiring policies, and professional development. Different institutions and educators approach IFL differently based on their worldviews and, therefore, have different foci. Some programs will focus on this integration occurring at the student level, others will focus on the curriculum as a whole or as individual teaching moments, and others will focus on the school or community as a whole. The policies implemented and the techniques to assess their efficacy will vary based on the focus most important to a particular school (Badley, 2009).

Lawrence (2007) illustrates the importance to Christians of a strong IFL at the K-12 and undergraduate level because students will often encounter the bias of opposing viewpoints in secular textbooks or higher education.

Lawrence et al. (2005) differentiated between faith-learning integration and faith-teaching integration after surveying an education class of college students. When asked to define IFL, the majority of students focused on the professor's teaching behaviors rather

than their learning behaviors. Only twenty percent of the responses indicated student behavior. Lawrence's findings imply that teachers and professors have the opportunity to affect change through IFL since students believe the burden of IFL falls more heavily on the instructor's actions than their own.

Sherr et al. (2007) surveyed undergraduate students from a variety of Christian colleges and universities asking similar questions and drew similar conclusions. Students associate the teacher's competence and the teacher's relationship with God and students with IFL. These key professor-led behaviors emphasize integrated faith and teaching more than integrated faith and learning.

Sites (2009) focused more specifically on eight undergraduate faculty to better describe the practical applications of IFL. This study found that a professor's relationship with God is the foundation for effective IFL.

Contrary to the previous work (Lawrence et al., 2007; Sherr et al., 2007; Sites, 2009), Bailey (2012) focused on how students can more actively participate in IFL. Project-based learning is one teaching method to build critical thinking and therefore shift the work of IFL towards the student. As students' critical thinking skills improve, they will better be able to integrate their faith into their education.

Worldview

As Wenneborg (2019) points out, one of the considerations within formal education is balancing exposure to a diversity of viewpoints with building a positive, committed worldview. Teaching students only one specific viewpoint risks indoctrination and discourages independent thinking. Exposing students to too many differing viewpoints risks them never creating and committing to their worldview or identity. In

American public schools, students are typically exposed to a much wider variety of viewpoints than they are in private Christian schools. However, Christian school students often engage with more diverse viewpoints than public school students. This is because the different viewpoints often found in Christian schools are simply different interpretations of the same biblical foundation. Since these viewpoints are more similar at their core to what students may have been raised believing, it is easier to incorporate some aspects into their existing worldview (Wenneborg, 2019).

Worldview Definition

By definition, a worldview is "a fundamental orientation of the heart" about reality that people use to make sense of the world around them (Sire, 2009, p. 20). A worldview can change and evolve as people mature and encounter new experiences. It is commonly shared as either a story or a list of assumptions. It should integrate all aspects of one's life and give meaning to life, especially hardships. (Sire, 2009; van der Walt, 2017).

Worldview Questions

Different philosophers use somewhat different questions to frame a worldview, but there are many similarities. For example, Shankle (2023), uses the following five questions: “Who is God? …Who am I? …Why am I here? … Why are people the way they are? … What is the remedy?” (p. 20)

Christian Worldview

In general, a Christian worldview is based on the Bible, using Scripture to answer the questions that can be asked to formulate a worldview. Although different Christians, especially those from different denominations, would likely answer the worldview

questions slightly differently, they all would agree that the Bible should guide their answers (Shankle, 2023).

The five previously mentioned worldview questions could be answered generally for a Christian worldview as follows. “Who is God?” God is the Creator of everything (Genesis 1:1). “Who am I?” I am created in God’s image (Genesis 1:27) but I am a sinner (Psalm 14:3; Romans 3:23). “Why am I here?” I am here to spread the gospel of Jesus to everyone (Matthew 28:19-20; Mark 16:15) and to serve God in all that I do (Colossians 3:23-24). “Why are people the way they are?” People are the way they are because they have sinned and are far from God. (Ephesians 2:3; Proverbs 15:29). “What is the remedy?” The only remedy for sin is repentance and faith in Jesus Christ (Acts 16:31; Acts 17:30; Romans 10:9-10). A Christian worldview will use these ideas to answer the philosophical questions in life. (Shankle, 2023).

Affirmation and Antithesis. Christians can analyze other worldviews using two principles: affirmation and antithesis. In affirmation, one searches for and celebrates aspects from a non-Christian worldview that are consistent with a Christian worldview. In antithesis, the points of contention between a non-Christian worldview and a Christian one are analyzed, and those differences are recognized as conflict (Wenneborg, 2019).

Creation, Fall, Redemption, and Restoration. One story that Christian educators often use to convey the ideas in a Christian worldview is one of “Creation, Fall, Redemption, and Restoration” (Shankle, 2023, p. 19). This story invokes the Biblical accounts of God creating everything, humans sinning, Jesus Christ redeeming believers, and looking ahead to when God will restore Creation to His original intent. Through this

story, students can internalize these principles and apply them to their own lives and academic disciplines of study (Shankle, 2023).

Kant's Bifurcated Worldview

A popular, opposing view to a Christian worldview that allows for the integration of faith and education is Immanuel Kant's bifurcated worldview. This worldview was shaped by Kant's background in math and science, especially the then-recent work of Sir Isaac Newton. As did many others, Kant believed that Newton had figured out the mysteries of the physical universe and that those mathematical and scientific principles were absolute truth. Kant's bifurcated worldview theory differentiates between knowing and thinking, between science and morality. In this bifurcated worldview, Christianity, or any other religion, and science are disparate fields, unable to be integrated (Smith, 2017).

However, Smith (2017) illustrates a flaw with Kant's bifurcated worldview: Christianity greatly influenced both the growth of Western civilization and scientific discoveries more specifically. The advancements in science would not have happened without the influence of religion; these two fields are intrinsically integrated.

Relationship between Christianity and Science

Manogu (2019) posited that the relationship between Christianity and science is a highly contested and complex one. The most probable cause for this is that Christianity and science both seek to achieve the same purpose of understanding universal truths but use vastly different methods to achieve that goal. Science requires one to believe only what the data and evidence prove to be true. Christianity requires one to possess blind faith and accept ideas as true without any proof. Manogu (2019) classifies the wide

variety of relationship models between Christianity and science into four categories: “conflict, independence, dialogue, and integration” (p. 25).

Christianity and Science Relationship Models

Conflict Model. The conflict approach that Manogu (2019) explained argues that science and Scripture are at odds with each other and has been adopted by both non-Christian scientists and non-scientist Christians. Scientific materialism theorizes that reality consists of only the natural; there is no supernatural. Proponents of this viewpoint argue that the scientific method and reproducible data are the only paths to knowledge and that measurable matter and energy are all that exist. Peters (2021) calls this "aggressive scientism" (p. 13). Biblical literalism theorizes that the Bible should be interpreted literally, which disagrees with scientific discoveries and, therefore, is incompatible with science. Proponents of this viewpoint believe that the Bible is the only path to knowledge and that Christians have no need for knowledge outside of the realm of Scripture. Both of these groups believe that one cannot be both a scientist and a believer because Christianity and science conflict with each other (Manogu, 2019; Sakorrafou, 2020).

History. Tirosh-Samuelson (2010) outlined a brief history of modern science to show the interconnectedness of science and Christianity. Compared to the field of science, the conflict approach is relatively young, beginning in the mid-nineteenth century with Charles Darwin's theory of evolution. There were several books written over the next half-century on the conflict theory of science and religion, beginning with John William’s *History of the Conflict between Religion and Science*. Although there were also Protestant and Catholic historians who wrote of the Reformation by Christians as a

catalyst for scientific discovery, the conflict model became popularized from both sides: Christianity and science.

By contrast, Ungureanu (2018) argues that the conflict model originated later in the late nineteenth and early twentieth centuries due to the growing popularity of the discipline of science history. Instead, Ungureanu (2018), argued that this concept originated with the historian James Moore, who used the term cognitive dissonance to describe the conflict between science and religion, arguing that Biblical literalism had no place in the scientific discussion.

Independence Model. The independence approach, one popularized by Kant, argues that Christianity and science describe different aspects of reality and do not overlap in any way (Manogu, 2019; Smith, 2017). Although the literal interpretation of the Bible may seem to disagree with scientific discoveries, they are not in conflict because faith and science exist independently of each other. Proponents of this viewpoint argue that science and Christianity use different languages to describe different functions of reality. Science uses objective, empirical research to describe the physical world, whereas Christianity uses subjective, faith-based research to describe more abstract concepts. According to this approach, science and Christianity are entirely disparate, with no overlap, working independently to explain different aspects of reality. (Manogu, 2019; Sakorrafou, 2020).

Dialogue Model. The dialogue approach theorizes that Christianity and science do overlap and interact with each other, but they are not integrated. This approach uses Scripture to answer questions that are currently asked but unanswered by science and focuses on the similarities between the two fields, acknowledging an overlap in a few

select areas. There are enough similarities between science and Christianity to communicate between the two, but there are sometimes competing, opposing theories to explain observed phenomena (Manogu, 2019).

Integration Model. The integration approach theorizes that science and Christianity complement each other and work together to create a complete picture of reality. Science cannot be fully understood without Christianity and Christianity cannot be fully understood without science. Sometimes, this approach is further broken down into three subgroups: "natural theology, theology of nature and synthesis theology" (Manogu, 2019, p. 29). Natural theology argues that science can be used to better understand the nature of the universe, which suggests the existence of God. Thomas Aquinas, Sir Isaac Newton, Charles Boyle, and others were proponents of natural theology. This subgroup believes that studying science reveals more information about God through his Creation. Theology of nature argues that the Bible should be used as a reference but that some traditional beliefs need to be changed to fit scientific discoveries. Proponents of this subgroup believe that science and Christianity overlap in a few areas, and when there is a disagreement between the two, the Christian belief system should be adjusted. Systematic synthesis theorizes that science and Christianity should be integrated completely, and in a balanced way, into a single framework for understanding reality (Manogu, 2019).

Badger et al. (2009) provided an example of how a Christian worldview is integrated into the study of science with the following statements: "The natural world is God's creation. …God constantly rules his creation in a providential way. …Science is the study of God's orderly creation. …Science is a human process shaped by the

surrounding culture and influenced by the fallibility and sinfulness of its human practitioners. …Science and the scientific method are limited. …Science provides vital information and tools for effective stewardship of the creation" (p. 2-7). Badger (2009) also added that the entire field of science is made possible through the orderliness of God; if God did not create order and patterns in the natural world, pursuing science would be futile.

Model Analysis. Manogu (2019) analyzed these four different approaches using Biblical arguments, quickly eliminating the conflict and independent models based on general and special revelation, inexorably linking faith and science together. Manogu also eliminated the dialogue model, arguing that "Teachings from the Bible are not only necessary for supernatural happenings; they are also crucial for us to have the right understanding of the natural world" (Manogu, 2019, p. 37). By eliminating these three other models, only the integration model remains as a Biblically-sound model.

Political Influence

Dixon (2022) described how the conflict between Christianity and science is influenced by their political and cultural aspects, not simply their compatibility. In the nineteenth century, the authority of the church was questioned while scientific discoveries were being made at an increasing rate. This political and cultural debate influenced the opinion of how well science and Christianity can coexist.

Scientists' Views on Religion

Ancient Greek Philosophers. The earliest recorded scientific thinkers were ancient Greek philosophers, namely Democritus, Plato, and Aristotle. Their ideas would be considered speculations, or untested hypotheses, in modern science, but they

dominated the field that would become science until the Middle Ages. Although these philosophers were not Christians, they easily accepted their ideas partly because they fit with biblical literalism (Badger et al., 2009).

Democritus. Democritus is credited with the introduction of the term "atom," as well as some ideas on the nature of matter. He believed that deeper knowledge could be discovered through more advanced instrumentation than simply the human senses and extrapolation of data. (Badger et al., 2009).

Plato. Plato separated knowledge into two categories: technical knowledge and pure knowledge. He considered technical knowledge to be inferior to pure knowledge, as it dealt with the flawed natural universe. Pure knowledge was a loftier idea to Plato because it dealt with an idealized philosophical world (Badger et al., 2009).

Aristotle. Although Aristotle was one of Plato's students, he saw great value in studying the natural world. He focused on using common sense to unify observations from a variety of fields. His writings were rediscovered by the Western world in the twelfth and thirteenth centuries. After the Crusades, there was increased contact between the Middle East and Europe, so Aristotle's writings were translated from Arabic during this period (Badger et al., 2009).

Aristotle named a Prime Mover the cause for the creation and movement of the universe; it was easy for Christians to substitute God for this Prime Mover instead and integrate Aristotle's ideas with biblical descriptions of the natural world. From Aristotle's writings, the following points, among others, were adopted by Christian scholars during the Middle Ages. The universe is geocentric, with a stationary Earth at the center and everything else revolving around Earth. There are four earthly elements: earth, air, water,

and fire, and their movement is a result of their tendency to move back to their natural place. Objects on Earth are stationary and require something to continuously move them if they are in motion, but objects in the “heavens” are in motion naturally. There are different substances on Earth than there are in the "heavens." Circular motion is the most natural and therefore the planets orbit Earth in circular orbits. A vacuum cannot exist. To understand an event, one must know the four causes of it: material, formal, efficient, and final cause (Badger et al., 2009).

Christian Scientists.

Copernicus and Kepler. In the sixteenth century, Nicolaus Copernicus wrote an argument for the heliocentric model, which placed the sun at the center of the solar system. This model somewhat explained the motion of the other planets, but still maintained the idea of circular orbits and therefore had relatively low accuracy. He was a leader in his church and “saw no conflict between science and faith” (Badger et al., 2009, p. 52). Copernicus’ heliocentric theory was supported by astronomical observations by Johannes Kepler, but he theorized that the planets’ orbits were elliptical, not circular, which more accurately explains planetary motion (Badger et al., 2009).

Galileo. In the early seventeenth century, Galileo Galilei studied motion and invented a superior telescope and used it to gather astronomical observations that contradicted the ideas about the universe from Aristotle that Christian scholars had adopted. Not only that, but Galileo also broke tradition and instead of publishing his scientific ideas in Latin, he wrote his book, *Dialogue on the Two World Systems*, in Italian so that it was accessible to everyone, not just scholars. This book was written as a conversation between a moderator and two characters who held conflicting views: one

held the heliocentric view of Copernicus, Kepler, and Galileo himself and the other held the geocentric view of Aristotle and many Christian scholars. In addition, he used a facetious name for the character who supported the geocentric view: Simplicio, meaning simple. Unsurprisingly, a great deal of conflict occurred as a result of this publication. Galileo was punished with house arrest since he had previously agreed not to teach the heliocentric model. This is often cited as an example of a conflict between science and religion, but it was "actually mostly a matter of personalities, pride, and power-plays among scholars" (Badger et al., 2009, p 24).

Newton. Approximately a century later, Sir Isaac Newton invented calculus and used it to combine the ideas of Galileo and Kepler as well as observations from his experiments. Newton wrote a book called *Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy)*, which included the three ideas that have become known as Newton's Laws of Motion. Newton credited the first two laws of motion to Galileo, but Newton was able to define them mathematically. Newton's first law of motion states, in part, that if an object is in motion, it will remain in motion at constant velocity unless acted upon by an external force; this is in direct opposition to Aristotle's theory that for an object to stay moving, it must have a continuous cause. However, the politics of science had changed enough by Newton's time that Aristotle's work was allowed to be questioned, so Newton's work was accepted in the scientific community (Badger et al., 2009).

Newton also studied gravity and light, theorizing that white light is a collection of different color particles moving extremely fast in a straight line. Additionally, he invented the reflecting telescope. He is also often credited with inventing the scientific

method, as he was notorious for his diligent experimentation methods (Badger et al., 2009).

In addition to science, Newton also studied the Bible extensively, searching for scientific information and hidden messages (The Associated Press, 2007).

Joule. In the mid-nineteenth century, James Prescott Joule was a physicist who designed an extremely sensitive thermometer that could detect small, previously undetectable temperature changes. He also published theories on heat and energy and helped his colleague, Lord Kelvin, with experiments studying gas expansion. Joule believed in the integration of science and Christianity, as demonstrated by this quote, "After the knowledge of, and obedience to, the will of God, the next aim must be to know something of His attributes of wisdom, power, and goodness as evidenced by His handiwork. It is evident that an acquaintance with natural laws means no less an acquaintanceship with the mind of God therein expressed" (Badger et al., 2009, p. 97).

Faraday. Michael Faraday worked under Sir Humphrey Davy in the early nineteenth century, discovering electromagnetic induction, proposing laws of electrolysis, and discovering a variety of hydrocarbons, including benzene. His Christian beliefs helped strengthen his certainty that the natural universe was both orderly and unified. Without this certainty of unification, he may not have discovered electromagnetic induction, which is the interaction between electricity and magnetism (Badger et al., 2009).

Maxwell. In the mid-nineteenth century, James Clerk Maxwell studied electricity, magnetism, and waves. He built upon Faraday's ideas and found that electrical waves and magnetic waves combine to form light waves. Maxwell's most notable contribution to

science is Maxwell's equations, a set of four equations that describe how currents and charges affect electrical and magnetic fields and how magnetic fields, and electric fields interact with each other. Like Faraday, Maxwell's faith convinced him that the natural world was orderly, which helped him to discover parallel electromagnetic relationships. In addition, when Darwin's Theory of Evolution became popularized, Maxwell publicly argued against Darwin and his proponents, emphasizing that the universe and life were made by a creator, not random chance (Badger et al., 2009).

Priestly. In the late eighteenth century, Joseph Priestley, who made significant contributions to the field of chemistry, including the discovery of oxygen, was also a minister. He "saw no disintegration between the spiritual and material descriptions of the world" (Badger et al., 2009, p. 156).

Dalton. John Dalton laid the groundwork for the field of modern chemistry with his atomic theory, a building upon Democritus' work. Additionally, he contributed to a better understanding of weather and color blindness. As a skilled communicator, Dalton used examples and diagrams to explain all his ideas thoroughly, which led to easy acceptance of them in the scientific community. Dalton was a Quaker and "the impact of his faith may be seen in his steadfast and persevering manner, and in the thoroughness and honesty of his work" (Badger et al., 2009, p. 156).

Boyle. Robert Boyle is most famously known for the discovery of Boyle's Law in the mid-seventeenth century, which describes the inverse relationship between pressure and volume. Additionally, he worked to bring Newton's scientific method into the discipline of chemistry. Not only that, but he wrote extensively on the reconciliation of Christianity and science and left an endowment to continue lectures, known as the Boyle

lectures, annually on the topic. He also made significant donations towards Christian missionary work and Bible translation (Badger et al., 2009).

Pasteur. Louis Pasteur's claim to fame is the mid-nineteenth-century invention of the process to kill bacteria in milk, known as pasteurizing. He also laid the foundation for microbiological and medicinal discoveries such as germ theory and immunization, specifically for rabies. Additionally, he discovered handedness in organic molecules, which led to discoveries in molecular geometry. Pasteur is reported to have "strong beliefs in an infinite God, the immortality of the soul, and a God-given responsibility for morality and stewardship" (Badger et al., 2009, p. 193).

Hales. Stephan Hales was responsible for bringing the scientific method into the field of biology near the turn of the eighteenth century. His support for this is faith-based, as he stated, "And since we are assured that the all-wise Creator has observed the most exact proportions, of number, weight, and measure, in the make of all things; the most likely way, therefore, to get any insight into the nature of those parts of the creation, which come within our observation, must in all reason be to number, weigh, and measure" (Badger et al., 2009, p. 252).

Ray. John Ray was a seventeenth-century botanist who worked to create a comprehensive encyclopedia of British plants. He also wrote a popular book that integrated faith and science, called *Wisdom of God in Creation*. Ray is quoted as saying, "There is for a free man no occupation more worthy and delightful than to contemplate the beauteous works of nature and honor the infinite wisdom and goodness of God" (Badger et al., 2009, p. 263).

Non-Christian Scientists.

Darwin. Charles Darwin, who popularized the theory of evolution and common descent in his 1859 book, *On the Origin of Species*, was once an orthodox Christian, then a deist, then finally an agnostic. Although Christians generally accepted Darwin's theories of evolution and common descent as not necessarily conflicting with Scripture, they were an impetus for secular movements because they provided an alternate explanation for the origin of life (Brooke, 2018).

Dawkins. Richard Dawkins, a modern, atheist biologist, spoke out strongly, using science to discredit religion. Dawkins was a strong proponent of evolution, taking on Darwinism as his worldview. In his book, *A Devil's Chaplain*, he calls religion "a virus of the mind" and outlines three arguments against religion: "religion is just plain false…religion is the root of much evil…the presumed historical opposition between science and religion" (Giberson & Artigass, 2007, p. 46-49).

Gould. Stephen Jay Gould was an agnostic evolutionary biologist of the mid- to late-twentieth century. His theory of note is punctuated equilibrium, which states that species go long periods without much change and then suddenly change quickly on a geological timescale. Additionally, he believed that evolution just happened to create humans through a random, unpredictable process. Gould also spoke out on the topic of science and religion, arguing that there is no conflict between them nor is there an overlap between them. In his book, *Rocks of Ages*, he called this theory Non-Overlapping Magisteria, or NOMA (Giberson & Artigass, 2007).

Hawking. Stephen Hawking is one of the best-known physicists of the modern era. He is said to not have approved of the label of "atheist" but stated in multiple

interviews that he did not believe in God but left the details vague. Hawking wrote quite a bit about physics and God and even met with Pope John Paul II (Giberson & Artigass, 2007).

As Giberson and Artigass (2007) pointed out, most of Hawking's work focused on singularities, involving both black holes and the beginning of the universe. At this time, there were three sets of the laws of physics: relativity, which applied to large scale; quantum mechanics, which applied to the small scale; and Newtonian physics, which applied to everyday life, the scale with which humans interact. At a singularity, none of these laws of physics are applicable. Hawking's mathematical aptitude and intellectual creativity allowed him to tackle these problems, and he conceptualized the formation of a black hole and the Big Bang at the beginning of the universe as being opposite processes. According to the Big Bang theory, the universe began as essentially a black hole, a very dense point mass (Giberson & Artigass, 2007).

In 1981, Hawking was invited to present his work at The Pontifical Academy of Sciences and spoke on his theory that the universe did not have a beginning, which would rule out Creation (Giberson & Artigass, 2007). Afterward, Hawking met Pope John Paul II and wrote about it in his book, *A Brief History of Time*, "At the end of the conference the participants were granted an audience with the Pope. He told us that it was all right [*sic*] to study the evolution of the universe after the Big Bang, but we should not inquire into the Big Bang itself because that was the moment of Creation and therefore the work of God. I was glad then that he did not know the subject of the talk I had just given at the conference—the possibility that space-time was finite but had no boundary, which means that it had no beginning, no moment of Creation. I had no desire to share the fate of

Galileo, with whom I felt a strong sense of identity, partly because of the coincidence of having been born exactly 300 years after his death!" (Hawking, 1989; Giberson & Artigass, 2007, p. 101).

Hawking concluded *A Brief History of Time* with the assertion that if scientists could figure out a "theory of everything," an integrated set of laws of physics that are applicable at all scales, including singularities, they would "know the mind of God" (Hawking, 1989). Giberson & Artigass (2007) discussed Hawking's use of this phrase as possibly a publicist's attempt at sensationalism because it seems at odds with Hawking's disbelief in God. Although he clearly stated repeatedly that he did not believe in God, Hawking referenced Him often. If not just for a boost in book sales and fame, it is possible that Hawking was using God's name as a familiar explanation for the unknowable, or questions that Hawking did not believe humans would ever be able to answer (Giberson & Artigass, 2007).

In 1989, Hawking said, "It is difficult to discuss the beginning of the universe without mentioning the concept of God. My work on the origin of the universe is on the borderline between science and religion, but I try to stay on the scientific side of the border. It is quite possible that God acts in ways that scientific laws cannot describe. But in that case one would just have to go by personal belief" (Giberson & Artigass, 2007, p. 104). Hawking argued that God should not be considered until science cannot explain the phenomenon or answer the question at hand (Giberson & Artigass, 2007). This statement implies that although Hawking did not believe in God, he held the belief that Manogu (2019) would have labeled as the independence model: science and religion function independently and address different questions.

Sagon. Carl Sagon is best known for being a public science educator, with his most popular contributions being the 1980's TV series, *Cosmos*, and book of the same name. Sagon also was a science activist, arguing against the development and production of nuclear weapons. Sagon was not necessarily hostile towards religion but was a skeptic because religious ideas could not be proven in the same way that scientific ideas can be proven. In *Cosmos*, Sagon posited that religion was invented to explain natural phenomena. Now that scientific discoveries have been made to better explain these phenomena, there is no need for religion anymore (Giberson & Artigass, 2007). This would be categorized as Manogu's (2019) conflict theory on the relationship between science and religion. Sagon is credited with using his popularity to encourage the continuation of belief in the conflict theory of science and religion (Giberson & Artigass, 2007).

Weinberg. Steven Weinberg, a Nobel Prize winner for his work on the electroweak interaction theory, was also a public intellectual known for his anti-religious viewpoints. He is a self-identified "unreligious American Jew" and included a chapter on God in his book, *Dreams of a Final Theory*, in which he wrote about how science has taken over the role of religion and demystified the universe (Giberson & Artigass, 2007, p. 175).

Weinberg was hostile towards religion and faced a significant amount of backlash for a portion of a speech he gave in 1999, in which he said, "With or without religion, good people can behave well and bad people can do evil; but for good people to do evil—that takes religion" (Giberson & Artigass, 2007, p. 183). Giberson & Artigass (2007) argued that this worldview comes from many of his relatives suffering during the

Holocaust, quoting Weinberg as saying, “Religious people have grappled for millennia with the theodicy, the problem posed by the existence of suffering in a world that is supposed to be ruled by a good God. They have found ingenious solutions in terms of various supposed divine plans. I will not try to argue with these solutions, much less to add one more of my own. Remembrance of the Holocaust leaves me unsympathetic to attempts to justify the ways of God to man. If there is a God that has special plans for humans, then He has taken very great pains to hide His concern for us. To me it would seem impolite if not impious to bother such a God with our prayers" (p. 177). Likely, this hostility towards God and support of the conflict theory of religion and science is shaped more by Weinberg's pain and anger regarding the atrocity of the Holocaust than by his scientific or theological expertise. Even Weinberg himself admitted that he was not an expert, yet he still shared very strong opinions on the matter. (Giberson & Artigass, 2007).

Wilson. Edward O. Wilson was a sociobiologist and Pulitzer Prize winner for his book *Human Nature*. In this book, Wilson applied his scientific knowledge of sociobiology to people. Wilson was raised as a Southern Baptist, but after learning about evolution, could not reconcile the Bible with his scientific knowledge. He took on the approach that religion was the early explanation for natural phenomena and that scientific discoveries should replace religious beliefs and explanations. Evolution essentially became his religion (Giberson & Artigass, 2007). Although he was not hostile toward Christianity, Wilson's views best align with Manogu’s (2019) conflict approach. Giberson & Artigass (2007) explain that he respected religion but viewed it as unable to be used as

a guide for understanding life. Science, specifically evolutionary biology, was a more accurate worldview (Giberson & Artigass, 2007).

Nye. William Nye, more famously known as Bill Nye the Science Guy, is a mechanical engineer by training but is known for his work as a public science educator and science activist. Nye has written and starred in many TV shows, including *Bill Nye the Science Guy* and *Bill Nye Saves the World*. In addition, he is the chief executive officer of the Planetary Society. Nye argues that science and the Bible are in conflict with each other and implies that Christians are not reasonable. In 2014, Nye publicly debated Ken Ham on the topic of evolution versus young earth creationism, which assumes the literal meaning of Genesis, that Earth was created in six 24-hour periods. In a 2016 interview, Nye shared that, like Sagon, he is an atheist because there is not sufficient evidence to support religious claims. Additionally, Nye thinks that belief in the Bible will decrease scientific literacy (Giberson & Artigass, 2007; New American, 2014; Pietrus-Rajman, 2017).

Tyson. Neil deGrasse Tyson, an astrophysicist and public science educator, credits Carl Sagon as a strong influence on his career and hosted the 2014 remake of Sagon's TV show, *Cosmos*. Unlike Sagon, Tyson is extremely critical of Christians, especially scientists who believe in God, and often mocks their beliefs. Wathey (2018) reported that Tyson mentioned a survey that found 93% of the members of the National Academy of Sciences do not believe in "a personal God who answers prayer," and questioned, "Why do 7 percent of the most brilliant scientific minds in America believe in a personal God? Why isn't this number zero?" (p. 10).

Christian Leaders' Beliefs on Science

Pope Pius XII. In a speech to the Pontifical Academy of Science in 1951, Pope Pius XII said, "Contrary to rash statements in the past, the more true science advances, the more it discovers God, almost as though He were standing, vigilant and waiting, behind every door which science opens" (Giberson & Artigass, 2007, p. 102). This speech demonstrates that Pope Pius XII believed that science and Christianity were not in conflict with each other and that science supported Christian beliefs. (Giberson & Artigass, 2007; Pius XII, 1951).

Ken Ham. Ken Ham, a public Christian educator, founded the company Answers in Genesis, which created the Creation Museum and Ark Encounter. Ham speaks publicly and answers religious and scientific questions from his Christian worldview on his daily radio show and his website. He also has written a variety of books, including *Already Compromised,* which focuses on the topic of the diminished authority of the Bible at Christian colleges. Ham's educational background is in both education and applied science, specifically environmental biology. His approach would best fit with the integrated model of Manogu (2019) because he believes that science and mathematical discoveries point toward the existence of God (Ham, 2013; Ham 2023; Ham, n.d.).

Environmental Science Perspectives

One of the interesting, related scientific perspectives is the difference in perspective on environmental science based on the specific worldview that those educators hold. Anthony (2020) surveyed faculty at a Christian Higher Education Institution using the NEP (New Ecological Paradigm) survey to determine where their beliefs fell on the spectrum of worldviews. Biblical literalists were found to typically

possess an anthropocentric viewpoint that the priority is the health of humans, even at the expense of harming the environment. A theocentric perspective is more Biblically based and combines an anthropocentric viewpoint with an ecocentric one, which would typically focus on the well-being of the environment, and according to Anthony (2020) should be the goal of Christians to encourage students to become good stewards of the earth.

Motivation

Motivation is one of the important variables in effective teaching and learning that researchers are interested in studying. Motivation determines a student's engagement, behavior, and learning outcomes (Ajlouni, 2023). Hendijani and Steel (2023) argue that dualism places equal importance on both subsets of motivation: extrinsic and intrinsic. An understanding of a student's worldview can also play a significant role in their motivation to learn. For instance, students whose worldview emphasizes stewardship of the earth may be more intrinsically motivated to learn about environmental science. Considering motivation theoretical perspectives, one can better encourage more students to pursue science academically and professionally.

Extrinsic Motivation

Extrinsic motivation comes from outside sources, so this has traditionally been the easiest focus for teachers. Bear et al. (2017) found that both positive stimuli like praise and rewards and negative stimuli like consequences both increased extrinsic motivation for students. Chen (2018) found that peer interactions and competition increased motivation and also academic performance.

Social Effect on Science Interest. Jackson et al. (2018) studied the effect of the perception of social approval of college students' scientific interests on their interest in science. They theorized that "messages that suggest that one is or is not welcome within a context may serve to bolster or attenuate interest in those contexts." (Jackson et al., 2018, p. 149). Jackson et al. (2018) found that this social approval had the most effect on women with a low science identity, less so on women with a strong science identity, and no measurable effect on men. This implies that to increase diversity in scientists, receiving the social approval of peers is important to encourage the participation of those who might otherwise give up and change their academic and career plans. Similarly, Joy et al. (2023) found that informal youth science programs can increase the interest of adolescents, especially girls, which would also increase the diversity in scientific careers.

Intrinsic Motivation

Grigorescu (2020) argues that although extrinsic motivation was the traditional type of motivation for teachers to foster, they should be using intrinsic motivation. The argument for this change is that extrinsic motivation focuses on a finite goal such as tests, diplomas, and degrees whereas intrinsic motivation views education as an ongoing process. Since lifelong learning is a stated goal of many districts, this argument for the use of intrinsic motivation is valid. Bogner et al. (2023) measured intrinsic motivation on “four subscales: interest, perceived competence, pressure and perceived choice” (p. 136). Other researchers also included these same concepts of intrinsic motivation in their research (Areepattamannil et al., 2023; Egmond et al., 2020; Guay, 2017; Pečiuliauskienė, 2019; Pečiuliauskienė, 2020; Röllke & Großmann, 2022). Additionally, this fits well with the self-determination theory of basic psychological needs.

Self-Determination Theory. Self-determination theory can be used as a framework theory to explain intrinsic motivation. One of the sub-theories of self-determination theory is the basic psychological need theory, which states that intrinsic motivation is a product of how well the following needs are met: competence, relatedness, and autonomy (Egmond et al., 2020).

Competence. Areepattamannil et al., (2023) found "Intrinsic motivation to learn science was significantly related to science achievement…intrinsic motivation to learn science alone significantly mediated the relationship between science self-concept and science achievement" (p. 1). Pečiuliauskienė (2019) showed that perceived competence affected students' intrinsic motivation for learning science, more so than other factors studied. In 2020, Pečiuliauskienė also found that the related concept of student self-confidence increased motivation for learning science. Röllke and Großmann's 2022 study also supported this finding of an increased perceived competence increasing a student's intrinsic motivation.

Relatedness. Guay (2017) found that relatedness to teachers had a significant impact on students' motivation, even though relatedness to their parents and friends did not. Similarly, Pečiuliauskienė (2019) also found that relatedness in general increased students' intrinsic motivation to learn science.

Autonomy. Röllke and Großmann (2022) showed that as students' perceived autonomy increased, so did their motivation for learning science.

Impact of Motivation on Self-Regulated Learning

One of the goals of education is to create lifelong learners. Xu et al. (2023) found that the higher a college student's intrinsic motivation, the higher their self-regulated learning ability.

Relationship between Motivation and Engagement and Well-Being

Cinar et al. (2023) found there was a positive relationship between a student's motivation and their engagement. Kotera et al. (2023) showed that student engagement increased with both their extrinsic and intrinsic motivation. Additionally, they found that the more compassionate and the less critical of themselves students were, the more likely their extrinsic motivation was to transition to intrinsic motivation.

Methods to Increase Motivation

There are numerous methods to increase students' motivation that have been found to be successful for students.

Ajlouni (2023) showed that the use of robotics in science classrooms increased students' intrinsic motivation. In this 2019-2020 school year study, fifth-grade students at a private school in Amman were split into two groups; one received robotics-based instruction and the other received traditional instruction for the learning topic of force and motion. The Intrinsic Motivation Towards Learning Science Scale was used to determine that the group of students who used robotics was significantly more intrinsically motivated to learn science.

Kolovou and Kim (2020) found that a method known as Integrative Drama-Inquiry Learning (IDI) met the psychological needs of self-determination theory and therefore increased intrinsic motivation and student achievement for a middle school

biology unit. As the name implies, this method was an inquiry-based approach that used drama to teach a scientific concept instead of traditional teaching methods.

Mackenzie et al. (2018) studied the effects of an "outdoor adventure-based science course" on student engagement, motivation, and self-determination and found a positive correlation with all of the variables. They argued that not only would a program such as this increase the predictors of student achievement, but it would also be beneficial to their physical health.

Röllke and Großmann (2022) found that student visits to laboratories outside of the school provided them with an inquiry-based real-world environment, which increased their intrinsic motivation. This was a case study in Germany in which students in eleventh and twelfth grade from different schools participated in a one-day workshop at a university research center. Their intrinsic motivation was measured using a variety of methods both before and after the workshop and showed that participation did increase their intrinsic motivation.

Measures of Motivation

There are a variety of existing measures of motivation: the Intrinsic Motivation Towards Learning Science Scale (Ajlouni, 2023), the Trends in International Mathematics and Science Study (TIMSS) (Areepattamannil et al., 2023),

Gap in Literature

Although the literature is quite extensive on the deficit of modern Christian scientists and the historical accomplishments of Christian scientists, there is a void in the effectiveness of Christian science education. This study investigates the effects of teaching science from an intentionally Christian worldview.

Summary

In summary, Christians are underrepresented in scientific fields due to a variety of reasons, including self-selection and avoidance of secular culture. This contributes to the nationwide shortage of STEM professionals and decreases the diversity of ideas in the scientific community. Christianity heavily influenced education and science historically, with the majority of early educational and scientific advancements accomplished by Christians. This defies the perception in society that science and Christianity oppose each other. By integrating faith with science education, both science and faith can be understood more fully with no conflict between them. Although there are a handful of scientists who are vocal about their opposition to Christianity, especially as it pertains to science, their arguments were focused on the lack of the need for religion, rather than a specific disagreement with it. Motivation can be strongly driven by the perceptions of others, which influences potential Christian scientists to choose alternative fields of study. Additionally, competence affects intrinsic motivation so the more effective a science education is for Christians, the more likely they are to be intrinsically motivated to pursue a scientific career, thus diversifying the pool of STEM candidates.

CHAPTER III

METHODS

Introduction

The current investigation will examine the association between teaching middle school science intentionally from a Christian worldview and student interest in science. The state test scores of students at a Christian school were compared to the years of student enrollment at that particular school, as well as a variety of other demographic variables to further determine the differences in the association for different subgroups.

Research Questions

This study aimed to answer two primary research questions.

1. What is the association between teaching middle school science intentionally from a Christian worldview, based on years enrolled at Heritage Christian School, on student interest in science, based on total Science state test scores, and in the following areas: Earth Science, Life Science, and Physical Science.
2. What is the difference in this association based on the following variables for the students: grade level, gender, race, and level of support services received (IEP, 504, gifted, general education)?

Participants

Sample Selection

The sample for this research study is every student at the researcher's school in grades five through eight. This sample was selected to maximize data within a small population.

The sample size is 87 students. The sample demographics are as follows: 45% female, 55% male, 22% Black, 19.5% Hispanic, 34.5% White, and 24% Mixed Race. Student participants' ages ranged from ten to sixteen years old. The majority of students did not receive additional support services, but 7% had an IEP (Individualized Education Plan), 9% had a 504 plan, and 29% were classified as gifted and received additional gifted education.

Instrumentation

Ohio State Test scores in science were accessed for each student who was in fifth through eighth grade in the 2023-2024 school year. If students who were in sixth and seventh grade were at the same school in their fifth-grade year, that data was also included to increase the sample size. For each student for whom state testing data was available, demographic information was pulled from the school's student database. This information included the student's time at the school, grade level at the time of testing, gender, race, and level of educational support services. Once the data was matched, student names were deleted and managed on the aggregate level to protect students.

Dependent Variables

The dependent variables in this study were the scores that students received on each aspect of the Ohio State Science Tests, which were broken down into the following: Earth Science score, Life Science score, and Physical Science score. These were all interval measurements. Studying the varying subject areas separately was crucial to determine the differences between the association of teaching science intentionally from a Christian worldview and student interest in science.

Independent Variables

In this study, the independent variable was the years that a student was enrolled at this school at the time of testing, which was a ratio measurement. This variable was a good approximation of how long a student was exposed to being taught science from an intentionally Christian worldview.

Control Variable

The control variable was the school attended at the time of testing.

Covariables

The covariables were the following demographics: students' grade level, gender, race, and level of support services received at the school. The student's grade level is an ordinal measurement. The student's gender is a binary measurement since all students were reported as either male or female. The students' race and level of support services were both nominal measurements. These variables were selected to eliminate the possibility that a difference in test scores was a result of one of these variables instead of the independent variable. Also, by considering the differences in association between these different subgroups, a better understanding of the relationship between teaching from an intentionally Christian worldview and science mastery could be established.

Procedures

Permission from the school was acquired and IRB approval was obtained (See Appendix C). Data was provided without identifying information.

Proposed Data Analysis

This data was analyzed using a correlational analysis, more specifically, a multivariate analysis of variants (MANOVA) to determine the correlation between the

included variables. The Pearson correlation between all of the variables was calculated. This value ranges between -1 and 1, with a value of -1 indicating a total negative linear correlation, +1 indicating a total positive linear correlation, and 0 indicating that there is no correlation. (Trochim, 2021).

Summary

The current investigation is a causal-comparative study. This methodology was an effective, valid, and reliable way to determine the effects of teaching middle school science intentionally from a Christian worldview. The MANOVA was able to isolate each variable to determine which subgroups benefit the most from this type of education.

CHAPTER IV

RESULTS

Introduction

The current investigation examines the association between teaching middle school science intentionally from a Christian worldview, based on years enrolled at a private Christian school, and student interest in science, as measured by state test scores. It also examined the difference in this association based on subgroups of the total student population of $n = 87$.

Descriptive Statistics

The descriptive analyses indicate that the sample included $n = 48$ (55%) males and $n = 39$ (45%) females, with $n = 30$ students identifying as "White" (34.5%), $n = 21$ students identifying as "multiple or mixed races" (24%), $n = 19$ students identifying as "Black" (22%), and $n = 17$ students identifying as "Hispanic" (19.5%), and with $n = 69$ students who tested in fifth grade (79%) and $n = 18$ students who tested in eighth grade (21%)

Preliminary Analyses

Statistical Assumption Tests

For the number of years enrolled and the science raw score, the skewness (0.64 and 0.55 respectively) and kurtosis (-0.74 and -0.29 respectively) are within acceptable ranges.

Correlation

The Pearson's Zero-Order correlation results for the science raw score are shown in Table 1 below.

Table 1. *Pearson's zero-order correlation of science raw score*

	Science Raw Score	Years Enrolled	Gender	Race	Support Services	Grade Level at Testing
Years Enrolled	-0.03	-				
Gender	-0.14	0.17	-			
Race	0.28**	0.04	0.10	-		
Support Services	-0.39**	-0.14	0.04	-0.06	-	
Grade Level at Testing	-0.09	0.25*	0.22*	0.08	-0.02	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 1, above, indicates that there may be a significant correlation between the science score and race and support services, $r(85) = .28$, $p = .010$ and $r(85) = -.39$, $p = .000$, respectively.

The Pearson's Zero-Order correlation results for years enrolled are shown in Table 2 below.

Table 2. *Pearson's zero-order correlation of years enrolled*

	Years Enrolled	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
Earth Science Raw Score	0.04	-		
Life Science Raw Score	-0.10	0.50**	-	
Physical Science Raw Score	0.01	0.28**	0.70**	-

**. Correlation is significant at the 0.01 level (2-tailed).

No correlation is indicated between the years enrolled and the student scores in the various disciplines of science, as shown in Table 2 above.

Results

Research Question #1

The first research question asked about the association between the years enrolled and the science state test scores, including the total science score and the earth science, life science, and physical science scores. As seen in Table 2 above, there was no correlation between the number of years enrolled and each subtopic's score. However, a correlation was found between the science score and support services and race, as seen in Table 1 above, it was investigated further with a general linear modeling (GLM) analysis. Since not all of the groups had good representation, with fewer than five cases in multiple groups, to increase the power, the support services categories were condensed into three categories: gifted, IEP/504, and no services received for this analysis. The Levene's Test of Homogeneity of Variance indicates that the assumption of homogeneity is tenable, F (10,76) = 1.78, p = .079. The Between-Subjects Effects show no significant interaction between the variables. There is a significant main effect for the support services received on the science test score, F (2, 75) = 25.78, p = .000. There is not a significant main effect for the years enrolled on the science test score.

Research Question #2

The second research question asked about the association between years enrolled and the science state test scores for various subgroups of students, including grade level, gender, race, and level of support services received.

Table 3 below shows the Pearson's correlations with the data split by grade level.

Table 3. *Pearson's zero-order correlation by grade level*

Grade Level at Testing		Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
5	Science Raw Score	-0.09	-			
	Earth Science Raw Score	-0.20	0.81**	-		
	Life Science Raw Score	-0.12	0.93**	0.68**	-	
	Physical Science Raw Score	0.09	0.83**	0.45**	0.68**	-
8	Science Raw Score	0.31	-			
	Earth Science Raw Score	0.30	0.97**	-		
	Life Science Raw Score	0.35	0.89**	0.83**	-	
	Physical Science Raw Score	0.20	0.87**	0.80**	0.60**	-

**. Correlation is significant at the 0.01 level (2-tailed).

When broken down by grade level, there were significant positive correlations between the three subject area test scores and the overall score for all students, $r(82) = 0.81$, $p = .000$ for Earth Science, , $r(82) = 0.93$, $p = .000$ for Life Science, and $r(82) = 0.83$, $p = .000$ for Physical Science. There were no significant correlations between the years enrolled and any of the test scores. However, there were quite a few insignificant positive correlations, as shown in Table 3 below. For both fifth- and eighth-grade students there was a small positive correlation between years enrolled and physical science score, $r(82) = 0.09$, $p = .45$ for fifth-grade students, and $r(82) = 0.20$, $p = .43$ for eighth-grade students. For eighth-grade students, there were also moderate

positive correlations between years enrolled and the total science score, $r(82) = 0.31$, $p = .21$, earth science score, $r(82) = 0.30$, $p = .23$, and life science score, $r(82) = 0.35$, $p = .15$.

Table 4 below shows the Pearson's correlations with the data split by student gender.

Table 4. *Pearson's zero-order correlation by gender*

Gender		Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
F	Science Raw Score	0.09	-			
	Earth Science Raw Score	0.18	0.73**	-		
	Life Science Raw Score	-0.03	0.90**	0.52**	-	
	Physical Science Raw Score	0.06	0.76**	0.21	0.65**	-
M	Science Raw Score	-0.08	-			
	Earth Science Raw Score	-0.11	0.73**	-		
	Life Science Raw Score	-0.12	0.91**	0.49**	-	
	Physical Science Raw Score	0.03	0.85**	0.36*	0.74**	-

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4 above indicates a small positive correlation between years enrolled and total science score, $r(82) = 0.09$, $p = .591$, and earth science score, $r(82) = 0.18$, $p = .279$, for female students.

Table 5 below shows the Pearson's correlations with the data split by student race.

Table 5. *Pearson's zero-order correlation by race*

Race		Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
B	Science Raw Score	-0.48*	-			
	Earth Science Raw Score	-0.48*	0.85**	-		
	Life Science Raw Score	-0.42	0.95**	0.76**	-	
	Physical Science Raw Score	-0.33	0.77**	0.38	0.68**	-
H	Science Raw Score	-0.29	-			
	Earth Science Raw Score	0.01	0.63**	-		
	Life Science Raw Score	-0.53*	0.90**	0.38	-	
	Physical Science Raw Score	-0.10	0.81**	0.17	0.69**	-
M	Science Raw Score	0.37	-			
	Earth Science Raw Score	0.38	0.65**	-		
	Life Science Raw Score	0.06	0.81**	0.28	-	
	Physical Science Raw Score	0.30	0.70**	0.00	0.55**	-
W	Science Raw Score	-0.06	-			
	Earth Science Raw Score	-0.02	0.72**	-		
	Life Science Raw Score	-0.07	0.93**	0.52**	-	
	Physical Science Raw Score	-0.05	0.90**	0.47**	0.80**	-

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

A few statistically significant correlations are indicated when the data is split by race, as shown in Table 5. There are moderate negative correlations for Black students between years

enrolled and total science score, $r(82) = -0.48$, $p = .039$, and earth science score, $r(82) = -0.479$, $p = .038$. For Hispanic students, there is a large negative correlation between years enrolled and life science score, $r(82) = -0.53$, $p = .027$. There are also statistically insignificant moderate positive correlations for mixed race students between the years they were enrolled and the total science score, $r(82) = 0.37$, $p = .102$, earth science score, $r(82) = 0.38$, $p = .093$, and physical science score, $r(82) = 0.30$, $p = .190$.

Table 5 below shows the Pearson's correlations with the data split by the support services that students received.

Table 6. *Pearson's zero-order correlation by level of support services*

Support Services		Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
504	Science Raw Score	0.03	-			
	Earth Science Raw Score	-0.18	0.70	-		
	Life Science Raw Score	-0.19	0.83*	0.33	-	.
	Physical Science Raw Score	0.34	0.83*	0.21	0.77*	-
Gifted	Science Raw Score	0.08	-			
	Earth Science Raw Score	0.21	0.52**	-		
	Life Science Raw Score	-0.06	0.85**	0.11	-	
	Physical Science Raw Score	-0.00	0.79**	-0.02	0.73**	-
IEP	Science Raw Score	-0.57	-			

None	Earth Science Raw Score	-0.82	0.83	-		
	Life Science Raw Score	-0.43	0.90*	0.59	-	
	Physical Science Raw Score	0.70	-0.68	-0.69	-0.78	-
	Science Raw Score	-0.44**	-			
	Earth Science Raw Score	-0.23	0.59**	-		
	Life Science Raw Score	-.41**	0.89**	0.33*	-	
	Physical Science Raw Score	-0.34*	0.75**	0.06	0.63**	-

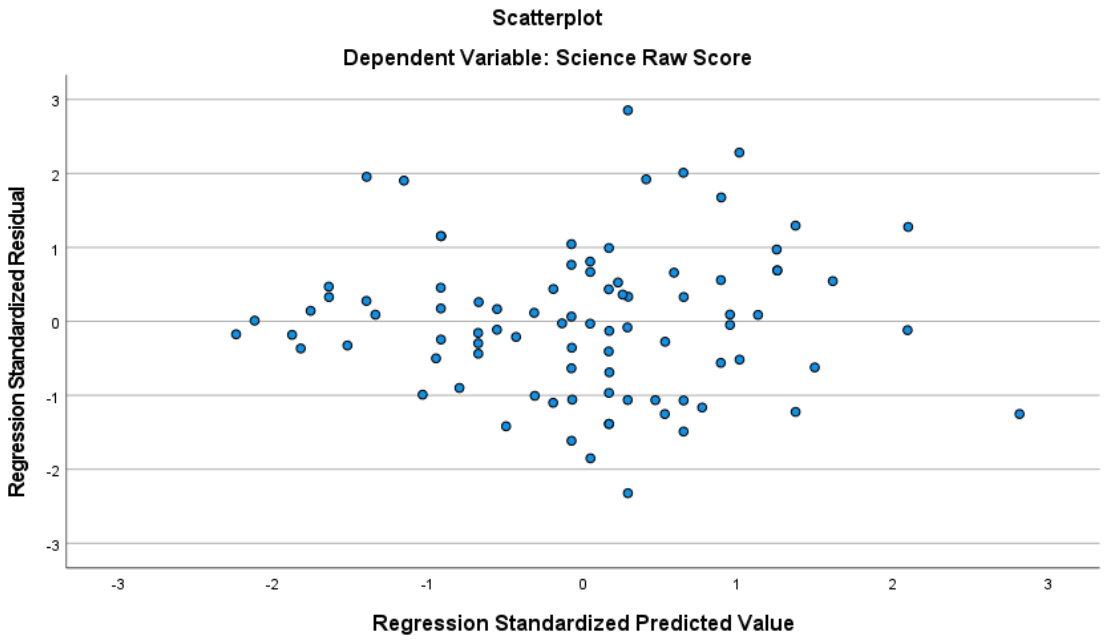
*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 6 above indicates a few statistically significant negative correlations. For general education students receiving no additional support services, there is a moderate negative correlation between the years enrolled and the science score, $r(82) = -0.44$, $p = .002$, life science score, $r(82) = -0.41$, $p = .004$, and physical science score, $r(82) = -0.34$, $p = .017$. A few statistically insignificant positive correlations also exist. Students with a 504 Plan have a moderate positive correlation between years enrolled and physical science score, $r(82) = 0.34$, $p = .462$. Gifted students have a small positive correlation between years enrolled and earth science, $r(82) = 0.21$, $p = .307$. Students with an Individualized Education Program (IEP) have a large positive correlation between years enrolled and physical science score, $r(82) = 0.70$, $p = .186$.

Figure One, below, shows a scatter plot of the total science raw scores.

Figure One.

Visual depiction of science raw scores.



As seen in Figure One below, there were potentially influential outliers that may be impacting the overall results due to the small sample size.

Conclusion

Overall, there was no significant association between the years enrolled and the science state test score. There were no significant associations between years enrolled and the science test scores based upon gender or grade level. For Black students, there was a negative significant moderate correlation between years enrolled and the total science and earth science scores. For Hispanic students, there was a large significant negative correlation between years enrolled and the life science score. And general education students saw a moderate significant negative correlation between the years enrolled and the total science score, life science score, and physical science score. There were a few positive correlations between years enrolled and science scores, but they were not statistically significant, likely due to the small sample size.

CHAPTER V

DISCUSSION

Introduction

This study aimed to determine what correlations exist between teaching middle school science from an intentionally Christian worldview and student interest in science. This chapter contains a summary, interpretation, and implications of the findings, followed by a discussion of the study's limitations and the promising future directions of this research.

Summary of Findings

Overall, the data fails to reject the null hypothesis of no association. Research question #1 was addressed by the finding that there were no significant associations between the years enrolled and the student science scores, as a whole, or for any of the individual subtopics. Research question #2 found no significant correlations between years enrolled and science test scores based on gender or grade level. For Black and Hispanic students, there was a negative correlation between years enrolled and the total science score and the earth science score. For general education students, there was a negative association between the years enrolled and the total science score, life science score, and physical science score. There were positive associations between years enrolled and physical science score for both fifth- and eighth-grade students, and total science score, earth science score, and life science score for eighth-grade students. Also, there was a positive correlation between the years of enrollment of mixed-race students and the total science score, earth science score, and physical science score. There was an association between years enrolled and physical science score for students with 504 Plans and IEPs and with earth science for gifted students.

Implications

Research Question #1: Association between Christian Science Education and Interest

The first research question addressed the association between intentionally teaching middle school science from a Christian worldview and student interest in science, both in general and in each of the subtopics. No association for the total science score or subtopic scores was found in this study for the population as a whole. This implies that simply teaching science from an intentionally Christian worldview is not sufficient to overcome the barriers for Christian middle school students' interest in science, such as self-selection due to a perceived incompatibility between science and religion, a belief in negative stereotypes, or an avoidance of the secular culture of science (Ecklund & Park, 2009; Ecklund et al., 2016; Leicht et al., 2021; Rios et al., 2015; Sharp et al., 2022).

Research Question #2: Association for Various Student Subgroups and Science Topics

The second research question addressed this association based on grade level, gender, race, and level of support services received. The negative correlations that were found imply that those subgroups of students lost interest in science as a result of being taught science from an intentionally Christian worldview. More time enrolled at a Christian school may increase the likelihood that they are exposed to models of the relationship between Christianity and science that harm their interest in science, such as the conflict model, independence model, or dialogue model (Manogu, 2019). The statistically non-significant positive correlations found imply that for those subgroups of students, teaching science from an intentionally Christian worldview may increase scientific interest. Of note, the subtopic of physical science is most often correlated in these findings. This aligns with Christian scientists historically contributing more to the field of physical science than other scientific disciplines (Badger et al., 2009)

Limitations

The three primary limitations of this study are the small sample size, the narrow scope of data from only one school, and only one tool, the science state test, for measuring student interest. The small sample size did not provide the necessary power to show the effects where they exist. Specifically, the current sample size did not have enough power to support significant findings, even when moderate to strong associations were revealed. Additionally, some of the students who are typically lower performing may be at the Christian school because they need more help than the local public school can provide; so, students who have been enrolled for more years may be fundamentally different from students who only attended for a couple of years. The sample size in this study is too small to control for those differences. The narrow scope of the data may be helpful to individual schools, but, as a whole, this study would be more meaningful if the conclusions applied to a wider range of students and schools. Finally, student interest in science may not have been accurately captured using state test scores, which was the only working measure for student interest in this study.

Discussion

This study found no statistically significant correlation between teaching middle school science from an intentionally Christian worldview, as measured by years enrolled at a particular Christian school, and interest in science, as measured by state test scores. For some subgroups of students, science interest decreased with years enrolled, pointing towards the need to implement more intensive faith-based interventions, especially for Black, Hispanic, and general education students. Explicitly discussing Manogu's (2019) models of the relationship between Christianity and science, and evaluating each of them biblically, scientifically, and logically would be one such intervention that may help. Also, the social effect on science interest could be utilized by

introducing students to successful Christian scientists in a variety of local career fields, especially through after-school science programs at science labs (Jackson et al., 2018; Joy et al., 2023; Röllke and Großmann, 2022). Since this is the first known study in this field, these results are of interest, especially towards guiding future research.

Future Research

As this is the first study known to the author on this topic, it opens the door to a novel direction of research for private Christian schools. Additional studies involving a larger sample size, either by including more years of data at one school, especially a school that includes high school, unlike this study's school, or collecting data from multiple schools, would be the most relevant continuance. Providing students with one or more of the more intensive interventions mentioned in the previous section and then measuring student interest would allow for an evaluation of those interventions. Also, it would be interesting to note how the results would differ if student interest in science were measured a different way, like a student interest survey, or by college major or career field chosen. Future studies could also focus specifically on the subgroups of students and science topics mentioned to expand upon the statistically insignificant positive correlations found in this study. Public schools, especially those with a significant transient student population, could also utilize these methods for a matched-group study to analyze correlations between their school culture and student interest in science.

Conclusion

As the first known study of its kind, it opened the door to a variety of future research projects. Teaching science from a Christian worldview can positively impact students by nurturing both their intellect and spirit. This approach allows students to explore the world through the lens of a higher purpose, encouraging them to see the integration of faith and

knowledge. It expands their understanding by framing scientific discovery within the broader context of God's Creation, fostering a deeper sense of meaning and connection to the world around them. This holistic perspective promotes critical thinking, while also feeding their spiritual growth. Although the current investigation did not demonstrate these connections through data, people of faith know that this approach teaches and reaches the whole child.

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Appendix A CITI Program Certificate

CITI PROGRAM

Completion Date 03-Jul-2023
Expiration Date 03-Jul-2026
Record ID 56863711

This is to certify that:

Kristin Davies

Not valid for renewal of certification through CME.

Has completed the following CITI Program course:

Social & Behavioral Research - Basic/Refresher
(Curriculum Group)
Social & Behavioral Research - Basic/Refresher
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Youngstown State University

CITI
Collaborative Institutional Training Initiative
101 NE 3rd Avenue, Suite 320
Fort Lauderdale, FL 33301 US
www.citiprogram.org

Verify at www.citiprogram.org/verify/?w991ef68e-f1d3-4b8a-80f2-3eddab9a4de0-56863711

Appendix B IRB Request

Submission Type: Initial Date: 3-28-2024
IRB #: 2024-193
Title: The association between teaching middle school science from an intentionally Christian worldview and student interest in science as measured by state test results
Creation Date: 2-16-2024
Status: Unsubmitted
Principal Investigator: Karen Larwin
Getting Started
I have read the information above and I am ready to begin my submission.
✓ Yes
Study Information
Is this a student-conducted study /project?
All students conducting a study/project are required to list their faculty advisor(s)/Principal
Investigator (PI) in the YSU study personnel section.
✓ Yes
What is your status at Youngstown State University?
✓ Student
✓ Graduate Student
Youngstown State University Study Personnel
List all YSU study personnel involved in the conduct of this study.
If you cannot find a person in the people finder, please contact the IRB Office immediately at YSUIRB@ysu.edu

Principal Investigator or Faculty Advisor
Provide the name of the Principal Investigator or the Faculty Advisor for student-conducted studies.
Name: Karen Larwin
Organization: Teacher Ed and Leadership St
Address: One University Plaza, Youngstown, OH 44555-0001
Phone: 330-941-2231
Email: khlarwin@ysu.edu

Primary Contact
Provide the name of the Primary Contact of this study.
Please note: if you are a student, the Faculty Advisor should be the Primary Contact.
Name: Karen Larwin
Organization: Teacher Ed and Leadership St
Address: One University Plaza, Youngstown, OH 44555-0001
Phone: 330-941-2231
Email: khlarwin@ysu.edu

Student Investigator(s)
Provide the name of the Student Investigator(s) for this study.
Name: Kristin Davies
Organization: Teacher Ed and Leadership St

Address: 1 Tressel Way, Youngstown, OH 44555-0001
Phone:
Email: kdavies02@student.ysu.edu

Co-Investigator(s)

Provide the name(s) of Co-Investigator(s) for this study.

Non-Youngstown State University Personnel

✓ No

Sponsor

Will this study be supported by an external agency?

✓ No

Study Dates

Provide the anticipated study start and end dates.

Start Date

07-01-2024

End Date

08-18-2024

Submission Information

Where will this study/project take place?

Location of research

✓ Other facility

Attach a Letter of Cooperation

The Letter of Cooperation should be on the letterhead of the facility.

Name of the facility

Heritage Christian School

Name of the contact person

Sharla Elton

Phone Number of the contact person

330-452-8271 Ext 302

Email of the contact person

selton@heritagechristianschool.org

Multiple other facilities

What type of study/project is this submission?

Type of research

✓ Research Study/Creative Investigation

A research study or creative investigation is a project that uses systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge (45 CFR 46.102(d)).

Will this study/project ONLY use pre-existing data?
Pre-existing data means the data existed before or was collected prior to the study/project was proposed for a purpose other than the proposed study/project. (For purposes of a grant, this refers to data collected prior to the time the study/project was proposed.) Select no if the study includes a combination of pre-existing and new data.
✓ Yes

Is the pre-existing data publicly available
✓ No

How and when was the data originally collected?
Is there permission of the owner of the data?
The data was collected through state testing results and school database records.
Yes, there is permission of the owner of the data.

Provide a short description of the study/project
Multivariable correlations will be analyzed for the scores students earned on each aspect of the Ohio State Science tests and the types of questions, as broken down by the Ohio Department of Education and Workforce, the years that each student was enrolled at this particular Christian private school, and Math and ELA Ohio State Test scores and various other demographics, such as grade level, gender, race, and level of support services received at the school. State testing data will be used from multiple years and aggregated. Demographic information will be pulled from the school's database and also aggregated.
Informed Consent
Informed Consent procedures/methods and forms
Identify the procedures/methods and consent forms to be used in your study:
✓ Not applicable

Explain why no consent document is required.
Only pre-existing data will be used, and no intervention will be performed.
Conflict of Interest
Do you or any investigator(s) participating in this study have a financial interest related to this
research project?
✓ No

Appendix C IRB Approval

YOUNGSTOWN STATE UNIVERSITY

Jul 8, 2024 9:35:36 AM EDT

Karen Larwin
Teacher Ed and Leadership St

Re: Exempt - Initial - 2024-193 The association between teaching middle school science from an intentionally Christian worldview and student interest in science

Dear Dr. Karen Larwin:

Youngstown State University Human Subjects Review Board has rendered the decision below for The association between teaching middle school science from an intentionally Christian worldview and student interest in science

Decision: Exempt

Selected Category: Category 1. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
Category 3.(i)(A). Research involving benign behavioral interventions in conjunction with the collection of information from an adult subject through verbal or written responses (including data entry) or audiovisual recording if the subject prospectively agrees to the intervention and information collection.
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

Any changes in your research activity should be promptly reported to the Institutional Review Board and may not be initiated without IRB approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly
reported to the IRB.

The IRB would like to extend its best wishes to you in the conduct of this study.

Sincerely,
Youngstown State University Human Subjects Review Board

Appendix D Data Analysis Outputs

Frequency Table

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	39	44.8	44.8	44.8
	M	48	55.2	55.2	100.0
	Total	87	100.0	100.0	

Race

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	B	19	21.8	21.8	21.8
	H	17	19.5	19.5	41.4
	M	21	24.1	24.1	65.5
	W	30	34.5	34.5	100.0
	Total	87	100.0	100.0	

Support Services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	504	7	8.0	8.0	8.0
	504 & Gifted	1	1.1	1.1	9.2
	Gifted	25	28.7	28.7	37.9
	IEP	5	5.7	5.7	43.7
	IEP & Gifted	1	1.1	1.1	44.8
	None	48	55.2	55.2	100.0
	Total	87	100.0	100.0	

Grade Level at Testing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5	69	79.3	79.3	79.3
	8	18	20.7	20.7	100.0
	Total	87	100.0	100.0	

Statistics

		Years Enrolled	Science Raw Score
N	Valid	87	87
	Missing	0	0
Mean		3.3448	22.95
Std. Deviation		2.47553	9.063
Skewness		0.635	0.549
Std. Error of Skewness		0.258	0.258
Kurtosis		-0.740	-0.290
Std. Error of Kurtosis		0.511	0.511

Correlations

		Science Raw Score	Years Enrolled	Gender	Race	Support Services	Grade Level at Testing
Science Raw Score	Pearson Correlation	1	-0.025	-0.136	.276**	-.387**	-0.089
	Sig. (2-tailed)		0.821	0.208	0.010	0.000	0.414
	N	87	87	87	87	87	87
Years Enrolled	Pearson Correlation	-0.025	1	0.167	0.044	-0.139	.251*
	Sig. (2-tailed)	0.821		0.122	0.686	0.200	0.019
	N	87	87	87	87	87	87
Gender	Pearson Correlation	-0.136	0.167	1	0.104	0.041	.224*
	Sig. (2-tailed)	0.208	0.122		0.336	0.708	0.037
	N	87	87	87	87	87	87
Race	Pearson Correlation	.276**	0.044	0.104	1	-0.063	0.078
	Sig. (2-tailed)	0.010	0.686	0.336		0.561	0.473
	N	87	87	87	87	87	87
Support Services	Pearson Correlation	-.387**	-0.139	0.041	-0.063	1	-0.019
	Sig. (2-tailed)	0.000	0.200	0.708	0.561		0.863
	N	87	87	87	87	87	87
Grade Level at Testing	Pearson Correlation	-0.089	.251*	.224*	0.078	-0.019	1
	Sig. (2-tailed)	0.414	0.019	0.037	0.473	0.863	
	N	87	87	87	87	87	87

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		Years Enrolled	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
Years Enrolled	Pearson Correlation	1	0.036	-0.098	0.011
	Sig. (2-tailed)		0.743	0.366	0.921
	N	87	87	87	87
Earth Science Raw Score	Pearson Correlation	0.036	1	.498**	.280**
	Sig. (2-tailed)	0.743		0.000	0.009
	N	87	87	87	87
Life Science Raw Score	Pearson Correlation	-0.098	.498**	1	.699**
	Sig. (2-tailed)	0.366	0.000		0.000
	N	87	87	87	87
Physical Science Raw Score	Pearson Correlation	0.011	.280**	.699**	1
	Sig. (2-tailed)	0.921	0.009	0.000	
	N	87	87	87	87

**. Correlation is significant at the 0.01 level (2-tailed).

Descriptive Statistics

Dependent Variable: Science Raw Score

Support3	Race	Mean	Std. Deviation	N
None	Black	17.38	7.927	8
	Hispanic	19.40	6.033	15
	Mixed	18.40	4.904	10
	White	21.20	6.930	15
	Total	19.42	6.408	48
IEP or 504	Black	14.00	3.899	6
	Mixed	21.00		1
	White	20.20	7.530	5
	Total	17.17	6.206	12
Gifted	Black	28.40	11.014	5
	Hispanic	33.00	4.243	2
	Mixed	30.70	7.243	10
	White	34.40	7.245	10
	Total	31.81	7.815	27
Total	Black	19.21	9.467	19
	Hispanic	21.00	7.306	17
	Mixed	24.38	8.535	21
	White	25.43	9.435	30
	Total	22.95	9.063	87

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Science Raw Score

F	df1	df2	Sig.
1.780	10	76	0.079

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + YearsEnrolled + Support3 + Race + Support3 * Race

Tests of Between-Subjects Effects

Dependent Variable: Science Raw Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3649.226[a]	11	331.748	7.287	0.000
Intercept	12253.343	1	12253.343	269.139	0.000
YearsEnrolled	174.185	1	174.185	3.826	0.054
Support3	2347.688	2	1173.844	25.783	0.000
Race	273.237	3	91.079	2.001	0.121
Support3 * Race	17.115	5	3.423	0.075	0.996
Error	3414.590	75	45.528		
Total	52903.000	87			
Corrected Total	7063.816	86			

a. R Squared = .517 (Adjusted R Squared = .446)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	9.534	2.268		4.203	0.000	5.022	14.045		
	ELA Raw Score	0.684	0.093	0.646	7.361	0.000	0.499	0.868	0.938	1.066
	Years Enrolled	-0.680	0.321	-0.186	-2.115	0.037	-1.319	-0.041	0.938	1.066

a. Dependent Variable: Science Raw Score

Correlations

		Years Enrolled	Science Raw Score	ELA Raw Score	Math Raw Score
Years Enrolled	Pearson Correlation	1	-0.025	.249*	0.174
	Sig. (2-tailed)		0.821	0.020	0.106
	N	87	87	87	87
Science Raw Score	Pearson Correlation	-0.025	1	.600**	.665**
	Sig. (2-tailed)	0.821		0.000	0.000
	N	87	87	87	87
ELA Raw Score	Pearson Correlation	.249*	.600**	1	.696**
	Sig. (2-tailed)	0.020	0.000		0.000
	N	87	87	87	87
Math Raw Score	Pearson Correlation	0.174	.665**	.696**	1
	Sig. (2-tailed)	0.106	0.000	0.000	
	N	87	87	87	87

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		Science Raw Score	ELA Raw Score	Years Enrolled
Pearson Correlation	Science Raw Score	1.000	0.600	-0.025
	ELA Raw Score	0.600	1.000	0.249
	Years Enrolled	-0.025	0.249	1.000
Sig. (1-tailed)	Science Raw Score		0.000	0.411
	ELA Raw Score	0.000		0.010
	Years Enrolled	0.411	0.010	
N	Science Raw Score	87	87	87
	ELA Raw Score	87	87	87
	Years Enrolled	87	87	87

Correlations

Gender			Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
F	Years Enrolled	Pearson Correlation	1	0.089	0.178	-0.028	0.063
		Sig. (2-tailed)		0.591	0.279	0.865	0.703
		N	39	39	39	39	39
	Science Raw Score	Pearson Correlation	0.089	1	.732**	.903**	.763**
		Sig. (2-tailed)	0.591		0.000	0.000	0.000
		N	39	39	39	39	39
	Earth Science Raw Score	Pearson Correlation	0.178	.732**	1	.515**	0.214
		Sig. (2-tailed)	0.279	0.000		0.001	0.191
		N	39	39	39	39	39
	Life Science Raw Score	Pearson Correlation	-0.028	.903**	.515**	1	.647**
		Sig. (2-tailed)	0.865	0.000	0.001		0.000
		N	39	39	39	39	39
	Physical Science Raw Score	Pearson Correlation	0.063	.763**	0.214	.647**	1
		Sig. (2-tailed)	0.703	0.000	0.191	0.000	
		N	39	39	39	39	39
M	Years Enrolled	Pearson Correlation	1	-0.083	-0.107	-0.123	0.031
		Sig. (2-tailed)		0.573	0.469	0.403	0.837
		N	48	48	48	48	48
	Science Raw Score	Pearson Correlation	-0.083	1	.729**	.911**	.845**
		Sig. (2-tailed)	0.573		0.000	0.000	0.000
		N	48	48	48	48	48
	Earth Science Raw Score	Pearson Correlation	-0.107	.729**	1	.491**	.360*
		Sig. (2-tailed)	0.469	0.000		0.000	0.012
		N	48	48	48	48	48
	Life Science Raw Score	Pearson Correlation	-0.123	.911**	.491**	1	.737**
		Sig. (2-tailed)	0.403	0.000	0.000		0.000
		N	48	48	48	48	48
	Physical Science Raw Score	Pearson Correlation	0.031	.845**	.360*	.737**	1
		Sig. (2-tailed)	0.837	0.000	0.012	0.000	
		N	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

Race			Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
B	Years Enrolled	Pearson Correlation	1	-.477*	-.479*	-0.415	-0.332
		Sig. (2-tailed)		0.039	0.038	0.077	0.165
		N	19	19	19	19	19
	Science Raw Score	Pearson Correlation	-.477*	1	.845**	.954**	.772**
		Sig. (2-tailed)	0.039		0.000	0.000	0.000
		N	19	19	19	19	19
	Earth Science Raw Score	Pearson Correlation	-.479*	.845**	1	.759**	0.376
		Sig. (2-tailed)	0.038	0.000		0.000	0.113
		N	19	19	19	19	19
	Life Science Raw Score	Pearson Correlation	-0.415	.954**	.759**	1	.676**
		Sig. (2-tailed)	0.077	0.000	0.000		0.002
		N	19	19	19	19	19
	Physical Science Raw Score	Pearson Correlation	-0.332	.772**	0.376	.676**	1
		Sig. (2-tailed)	0.165	0.000	0.113	0.002	
		N	19	19	19	19	19
H	Years Enrolled	Pearson Correlation	1	-0.291	0.010	-.534*	-0.104
		Sig. (2-tailed)		0.257	0.970	0.027	0.690
		N	17	17	17	17	17
	Science Raw Score	Pearson Correlation	-0.291	1	.625**	.903**	.808**
		Sig. (2-tailed)	0.257		0.007	0.000	0.000
		N	17	17	17	17	17
	Earth Science Raw Score	Pearson Correlation	0.010	.625**	1	0.383	0.167
		Sig. (2-tailed)	0.970	0.007		0.129	0.522
		N	17	17	17	17	17
	Life Science Raw Score	Pearson Correlation	-.534*	.903**	0.383	1	.686**
		Sig. (2-tailed)	0.027	0.000	0.129		0.002
		N	17	17	17	17	17
	Physical Science Raw Score	Pearson Correlation	-0.104	.808**	0.167	.686**	1
		Sig. (2-tailed)	0.690	0.000	0.522	0.002	
		N	17	17	17	17	17
M	Years Enrolled	Pearson Correlation	1	0.367	0.376	0.063	0.298
		Sig. (2-tailed)		0.102	0.093	0.785	0.190
		N	21	21	21	21	21
	Science Raw Score	Pearson Correlation	0.367	1	.649**	.811**	.695**
		Sig. (2-tailed)	0.102		0.001	0.000	0.000
		N	21	21	21	21	21
	Earth Science Raw Score	Pearson Correlation	0.376	.649**	1	0.279	0.004
		Sig. (2-tailed)	0.093	0.001		0.220	0.986
		N	21	21	21	21	21
	Life Science Raw Score	Pearson Correlation	0.063	.811**	0.279	1	.553**
		Sig. (2-tailed)	0.785	0.000	0.220		0.009
		N	21	21	21	21	21
	Physical Science Raw Score	Pearson Correlation	0.298	.695**	0.004	.553**	1
		Sig. (2-tailed)	0.190	0.000	0.986	0.009	
		N	21	21	21	21	21
W	Years Enrolled	Pearson Correlation	1	-0.057	-0.019	-0.070	-0.049
		Sig. (2-tailed)		0.764	0.919	0.715	0.798
		N	30	30	30	30	30
	Science Raw Score	Pearson Correlation	-0.057	1	.721**	.930**	.899**
		Sig. (2-tailed)	0.764		0.000	0.000	0.000
		N	30	30	30	30	30
	Earth Science Raw Score	Pearson Correlation	-0.019	.721**	1	.515**	.467**
		Sig. (2-tailed)	0.919	0.000		0.004	0.009
		N	30	30	30	30	30
	Life Science Raw Score	Pearson Correlation	-0.070	.930**	.515**	1	.796**
		Sig. (2-tailed)	0.715	0.000	0.004		0.000
		N	30	30	30	30	30
	Physical Science Raw Score	Pearson Correlation	-0.049	.899**	.467**	.796**	1
		Sig. (2-tailed)	0.798	0.000	0.009	0.000	
		N	30	30	30	30	30

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

Support Services			Years Enrolled	Science Raw Score	Earth Science Raw Score	Life Science Raw Score	Physical Science Raw Score
504	Years Enrolled	Pearson Correlation	1	0.034	-0.102	-0.193	0.336
		Sig. (2-tailed)		0.942	0.696	0.676	0.462
		N	7	7	7	7	7
	Science Raw Score	Pearson Correlation	0.034	1	0.696	.826*	.826*
		Sig. (2-tailed)	0.942		0.081	0.022	0.021
		N	7	7	7	7	7
	Earth Science Raw Score	Pearson Correlation	-0.102	0.696	1	0.326	0.206
		Sig. (2-tailed)	0.696	0.081		0.476	0.654
		N	7	7	7	7	7
	Life Science Raw Score	Pearson Correlation	-0.193	.826*	0.326	1	.770*
		Sig. (2-tailed)	0.676	0.022	0.476		0.043
		N	7	7	7	7	7
	Physical Science Raw Score	Pearson Correlation	0.336	.826*	0.206	.770*	1
		Sig. (2-tailed)	0.462	0.021	0.654	0.043	
		N	7	7	7	7	7
Gifted	Years Enrolled	Pearson Correlation	1	0.075	0.213	-0.058	-0.004
		Sig. (2-tailed)		0.723	0.307	0.783	0.985
		N	25	25	25	25	25
	Science Raw Score	Pearson Correlation	0.075	1	.520**	.846**	.786**
		Sig. (2-tailed)	0.723		0.008	0.000	0.000
		N	25	25	25	25	25
	Earth Science Raw Score	Pearson Correlation	0.213	.520**	1	0.109	-0.021
		Sig. (2-tailed)	0.307	0.008		0.604	0.920
		N	25	25	25	25	25
	Life Science Raw Score	Pearson Correlation	-0.058	.846**	0.109	1	.734**
		Sig. (2-tailed)	0.783	0.000	0.604		0.000
		N	25	25	25	25	25
	Physical Science Raw Score	Pearson Correlation	-0.004	.786**	-0.021	.734**	1
		Sig. (2-tailed)	0.985	0.000	0.920	0.000	
		N	25	25	25	25	25
IEP	Years Enrolled	Pearson Correlation	1	-0.573	-0.815	-0.431	0.703
		Sig. (2-tailed)		0.312	0.092	0.469	0.186
		N	5	5	5	5	5
	Science Raw Score	Pearson Correlation	-0.573	1	0.831	.901*	-0.692
		Sig. (2-tailed)	0.312		0.082	0.037	0.205
		N	5	5	5	5	5
	Earth Science Raw Score	Pearson Correlation	-0.815	0.831	1	0.594	-0.694
		Sig. (2-tailed)	0.092	0.082		0.291	0.193
		N	5	5	5	5	5
	Life Science Raw Score	Pearson Correlation	-0.431	.901*	0.594	1	-0.764
		Sig. (2-tailed)	0.469	0.037	0.291		0.117
		N	5	5	5	5	5
	Physical Science Raw Score	Pearson Correlation	0.703	-0.692	-0.694	-0.764	1
		Sig. (2-tailed)	0.186	0.205	0.193	0.117	
		N	5	5	5	5	5
None	Years Enrolled	Pearson Correlation	1	-.442**	-0.231	-.412**	-.343*
		Sig. (2-tailed)		0.002	0.114	0.004	0.017
		N	48	48	48	48	48
	Science Raw Score	Pearson Correlation	-.442**	1	.594**	.824**	.752**
		Sig. (2-tailed)	0.002		0.000	0.000	0.000
		N	48	48	48	48	48
	Earth Science Raw Score	Pearson Correlation	-0.231	.594**	1	.325*	0.057
		Sig. (2-tailed)	0.114	0.000		0.024	0.698
		N	48	48	48	48	48
	Life Science Raw Score	Pearson Correlation	-.412**	.824**	.325*	1	.832**
		Sig. (2-tailed)	0.004	0.000	0.024		0.000
		N	48	48	48	48	48
	Physical Science Raw Score	Pearson Correlation	-.343*	.752**	0.057	.832**	1
		Sig. (2-tailed)	0.017	0.000	0.698	0.000	
		N	48	48	48	48	48

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

b. Cannot be computed because at least one of the variables is constant.