ACHIEVEMENT IN SCIENCE EDUCATION:

UNDERSTANDING THE DIFFERENCES IN GENDER, ETHNICITY, AND SOCIOECONOMIC CLASS

By

Sammantha Van Orden

A Research Paper Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts in Education
Elementary and Middle Grades Science Concentration

Austin Peay State University
August 2021

Research Paper Committee:
Dr. Philip Short, Committee Chair
Dr. John McConnell

ACHIEVEMENT IN SCIENCE EDUCATION:
UNDERSTANDING THE DIFFERENCES IN GENDER,
ETHNICITY, AND SOCIOECONOMIC CLASS

Sammantha Van Orden

Approved:

Philip Short

July 21, 2021

Dr. Philip Short, Committee Chair — Date

July 21, 2021

Dr. John McConnell, Committee Member — Date

Chad Brooks

23 July 2021

Dr. Chad Brooks, Associate Provost and Dean, College of Graduate Studies — Date

Statement of Permission to Use

In presenting this research paper in partial fulfillment of the requirements for the Master of Arts in Education Elementary and Middle Grades Science degree at Austin Peay State University, I agree that the library shall make it available to borrowers under the rules of the library. Brief quotations from this research paper are allowable without special permission, provided that accurate acknowledgement of the source is made. Permissions for extensive quotation or reproduction of this research paper may be granted by my major professor, or in his/her absence, by the Head of the Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this research paper for financial gain shall not be allowed without my written permission.

Sammantha Van Orden

Student Name 7/23/2021

Sammantha Van Orden

Student Signature

ABSTRACT

The purpose of this study was to explore the influence of gender, ethnicity, and socioeconomic status on the achievement gap experienced in science education. This study utilized quantitative science assessment data from the state of Texas. The population consisted of fifth grade students across the state of Texas and the sample included those with reported scores on the Texas standardized assessment for science. This test was disaggregated into sub-categories based on the rate of proficiency as well as broken into raw score compilations. Determining the impact of factors on the science achievement gap allows educators to provide strength in teaching in an area where support is lacking, providing a more equitable education for all students.

Key Words: Achievement, Science achievement, socioeconomic levels, minority students, ethnicity, standardized testing

Table of Contents

List of tables

List of Figures

Chapter I

Introduction

Problem Statement

Students of different populations are scoring significantly lower than their counterparts on standardized testing. Statistics have revealed the achievement gap in science is both real and unchanged despite efforts to the contrary (Scogin et al., 2017). "For example, national estimates indicate that the 50th-percentile science scores of eighth graders who are Black approximate the 10th-percentile scores of eighth graders who are White" (Morgan et al., 2016). As the United States faces more income inequality, achievement gaps will be experienced by larger percentages of children in school (Morgan et al., 2016) and understanding the predictors for science achievement across differing demographics will allow educators to address these early on.

Understanding the Achievement Gap

"The achievement gap is the observed disparity in a number of educational measures in academic performance between different groups of students, especially groups defined by race/ethnicity, gender, and socioeconomic status" (Wenner, 2017, p. 117). Gender, socioeconomic status, and ethnicity are predictors for science achievement (Quinn & Cooc, 2015), and researchers are working to determine overall effects and implications of these predictors.

Globally, studies have been conducted to bring heightened awareness to inadequate science achievement among school aged children and the resulting potential long term affects. There has been an increased push in standardized testing among states, forcing science to the back while math and reading are frontloaded and become the focus. Overall, science scores of eighth-grade students have not improved since 1996, maintaining an average scale score of around 150 out of 300, and scores for students in Grade 12 in the United States have declined over time with an average scale score of 150 in 1996, 146 in 2000 and 147 in 2005 (Johnson, 2009).

Specific factors that are shown to have a greater influence on students' achievement, or lack thereof, are best identified at early onset in school. The factors influencing science achievement are heavily researched and show that there is a large disparity in the data between different populations of students based on gender, ethnicity, and socioeconomic status. "Another important social factor, socioeconomic status (SES), is regarded as a major factor correlated to, if not causal of, the lower achievement of minority students" (Qian et al., 2017, p. 2). Students from different economic backgrounds may face disparities in their science education experiences, providing less opportunities in some situations, or more in others. Students prior to kindergarten age show a higher gap in science knowledge due to fewer experiences in relation to math and science in both home environments and early schooling.

While SES is shown to have a large impact on the overall achievement of students in science, ethnicity is also a widely reported factor in achievement. In examining the factors affecting science achievement, gaps between minority and white students are wider and more influential on achievement than gaps in gender identity (Qian et al., 2017). While these factors were not inclusive, they told a larger story of inadequate instruction and inquiry-based science.

The ecological systems theory posits that students are influenced by their context, including the experiences in their schools, homes, neighborhoods, and broader communities (Curran, 2017). Within a social context, a child's family background, and school experiences can shape the child's development and have an even larger effect on a student's achievement in science (Valadez, 2010). A child's background is influenced by multiple outside sources and parental involvement is a large factor in a child's background. While it may be thought that lower income families provide less parental involvement, it is important to analyze all forms of involvement in all socioeconomic groupings. Parental involvement takes many forms such as reading to children, experiencing outside activities together, and carrying daily conversations with them. Involvement may not provide all sources of answers and understanding towards a student's achievement, but it may paint a clearer picture of all factors affecting children from early childhood through adolescence.

As the ecological systems theory discusses children influenced by their context, this study is built on the constructivist style of teaching students in science. Children need ample and structured time to discover and explore phenomena and construct their own understandings of the world around them.

Purpose of the Study

This study explored the differences in science achievement among gender, ethnicity and socioeconomic status on the achievement gap experienced in science education. Within this study, data from students in Grades 5, 8, and 10 within the state of Texas and their standardized progress on the State of Texas Assessment of Academic Readiness (STARR) on the science achievement test were gathered, examining the differences within the achievement of several student subgroups. Examining the differences between these factors on the overall scores of students in their science achievement was the primary focus of this study. Understanding the complete effects of these variables may help teachers attain a higher level of teaching and ability in reaching every single student in their science courses, while also increasing the small population of scientifically literate pupils, up from about one quarter of adults within the United States (Short, 2018).

Significance

The data from this study may be useful to other teachers, administrators, and school districts, providing background information on the achievement levels of student populations, to develop more successful interventions. Using the data within this research, interested parties may work to develop a more inclusive curriculum that promotes science education for all. Inquiry-based science instruction can provide a more meaningful education for students, as well as continue to help students observe the natural world (National Research Council, 2000). By increasing the experiences of students as well as the inquiry instruction upon entry into school, students may have a more successful path through science, increasing their conceptual understanding (Minner & Levy, 2009). If the achievement is affected by internal sources from educators, such as a lack of content knowledge, teacher preparedness, or inadequate teaching time, then the educator may examine current practices to determine a more effective plan to create the desired outcome.

Assumptions

Standardized tests can be used to accurately measure a student's ability and the results depict an accurate representation of their abilities. Students taking the assessment will complete the test with the greatest effort and provide educators with a clear picture of overall student knowledge. All students being tested are not taught specifically to the test, rather they are taught scientific literacy and content. Students will be able to apply scientific concepts from their inquiry-based lessons to standardized testing.

Limitations

In this study, I will be used a convenience sample of Texas state students who have taken the state assessment. Using a convenience sample provided by the state, it does not provide generalizability in the manner of understanding the differences among test scores. In essence, it will be difficult to apply a generalized understanding to the collected data and formulate conclusions that can apply to other situations with similar standings. Tests of this nature would need to be replicated with several other formats and samples to create a more complete understanding. As well as working with a convenience sample of students, another limitation faced through this research refers to an inadequate portrayal of student comprehension and scientific literacy skills. With a less than accurate representation, it can be difficult to lay claim in the data set provided when comparing achievement rates of students across different subgroups. Upon analyzing data from a different state, it is hard to know the specific details of their testing backgrounds, fidelity, and factors involved in their teaching and instruction.

Chapter II

Literature Review

Theoretical Framework

Science education is delving into the world of inquiry-based learning, and teachers owe that to several childhood philosophers and their constructivist theory of learning. Constructivism emphasizes the construction of knowledge and how learners construct knowledge outside of the human mind (Tam, 2001). The idea behind constructivism is for learning to be student-led and focused on constructing knowledge based on experiences. “Within constructivist learning theory it is assumed that the construction of knowledge results from discovering and engaging with material through experience and that through a process of social negotiation diverse truths are found” (Krahenbuhl, 2016, p. 100). In essence, constructivism is a view of learning that considers the learner as a responsible, active agent in his/her knowledge acquisition process, according to Loyens and Gijbels (2008).

Constructivism influenced the teaching standards we use today, the National Science Education Standards, which have been adapted by various states in multiple forms, such as the Next Generation Science Standards (NGSS; Matthews, 2002). Among the beginning published documents, writers debated over whose Nature of Science claims would be used and eventually the constructivist Nature of Science ideals were used and simply relocated to a different part of the document (Matthews, 2002). The constructivist learning theory places emphasis on the beliefs and knowledge a student may bring to their learning (Garbett, 2011), and curricula have been adapted to fit that style. Within the curriculum, students are expected to construct personal meaning (Matthews, 2002) in their science learning and question observations and truths of science.

Teachers must have the confidence and content knowledge to embrace a constructivist teaching and learning method (Garbett, 2011). Allowing students to question and develop understanding is crucial to their science foundation and a key factor in in educating, while supporting students in challenging them to work it out on their own (Garbett, 2011). “Teacher educators must continue to refine their approach to teaching and learning as well as clarify how their own experiences have formed their conception of how to teach science,” (Callahan & Dopico, 2015, p. 414). It has been said that any given learning experience in science is better when the students address the content with their own personal experiences (Callahan & Dopico, 2015), and develop an understanding based on their life. It is important to have the content knowledge behind the inquiry as students will still need the guidance of their teachers in developing strong scientific literacy skills.

Inquiry-Based Learning

Living in a global society in which understanding science on a basic level is important for the future citizens (McFarlane, 2013), science education must focus on developing strategies and solutions to modern day problems (McFarlane, 2013). Science must adapt through the times (McFarlane, 2013), and to do so, development through prior theoretical work can build the groundwork for successful inquiry learning. Constructivism-based instructional materials are commonly classified as inquiry-based and they include hands-on activities to motivate and engage students (Minner et al., 2009). Inquiry science instruction can be characterized as having three aspects: presence of science content, level of student engagement, and the student’s level of responsibility for learning (Minner et al., 2009). When discussing inquiry as a form of science education, there are three different forms; what scientists do, how students learn, and the approach that teachers employ (Minner et al., 2009). Inquiry education should move students into the direction of actively "doing" science, focusing on using their life experiences to develop their understanding further, making science more action-oriented (McFarlane, 2013). "To engage students in inquiry, teachers place less emphasis on covering material in science textbooks and more emphasis on having students working together to explore questions/problems and to debate evidence/conclusions, which is similar to what scientists do in the lab or in the field" (Hung, 2010, p. 5).

Constructivist style teaching has been leading the way, introducing inquiry-based instruction into schools around the world. This form of teaching has allowed for higher achievement among students in standardized testing. Student achievement in science is based on the National Assessment of Educational Progress (NAEP) and is ranked in three categories: basic, proficient, and advanced (Johnson, 2009). There have been studies showing a positive relationship between inquiry-based learning and science achievement, showing that students who participated in inquiry learning exceeded 87% of the scores in the national sample (Hung, 2010). When examining student achievement, inquiry instruction with little to no teacher guidance is less effective then explicit instruction (Lazonder & Harmsen, 2016). Instruction with more teacher-directed inquiry was shown to have a higher effect size on the overall achievement of students in the measured groups (Lazonder & Harmsen, 2016).

Inquiry-Based Learning and Teaching Methods

Teaching style plays an important role in the success of a classroom full of students and looking at inquiry instruction, it becomes a more prominent method of delivery, strengthening the overall achievement of students. An increasing body of research strongly links low student test scores to poor teaching, some to the extreme that the single most influential factor, next to parental involvement, in student success is the teacher (Munck, 2007). Teachers are more likely to improve student achievement when they begin planning with the learning outcomes in mind (Jackson & Ash, 2011). Teachers need ample time to plan activities aligned to standards and district guidelines, planning vertically, and ensuring academic vocabulary is addressed throughout the lessons. In planning the deliberate activities that are vertically aligned to other grade levels, teachers should be implementing the 5E inquiry lesson model to incorporate a more constructivist, hands-on learning experience for their students (Jackson & Ash, 2011). Among using the 5E inquiry learning model, teachers should plan to teach explicit vocabulary, including rich and varied language instruction throughout their units (Jackson & Ash, 2011).

Science Achievement

Looking at science achievement over the years, the NAEP assessments did not show any improvements in fourth grade learners between the years 1996-2000 (Munck, 2007), and students in the United States were being outperformed by students in other countries. When discussing the achievement of students in science, Cairns (2019) stated that an effective use of instructional time would incorporate more teacher directed inquiry learning. This would ensure that students are receiving the important content while investigating using scientific skills, better preparing students for achievement tests. Most content covered in elementary science standards was available through observation and experimentation (Jackson & Ash, 2011), providing more opportunity for standards connection, alignment, discovery learning and teacher-directed inquiry lessons.

Student achievement has been documented well over the years and has been studied intensely for irregularities and discrepancies. It is no secret that our students have been displaying data consistent with an underlying tone, the achievement gap. The achievement gap can be defined as “the observed disparity in a number of educational measures in academic performance between different groups of students, especially groups defined by race/ethnicity, gender, and socioeconomic status" (Wenner, 2017, p. 117). Gaps occur early and will typically follow one of three different projectories: gaps occur at early ages and are stable, students entering school enter with less informal science knowledge widening their gap as they continue in school, or students entering school with little prior knowledge may experience science and be able to make connections and grow to match their high-achieving classmates (Morgan et al., 2016). Upon further research, it was found that students who entered kindergarten with a large knowledge gap that continued through first grade became a large predictor of future science courses (Morgan et al., 2016). These gaps continued to widen through higher education and degree attainment, while a respective five million jobs will be in demand in the science and engineering workforce (Qian et al., 2017).

Early science gaps may be larger than those in reading in math due to the foundational nature of reading and math in science achievement (Curran, 2017). Within the literature and research, multiple reasons for the science achievement gaps are addressed, and socioeconomic status related gaps in achievement are largely growing compared to the racial gaps solely focused on (Curran, 2017). When looking at the available data from research, most is focused on the later years of schooling, typically high school age. This is problematic because socioeconomic disparities among students emerge early on in school (Betancur et al., 2018). These early onset disparities continue through schooling as multiple researchers have examined data between fourth, eighth and twelfth graders, determining that the low SES students score more than 0.6 standard deviations below their higher SES counterparts (Betancur et al., 2018).

Socioeconomic Level

Curran (2017) found that socioeconomic level impacted many families in the United States, widening vastly over the last several years, directly impacting students, making it one of the large contributors to an achievement gap in science (Wenner, 2017). Given that, in the United States, minority children are the fastest growing school population, and that 44% of children under 18 are from low-income families (Wenner, 2017), gaps in assessment data are widening, calling for a desperate look at research-based teaching methods to work against any disadvantages a student may come to school with. When examining the role that socioeconomic status may have on children, it is shown that higher SES students outperform their lower SES counterparts, for several reasons (Quinn & Cooc, 2015).

Researchers have addressed the problematic gaps seen across SES, but they have not completely delved into the causes for the SES disparities, simply putting them together without identifying differences to include parental education and involvement (Betancur et al., 2018). Examining some of the reasons for inequalities would be financial resources for parents to access learning materials, access to high-quality healthcare to promote cognitive development, higher educated parents tend to use more complex language skills with their children (Quinn & Cooc, 2015), and students typically have fewer opportunities to build background knowledge and experience in science (Curran, 2017) due to the lack of knowledge their parents may have themselves (Morgan et al., 2016), addressing the issue with parental education in science. Parents may lack the education to encourage science observation and questioning, limiting students' exposure to the nature of science, representing the gaps in opportunities to learn (Curran, 2017). In discussing the opportunity to learn, it refers to students learning only when they are given the opportunity to engage with the content to be learned (Curran, 2017).

In the United States, as income inequality grows, the gaps in science education begin to widen (Morgan et al., 2016). If the achievement gap continues to widen then students will grow to adults who do not have a strong understanding of the public policies and will be unable to use the scientific literacy needed in order to further promote and understand changes occurring (Morgan et al., 2016).

Ethnicity in Achievement

While socioeconomic status is a growing issue in students science achievement, research has shown that marginalized groups suffer from gaps that begin as early as kindergarten and rarely catch up, limiting their future career choices (Kaderavek et al., 2019). Minority students were more often left out of the conversation when discussing science achievement and academic progress with barriers in the way that often impede the overall progress, making the gap real (Scogin et al., 2018). Over several comparisons through the NAEP testing, students who were on free lunch programs scored typically .75 standard deviations lower than their counterparts not on free and reduced lunch, in science, lending itself to the conclusion that income disparity plays a role in the achievement gap of students (Curran, 2017). The results of the study found that science achievement gaps are prevalent at the earliest of schooling ages and can be largely accounted for due to parental education, out of school activities, ethnicity/race, and school effects. (Curran, 2017). These data demonstrate that there are disparities within the student body that are not being reached through the current method of teaching science, although research suggests using inquiry-based, 5E teaching methods to expose students to science at an early age.

Racial and ethnic gaps are shown in school quality examinations as Black and Hispanic students have typically less access to school resources as their counterparts (Quinn & Cooc, 2015). Researchers have argued that some school systems are designed for particular students to fail, offering a structured inequality within the system, imposing barriers on students and growing the achievement gap (Scogin et al., 2018). To expand this and promote more academic success, schools should implement special intervention programs that help minority students learn coping skills, specific attitudes and behaviors associated with education (Olszewski-Kubilius et al., 2004) instead of placing an increasing number of minority students in special education compared to a gifted program (Scogin et al., 2018). If these changes are not met, there can be considerable consequences to the future of our students. "In our increasingly diverse classrooms and nation, the persistence of significant achievement inequalities has huge personal costs in lower earnings, poorer health, higher rates of incarceration, and general loss of opportunity. Achievement gaps also cost our country over $1 trillion in economic output each year" (Metz, 2013, p. 6). With data showing disparity within ethnic groups, system level and school level agendas should be revisited to create more quality learning experiences that appeal to all students.

Racial, ethnic, and language minorities are more likely to be raised in families experiencing economic disadvantages and those children are twice as likely to live in poverty than their counterpart (Morgan et al., 2016). Interventions that are in place to counteract the perceived gaps are not enough and should be addressed at a younger age, outside of the classroom to begin. Examining the causes and explanations for the increasing gaps in White and African American children looks at the overall quality of school that each person attends (Chapin, 2006). Do the teachers teach the same material? Is there an active PTO? Are the school grounds kept tidy? Developing the school climate from the outside in promotes a better view of a given school. Predispositions and thoughts of a school based on its looks and placement can cause less than exemplary outcomes from the students within it.

Looking at a study completed by Scogin et al., (2018) on Grade 10 students from high achieving and low achieving, highly diverse schools, the resulting programs within the schools made for a difference within the students' achievement. Within the highly diverse and high achieving schools, it was found that students had much higher expectations set, they were encouraged to pursue college and STEM careers, and teachers took time to build relationships with them (Scogin et al., 2018). Quality education can make a difference in the overall achievement of students if given an ample chance, promoting strong science academia and interpersonal relationships with peers and teachers.

Gender Achievement

The lack of women in the numerous science fields has been well documented and studied. Minority groups and women are under-represented in the field of STEM due to the lagging number of students choosing a career in science, math, technology, and engineering (Louis & Mistelle, 2011). In a study conducted by Quinn and Cooc (2015), the scores of students in Grades 3, 5 and 8 were gathered and analyzed for gap size, finding that the gender gap between males and females was considerably different in Grade 3, closing slightly by the Grade 8. In prior studies, it is shown that gender gaps are prevalent in Grade 4 and continue through high school (Louis & Mistelle, 2011), but the reason is one to be determined. NAEP data indicate that each subject-specific achievement gap will increase over the next four years from the age of nine to 13 (Dee, 2006), showing that gaps are not closing appropriately with current methods. Moving on to the age range of 13-17-year-old students, the science achievement gap continues to grow significantly (Dee, 2006).

Identifying the causation for gender gaps is not as simple as identifying the SES of the area, because gender gaps are more likely explained by cultural ideas, norms, and stereotypes

(Quinn & Cooc, 2015). According to a study conducted by Louis and Mistelle (2011), the biggest predictor they found for gender related gaps was student self-efficacy in science, predicting their future in the STEM fields. The contribution of all factors including overall math achievement, explained the perceived gaps in the data (Quinn & Cooc, 2015).

Fewer studies regarding gender disparities have been completed, more specifically, in the elementary grades. Researchers have looked at the possibility of the same gender teacher effects on students (Dee, 2006), highlighting controversial evidence that teachers may respond to male students with praise and remediation and female students with acknowledgement (Dee, 2006).

According to Qian et al., (2017), three core cognitive abilities, verbal, quantitative, and visual-spatial abilities, crucial to learning are studied across the multitude of research in relation to gender gaps in math and science achievement. Studies have shown that males score higher in visual-spatial abilities, leading to the conclusion that this may be the cause for the major differences seen in the achievement and degree attainment of men and women (Qian et al., 2017).

Teacher Planning and Responsibility for Achievement Gap

Collaboration of student ideas among their peers is important for fostering positive and productive outcomes. It is especially important to promote conversations among diverse student populations. (Linn et al., 2016). To promote this type of collaboration, teachers need to be able to collaborate as a team and create engaging and interactive lessons. Teachers are more likely to see success when they participate in purposeful planning with their teammates, beginning with the learning outcomes that they wish for students to meet. Purposeful planning promotes conversation between teachers as well as focuses on the guidelines set forth by the standards, allowing teachers to plan engaging and purposeful lessons (Jackson & Ash, 2011). The beginning of closing an achievement gap will always begin with intentional and aligned planning, focusing on backwards design. Teachers must focus on the opportunity that students are given to collaborate with their peers of diverse backgrounds, aiding in merging ideas and outcomes.

Science education should be focused on from early elementary school (Curran & Kitchin, 2019), and should be given direct time and purpose. The success of students is dependent on the teachers' time and effort given to science instruction, providing opportunities for action-oriented science learning (McFarlane, 2013) and for students to learn through experiences.

Gaps in the Literature

To address the variables in this study, there are gaps in the literature that this study will aim to fill. This study is focused on identifying the gap scores on Grade 5, 8 and 10 students based on their standardized test data across all variables. Many studies have targeted ethnicity, gender, or SES, but few have covered all three, and few have delved into specifics of any commonalities across them all. When looking at SES, it remains a question to understand if gender, ethnicity, and SES are all interconnected to the idea that certain subgroups of students will score lower than their counter parts. It is also unclear in the literature if a particular variable affects more than itself, i.e., does a female in a low SES household have a lower score than a male in a low SES? In this study, the purpose is to identify some commonalities among the data, as well as aim to come to a better conclusion about the factors affecting students in their science achievement scores.

The literature discussed does not include information or results about Grade 5 data over a three-year period, comparing overall discrepancies within the data. My study aimed to close the gaps by providing data on ethnic student achievement, socioeconomic student achievement, and gender related student achievement in science education.

Research Question

The research question tested was as follows:

1) To what degree do students of low socioeconomic status, different ethnicities, and genders affect the achievement gap as observed by standardized test data?

Hypotheses

Null Hypothesis. Science scores are not different relative to ethnicity, socioeconomic status, and gender in terms of students taking the Texas state achievement test.

Alternative Hypothesis. This study was designed to test the hypothesis that gender, socioeconomic status, and ethnicity present disparities for science achievement, offsetting a students' chance at a quality science education, widening the overall achievement gap within these subgroups.

Chapter III

Methodology

The aim of the study was to find the differences in the science proficiency scores between student populations identified by different ethnicity, socioeconomic status, and gender. Student scores were gathered from Grades 5, 8 and 10 and examined for the discrepancies at each level in relation to the categories listed above.

Subjects involved in this study included Grade 5, 8, and 10 students across the state of Texas. This sample included over one million students in the respected categories but collected data for only those who have participated within the state achievement tests. This was not a true population collection because it did not include every student, testing at a rate of about 94% of all students. STAAR testing covers content area subjects across all grade levels over a vast majority of students. Fifth grade students tested in Texas represent 417,388 students, a large enough number to create a baseline for other states to follow. Following close behind, eighth grade students make up 395,567 of the population and tenth grade students make up 409,371 of the population.

Texas students participate in the STAAR test every year from Grade 3 through Grade 12. Each year the assessment is given near the last weeks of March through the first weeks of April. The science portion of the assessment tests students in Grade 5 science, Grade 8 science and Grade 10 Biology. The fifth-grade science test includes 36 questions, divided among four different domains (STAAR Science Resources | Texas Education Agency, 2020): Matter and Energy with four questions; Force, Motion and Energy with five questions; Earth and Space with 13 questions; Organisms and Environment with eight questions. Time limits for test administration are not given due to testing security.

Students in Grade 8 are tested on the same reporting categories as they are in fifth grade, with a slightly different blueprint of questioning. Students have nine questions in matter and energy, seven questions for force, motion, and energy, 14 questions for Earth and Space, and 13 questions for organisms and environment. These question topics are numbered similarly from fifth to eighth grade, leading the comparison of grade levels to be more accurate.

When students are tested in Grade 10 biology, the reporting categories change and are as follows: cell structure and function with six questions, mechanisms of genetics for seven questions, biological evolution and classification with nine questions, biological processes and systems with six questions, and interdependence within environmental systems with seven questions. The reporting categories in tenth grade vary greatly from those tested in fifth and eighth grade, but a possible conclusion could be drawn from the variation in overall scores to examine achievement differences among students.

Upon gathering data from each student, the state of Texas disaggregated the data into several subcategories. STAAR student data is disaggregated into the following categories: ethnicity of students categorized as White, African American, Hispanic, American Indian, and Pacific Islander; economically disadvantaged students; special education students; EL students, and those who have been continuously, or non-continuously enrolled in that school/district. These proficiency scores are presented in percentages based on the original raw score reported to the state and is used to determine the percent of students within each category that score at, above or below grade level proficiency. As well as percentages of proficiency, STAAR test reports include the mean, median and range of the scale scores, and the standard deviation. These scale scores are accompanied by the raw score comparison chart which identifies the range of scores that fall between “approaching”, “meets”, and “mastery”.

Standards adopted by Texas in 2017 refer to the name Texas Essential Knowledge Skills (TEKS), with the standard language rooted in the K-12 Framework for Science. Similarly, multiple states have adopted the Next Generation Science Standards (NGSS), or some variation built from the K-12 framework for science.

Design and Data Analyses

The table below shows the proficiency data for fifth, eighth, and tenth grade students from the science STAAR assessment in Texas. The table includes the percentage of "on-grade level" students of each student subgroup which was used to determine the differences, or lack thereof, within the student populations.

Table 1

2019 Average percent of students on grade level on the Texas State Assessment

Grade	State Average	A. American	White	Hispanic	Low SES	Male	Female
5	49	32	63	43	39	50	46
8	51	35	67	43	39	36	34
10	62	49	77	54	51	61	66

A one-way ANOVA statistical test was employed to determine the difference in the grade level scores ranging across fifth, eighth, and tenth grade (UCLA Statistical Consulting). A one-way ANOVA test was run on the data to begin statistically analyzing the observed achievement gap within the different student populations, such as minority, White, low SES, and genders. A one-way ANOVA aided in providing statistical understanding of the differences between the independent and dependent variables (UCLA Statistical Consulting). Following the ANOVA, *t*-tests were then used to analyze 2 samples together to determine any discrepancies. The *t*-test became crucial to aid in understanding the male/female differences and the White/low SES differences, determining if there were any statistically significant differences within the data.

Chapter IV

Results

Student Population Results

To what degree do students of low socioeconomic status, different ethnicities, and genders affect the achievement gap as observed by standardized test data? This research question was tested using Texas state assessment data and run through two ANOVA tests as well as 2 *t*-tests. By using ANOVA and *t*-tests, this increased the probability of a Type I error within the sample as multiple statistical tests were employed. The more statistical tests run, the risk of error increased as the chances of receiving data coinciding with the alternative hypothesis was collected. In response, below are the results following the analyses.

Table 2, below, displays the results for the ANOVA test run against all four student samples. This test included African American, White, Hispanic and Low SES students. The results of the ANOVA display a *p*-value of 0.005, showing that there is a significant difference between the 4 student groups tested. This, however, does not differentiate between the statistically different groups. There is also a larger standard deviation between the tested groups than reported within particular groups, from 0.16 between the groups and 0.04 within each individual group. This represents the closeness of scores to the group average, demonstrating that individual groupings scored closely among their given mean and variance among these groups is minimal. Between the groups there is a slightly higher standard deviation, with more scores further from the average. More tests were run following this ANOVA to dissect the groups and there differential scoring.

Table 2

ANOVA test for student populations

Groups	*Count*	*Sum*	*Average*	*Variance*
A.A.	3	1.160	0.387	0.008
White	3	2.070	0.690	0.005
Hispanic	3	1.400	0.467	0.004
Low SES	3	1.290	0.430	0.005

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.164	3	0.055	9.840	0.005	4.066
Within Groups	0.045	8	0.006			
Total	0.209	11				

*$p<0.05$

The second test run was an ANOVA to explore the differences in minority students, African American and Hispanic, and low socioeconomic status, with an attempt to identify where the significant difference was found within the first ANOVA. The results of this test display a *p*-value of 0.475, showing that there is not a significant difference between minority students and low socioeconomic status. The standard deviation between the groups in the table is 0.009 and the standard deviation within each group is 0.034, both numbers representing the scores are all near the average given. Table three lists the data compilation for the ANOVA test run between minority students and low SES.

Table 3

ANOVA test for Minority students Vs. Low SES

Groups	*Count*	*Sum*	*Average*	*Variance*
A.A.	3	1.160	0.387	0.008
Hispanic	3	1.400	0.467	0.004
Low SES	3	1.290	0.430	0.005

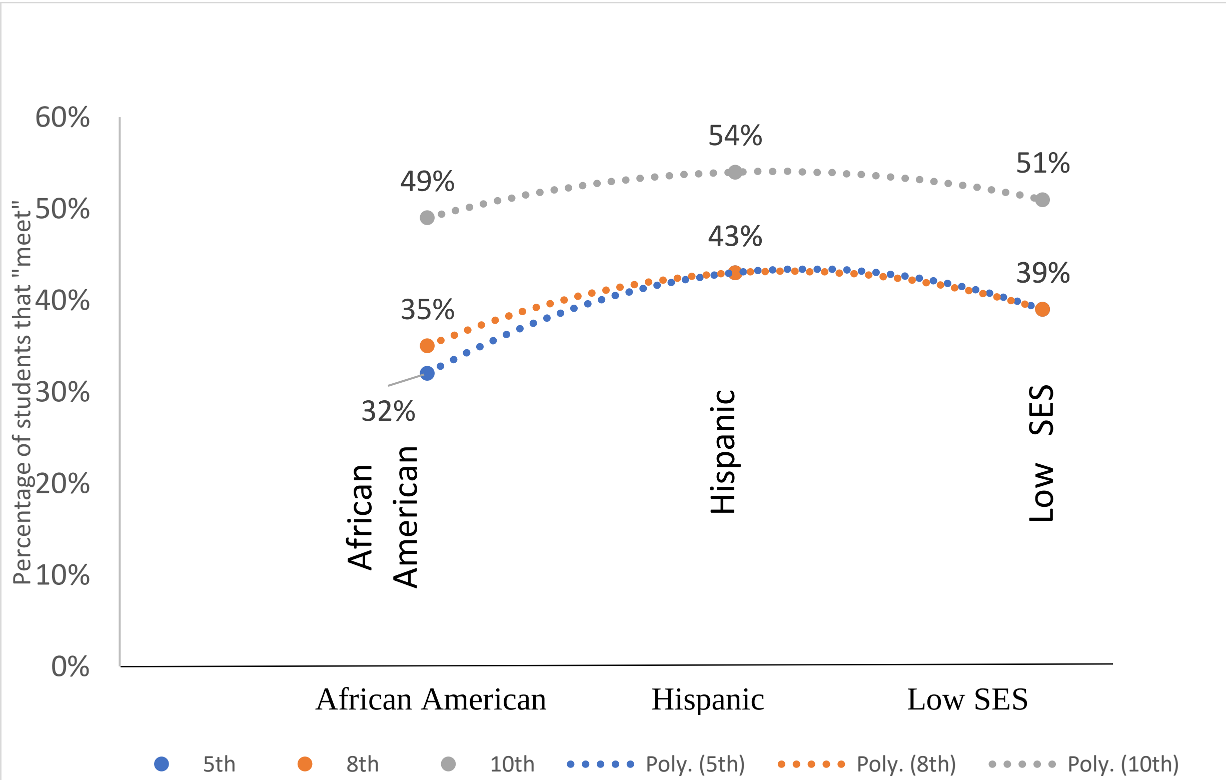
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.010	2	0.005	0.846	0.475	5.143
Within Groups	0.034	6	0.006			
Total	0.044	8				

*p>0.05

Figure 1 shows the comparison of scores between the minority students and low SES in fifth, eighth and tenth grade, representing the data from table 3 above. The figure displays results that show there is no statistically significant difference between the minority groups and low SES students. The average percentages do not change drastically, seen in the graph.

Figure 1

Minority Students Vs. Low Socioeconomic



After examining the data above, an alternate *t*-test needed to be run to examine the relationship between White students and those of low socioeconomic status in order to differentiate the cause of the statistically different results achieved from the initial ANOVA test run on all student subgroups. Examining the results from the minority and low SES ANOVA showed no significant difference in scores, so the difference first reported in the ANOVA needed to be identified, by running multiple follow-up tests. The next test needed was a *t*-test for White students and those of low SES, opposite of the ANOVA run on minority students and those of low SES. After running the following *t*-test, the results show that there is a significant difference between White students and those who are low SES, with a one-tailed *p*-value of 0.001 and a two-tailed *p*-value of 0.002.

Table 4

T-test for White Students Vs. Low Socioeconomic Status

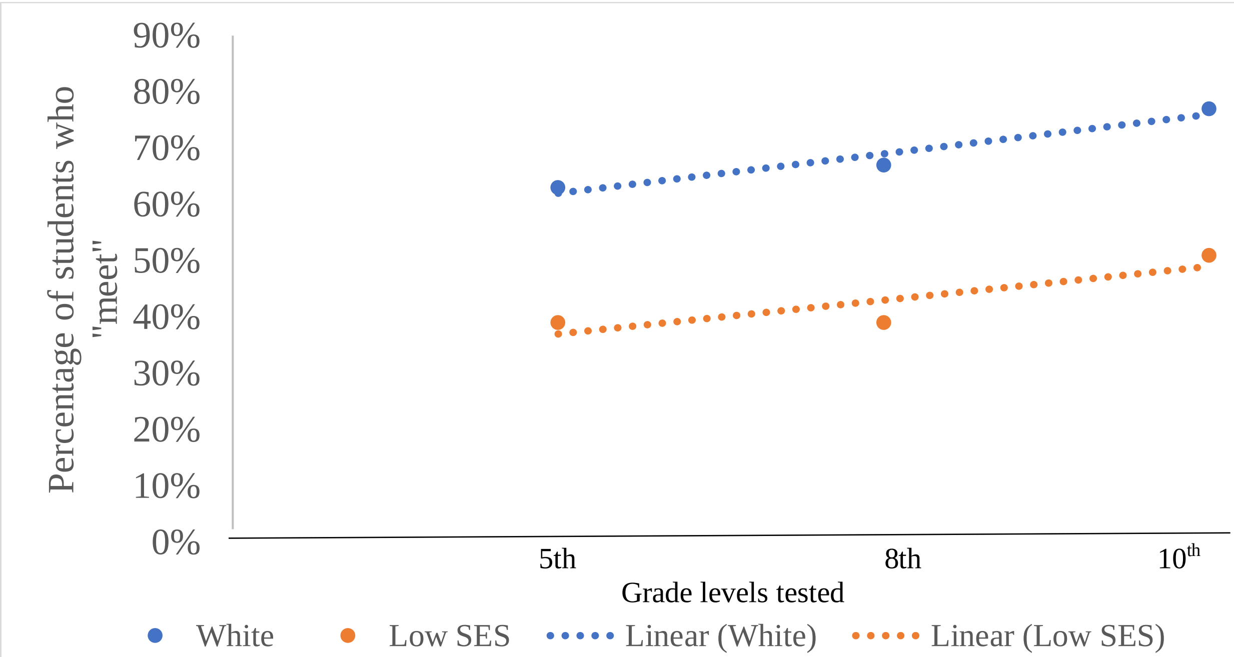
	White	*Low SES*
Mean	0.690	0.430
Variance	0.005	0.005
Observations	3	3
Pearson Correlation	0.961	
Hypothesized Mean Difference	0	
Df	2	
t Stat	22.517	
P(T<=t) one-tail	0.001	
t Critical one-tail	2.920	
P(T<=t) two-tail	0.002	
t Critical two-tail	4.303	

*$p<0.05$

Figure 2 demonstrates the data collected for the *t*-test presented on a graph, showing the linear relationship between students in each grade level that are white, compared to students who are low SES. The graph indicates a large disparity between the two categories, potentially accounting for the difference in overall score comparisons.

Figure 2

White Vs. Low Socioeconomic Student scores



Ethnically diverse and income related proficiency scores have been compared using several statistical analyses. In the latter part of the research question, gender is questioned regarding proficiency of male or female over the other. A *t*-test was run on male and female scores in fifth, eighth, and tenth grade to determine any differences within. Table 5 indicates the results of the test, with a one-tailed *p*-value of 0.457 and a two-tailed *p*-value of 0.914, displaying no significant difference between the male and female scores.

Table 5

T-test for Male Vs. Female Test Scores

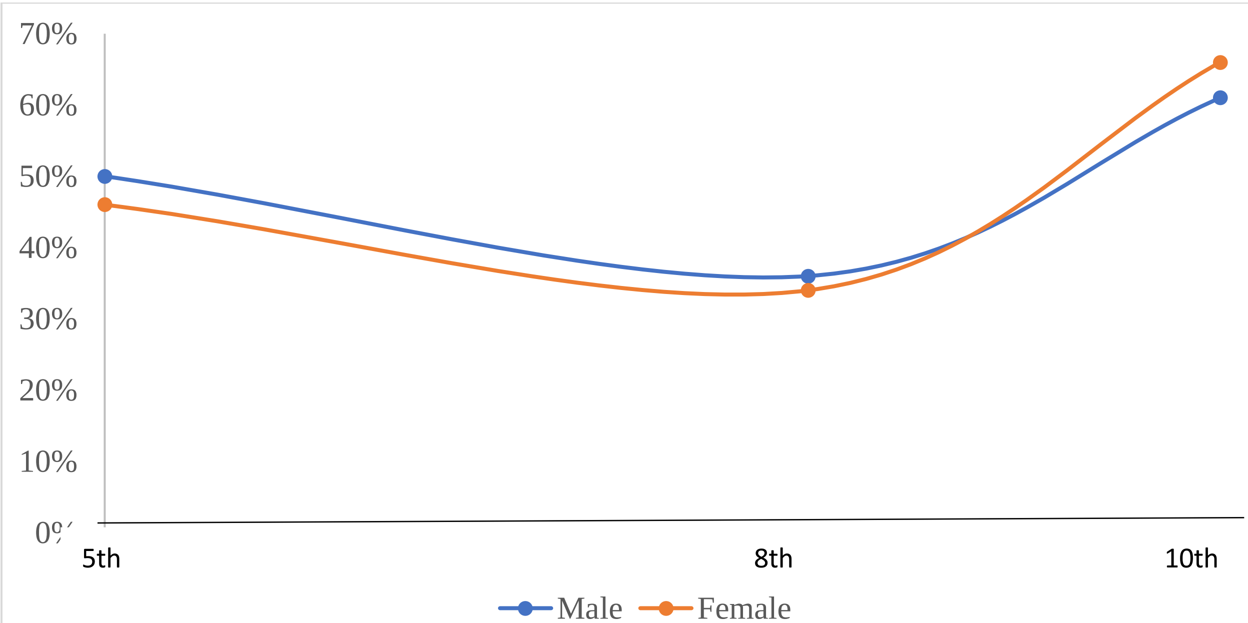
	Male	*Female*
Mean	0.490	0.487
Variance	0.016	0.026
Observations	3	3
Pearson Correlation	0.978	
Hypothesized Mean Difference	0	
df	2	
t Stat	0.122	
P(T<=t) one-tail	0.457	
t Critical one-tail	2.920	
P(T<=t) two-tail	0.914	
t Critical two-tail	4.303	

*p>0.05

Figure 3 below graphs the numerical data from the above *t*-test for male and female scores. The graph demonstrates low variability within the scores and shows a slight fluctuation between fifth, eighth, and tenth grade. Males score slightly higher in fifth, eighth, and then fall slightly below females in the tenth grade, overall. These scores are not indicative of ethnic differences and low socioeconomic differences experienced, as males and females fall into multiple categories as described above.

Figure 3

Male Vs. Female Scores at Grade Level



Chapter V

Discussion

The purpose of this study was to examine any potential differences between varying student populations such as White, African American, and Hispanic, on the Texas state assessment in science among fifth, eighth, and tenth grade students. Scores in these categories are often discussed and researched to assess the statistical difference they may hold in hopes to better understand the underlying achievement gap between these groups.

The data collection was through the Texas state reported assessment data and was collected for over one million students in fifth, eighth, and tenth grades. These students became the sample studied and analyzed for statistical trends.

The data collected includes the percentage of students who obtained a "meets grade level" score in each of the respective and studied categories. Deciding on this category for data collection was determined by the need for students to achieve on grade level or above to demonstrate their ability to be successful in the next grade level. The scale scores of student progress were reported in distinct categories of "did not meet", "approaches", "meets", and "masters", with "meets" representing a smaller scale than the other categories. To achieve within the category of "did not meet", a student would need to score between 1110 and 3507 (scaled score), for "approaches", 3550 to 3888, for "meets", 4000 to 4229, and to score within the "above" level, a student would need to score between 4402 and 5577.

The state of Texas reported the breakdown of scores and in turn, several statistical tests were run in response to the research question: To what degree do students of low socioeconomic status, different ethnicities, and genders affect the achievement gap as observed by standardized test data?

The ANOVA and *t*-tests were run based on the percentage of the student populations who scored within the on-grade level category. The tests analyzed the percentage of students across each category and compared them to determine if there was a statistically significant difference, or not, between them. The first ANOVA test between all ethnicities and low SES categories had a *p*-value of 0.004, demonstrating that there was a significant difference between the categories. The ANOVA, however, did not demonstrate where the discrepancy fell, only identifying that there was a difference between one or more of the listed groups of students. This initial finding suggested that there was an understood disparity between these student populations, but it does not lend itself to a detailed understanding of how different they were, and if the predicted subgroups showed the same disparity.

The second ANOVA test was run on the minority student groups, African American, Hispanic, and low SES group, and this test came back with a *p*-value of 0.475, demonstrating that there is no statistical difference between their scores. With this score, it helps better understand the difference that has occurred in the first ANOVA, showing that there is no difference between minority students and those of a low SES. In response, it was imperative to run a *t*-test comparing White and low SES students, the opposing comparison, to determine if the larger data discrepancy fell here.

A *t*-test was then run to examine White and low SES students, signifying the last group to be compared under the larger picture of data. In this *t*-test, the *p*-value of the one-tailed test returned as 0.001 and the two-tailed test returned a *p*-value of 0.002. Both values suggest that there is a statistical difference between these 2 subgroups.

The results from the preceding statistical tests suggest that minority students are facing a larger gap in their achievement scores than white students. Interestingly, students of low socioeconomic status and minority students are scoring similarly, while White students are scoring higher than those of low SES. This data suggests that minority students are those of low SES backgrounds, and as the result, suffer from larger inequities in their education.

There is a much larger social construct in the background of the data, suggesting minority students are those that make up the larger population of low SES backgrounds. “Historical and institutionalized racism, which manifests in systemic and structural barriers to equitable access to opportunity, lead to pronounced disparities in socio-economic experiences for a large share of America’s children” (Johnson-Staub, 2017, p. 2). The inequity of education stems from parental involvement, schools in particular low-income neighborhoods, and the lack of pertinent resources needed for students to be successful. “Children of color are more likely to experience the consequences of poverty, including negative effects on their educational experience and reduced success in adulthood. Moreover, their parents—who often struggle economically—are statistically least likely to be able to afford quality child-care and early education programs” (Johnson-Staub, 2017, p. 2).

The data of ethnicity-related scores make connections to the ideas above, that children from low SES backgrounds are given less chances at an equitable education and make fewer gains due to their position and their resources. While this was the major focus, male and female students were also analyzed to determine if this was potentially another factor in proficiency on state assessments. The data indicates that there was no significant difference between males and females, as they make up all tested categories and can be any ethnicity and socioeconomic status. Males and females have smaller amounts of research to explain the cause of score discrepancy, or lack thereof, and the data collected from this study exemplify why.

Chapter VI

Conclusion

Students of different populations are scoring significantly lower than their counterparts on standardized testing. Based on past research, students of marginalized backgrounds and low socioeconomic status are facing a large discrepancy in their overall achievement in science. Students of minority backgrounds are shown to have lower achievement due to the level of parental involvement and education, systemic social constructs, lower socioeconomic status, and access to fewer resources.

This research focused on looking into Texas state achievement scores due the large number of students who take the assessments each year. Texas adopted their current science standards based on the K-12 Framework for Science Education and tests students from fifth grade through high school in science knowledge. The collection of data was based on the percent of students who met the "grade level" equivalency in each of the student groups and categories and was run through several statistical analyses to determine any relationship prevalent.

After analyzing the data, it was found that minority students and low SES students shared many commonalities within their "on grade level" percentages, while white students were significantly higher than those of low SES. This data suggests that minority students are facing a larger gap and discrepancy in their achievement than white students, and that minority students and low SES students are scoring similarly in the lower achievement.

This research could be expanded in multiple avenues and should involve other states, districts, schools, and students. It would be beneficial to identify other connections to the data and examine outside factors, such as teacher preparation, parental education, equity in teaching, and education policies that could be influencing the data collection, signifying a trend occurring across the country, and its crucial need to be addressed within the public school system.

Collecting state data as well as classroom data could be used to then identify different levels of the achievement gap seen within varying student groups in both low performing and high performing schools. Will the data be the same? Do the resources available affect the overall outcome of a student's achievement? How do students of varying subgroups perform differently among different locations? These are all expansions on the idea and could be further studied.

The basis for understanding achievement gaps stems from low performing students within low performing schools and is often grouped into stereotypical groups. This research helps distinguish through some of the pretense and suggests how related groups perform both similarly and different from each other and provides a contextual background for understanding the relationships. School personnel can use this data to make their teaching more meaningful and purposeful to counteract the constructs that lie outside of a student's control.

References

Betancur Cortés, L., Votruba-Drzal, E., & Schunn, Christian. (2018). Socioeconomic gaps in science achievement. *International Journal of STEM Education*, *5*(38), 1-25. http://dx.doi.org/10.1037/edu0000439

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2013). Measuring test measurement error: A general approach. *Journal of Educational and Behavioral Statistics*, *38*(6), 629–663. http://dx.doi.org.ezproxy.lib.apsu.edu/10.3102/1076998613508584

Callahan, B. E., & Dopico, E. (2016). Science teaching in science education. *Cultural Studies of Science Education*, *11*, 411-418. https://doi.org/10.1007/s11422-015-9703-7

Cairns, D. (2019). Investigating the relationship between instructional practices and science achievement in an inquiry-based learning environment. *International Journal of Science Education*, *41*(15), 2113-2135. 10.1080/09500693.2019.1660927

Chapin, J. R. (2006). The achievement gap in social studies and science starts early: Evidence from the early childhood longitudinal study. *Social Studies, 97*(6), 231–238. http://dx.doi.org/10.3200/TSSS.97.6.231-238

Curran, F. C. (2017). Income-based disparities in early elementary school science achievement. *Elementary School Journal*, *118*(2), 207–231. https://doi.org/10.1086/694218

Curran, C. F., & Kitchen, J. (2019). Early elementary science instruction: Does more time on science or science topic/skills predict science achievement in the early grades. *AERA Open*, *5*(3), 1-18. https://doi.org/10.1177/2332858419861081

DeBacker, T. K., & Nelson, R. M. (2000). Motivation to learn science: Differences related to gender, class type, and ability. *Journal of Educational Research*, *93*(4), 245–254. https://doi-org.ezproxy.lib.apsu.edu/10.1080/00220670009598713

Dee, T. (2007). Teachers and the gender gaps in student achievement. *The Journal of Human Resources*, *42*(3), 528-554. http://www.jstor.org/stable/40057317

Efron, S. E., & Ravid, R. (2020). *Action Research in Education: A practical guide* (2nd ed.). The Guilford Press.

Garbett, D. (2011). Constructivism deconstructed in science teacher education. *Australian Journal of Teacher Education*, *36*(6). http://dx.doi.org/10.14221/ajte.2011v36n6.5

Hung, M. (2010). What matters in inquiry-based science instruction? [Doctoral dissertation, University of Utah]. Eric. https://eric.ed.gov/?id=ED514026

UCLA: Statistical Consulting Group. *What statistical analysis should I use?* UCLA Statistical Consulting. https://stats.idre.ucla.edu/sas/whatstat/what-statistical-analysis-should-i-usestatistical-analyses-using-sas/#1anova

Jackson, J., & Ash, G. (2012). Science achievement for all: Improving science performance and closing achievement gaps. *Journal of Science Teacher Education*, *23*(7), 723–744.

Johnson, C. C. (2009). An examination of effective practice: Moving toward elimination of achievement gaps in science. *Journal of Science Teacher Education*, *20*(3), 287–306. https://doi-org.ezproxy.lib.apsu.edu/10.1007/s10972-009-9134-y

Krahenbuhl, K, S. (2016). Student-centered education and constructivism: Challenges, concerns, and clarity for teachers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *89*(3), 97-105. https://doi.org/10.1080/00098655.2016.1191311

Lazonder, A., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research, 86*(3), 681-718. http://www.jstor.org/stable/24752879

Linn, M. C., Gerard, L., Matuk, C., & McElhaney, K. W. (2016). Science education: From separation to integration. *Sage Journals, 40*(1), 529-587. https://doi.org/10.3102/0091732X16680788

Louis, R.A., & Mistele, J.M. (2012). The differences in scores and self-efficacy by student gender in mathematics and science. *International Journal of Science and Math Education, 10***,** 1163–1190. https://doi.org/10.1007/s10763-011-9325-9

Loyens, S., & Gijbels, D. (2008). Understanding the effects of constructivist learning environments: Introducing a multi-directional approach. *Instructional Science, 36*(5/6), 351-357. http://www.jstor.org.ezproxy.lib.apsu.edu/stable/23372644

Matthews, M. (2002). Constructivism and science education: A further appraisal. *Journal of Science Education and Technology, 11*(2), 121-134. http://www.jstor.org/stable/40188717

McFarlane, D. A. (2013). Understanding the challenges of science education in the 21st century: New opportunities for scientific literacy. *International Letters of Social and Humanistic Sciences, 4*, 35-44. https://doi.org/10.18052/www.scipress.com/ILSHS.4.35

Metz, S. (2013). Science for all. *Science Teacher, 80*(4), 6. https://www.jstor.org/stable/i40141452

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984–2002. *Journal of Research in Science Teaching, 47*(4), 474–496. https://doi.-org.ezproxy.lib.apsu.edu/10.1002/tea.20347

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps form very early, persist, and are largely explained by modifiable factors. *Sage Journals, 45*(1), 18-35. https://doi.org/10.3102%2F0013189X16633182

Munck, M. (2007). Science pedagogy, teacher attitudes, and student success. *Journal of Elementary Science Education, 19*(2), 13-24. http://www.jstor.org/stable/43156159

National Research Council. 2000. *Inquiry and the National Science Education Standards: A guide for teaching and learning*. Washington, DC: The National Academies Press. https://doi.org/10.17226/9596

National Science Teaching Association. (2018). Position statement: Elementary school science. *NSTA.* https://www.nsta.org/nstas-official-positions/elementary-school-science

Olszewski-Kubilius, P., Lee, S., & Ngoi, M. (2004). Addressing the achievement gap between minority and nonminority children by increasing access to gifted programs. *Journal for the Education of the Gifted*, *28*(2), 127–158. https://doi.org/10.1177%2F016235320402800202

Quinn, D., & Cooc, N. (2015). Science achievement gaps by gender and race/ethnicity in elementary and middle school: Trends and predictors. *Sage Journals, 44*(6), 336-346. https://doi.org/10.3102%2F0013189X15598539

Scogin, S. C., Cavlazoglu, B., LeBlanc, J., & Stuessy, C. L. (2018). Inspiring science achievement: A mixed methods examination of the practices and characteristics of successful science programs in diverse high schools. *Cultural Studies of Science Education*, *13*(3), 649–670. https://doi.org/10.1007/s11422-016-9796-7

Short, P., (2018). Time for the science paradigm, a stalwart shift- not a tepid tweak. *Tennessee*

Educational Leadership Journal, *46(*1), 26-33.

https://www.apsu.edu/education/tel_issues/TEL46-1.pdf

Tam, M. (2000). Constructivism, instructional design, and technology: Implications for transforming distance learning. *Journal of Educational Technology & Society, 3*(2), 50-60. http://www.jstor.org/stable/jeductechsoci.3.2.50

Texas Education Agency. (2021, June 6). *STAAR Statewide Summary Reports 2018-2019*. https://tea.texas.gov/student-assessment/testing/staar/staar-statewide-summary-reports-2018-2019

Thompson, S. (2018). Achievement at school and socioeconomic background—an educational perspective. *npj Science Learners, 3*(5), https://doi.org/10.1038/s41539-018-0022-0

Valadez, J. R., (2010). Explaining the science achievement gap. *Leadership*, *1*(40), 30-38.

Wenner, J. A. (2017). Urban elementary science teacher leaders: Responsibilities, supports, and needs. *Science Educator*, *25*(2), 117–125. https://files.eric.ed.gov/fulltext/EJ1132097.pdf

Yilmaz, K. (2008). Constructivism: Its theoretical underpinnings, variations, and implications for classroom instruction. *Educational Horizons, 86*(3), 161-172. http://www.jstor.org.ezproxy.lib.apsu.edu/stable/42923724