5-2022

Gender, Socioeconomic Status, Race, and Change Over Time on Science Achievement for a Northwest Arkansas District

Billy Kim Maxey

GENDER, SOCIOECONOMIC STATUS, RACE, AND CHANGE OVER TIME ON SCIENCE ACHIEVEMENT FOR A NORTHWEST ARKANSAS DISTRICT

by

Billy Kim Maxey

Dissertation

Submitted to the Faculty of

Harding University

Cannon-Clary College of Education

in Partial Fulfillment of the Requirements for

the Degree of

Doctor of Education

in

Educational Leadership

December 2021

GENDER, SOCIOECONOMIC STATUS, RACE, AND CHANGE OVER TIME ON SCIENCE ACHIEVEMENT FOR A NORTHWEST ARKANSAS DISTRICT

by

Billy Kim Maxey

Dissertation

Dissertation Advisor — Date 12.02.21

Dissertation Reader — Date 12.02.21

Dissertation Reader — Date 12.02.21

Dean of the Cannon-Clary College of Education — Date 12-2-21

Provost — Date 12/7/21

ACKNOWLEDGMENTS

Many people contributed to the completion of this dissertation. I thank the Lord for the strength and ability to complete this journey. I honor my grandparents, Frank and Edna Maxey; Charlie and Beulah Cockburn, and parents, Whit and Louise Maxey, for instilling in me the ethic of hard work and the traits of honesty and integrity. My siblings, Bobby and Debbie, for great memories of a childhood long past. I honor my uncles and aunts: Jimmy and Eula Mills, and Bud and Mary Jo Maxey. Their influence was profound. I attribute my success in this endeavor to the staff and faculty of Harding University, Cannon-Clary College of Education. This project could not have been completed without the invaluable support of my dissertation team: advisor, Dr. Michael Brooks, and my readers, Drs. Kimberly Flowers, Darren Mathews, and Usenime Akpanudo. Many others contributed to the completion of this dissertation. I wish to thank my wife Traci, sons Brandon and Jon, daughters Kelli and Rachel, daughters-in-law Melissa and Cyrena, along with my grandchildren. Each is a source of happiness and inspiration to me. I also honor the mentors who inspired me to the acme of education: Ray and Vestal Rice, Betty and Charles Lyons, Amie Galloway, Betty Rice, Melba Owens, Eddie Harrison, Lou Ann Tucker, Denny Burdine, L.R. Sawyer, and James Staggs. Each nurtured me to be a patriotic citizen, contributor to society, and represent my hometown Waldron, Arkansas, with pride, honor, and dignity.

ABSTRACT

by
Billy Kim Maxey
Harding University
May 2022

Title: Gender, Socioeconomic Status, Race, and Change Over Time on Science Achievement for a Northwest Arkansas District (Under the direction of Dr. Michael Brooks)

The purpose of this dissertation was to determine the effects of gender, SES, race, and change over time on academic performance as measured by ACT Aspire Summative Science Assessment scores. Scores chosen for this study were from the 2018-2019 10th-grade students in a Northwest Arkansas school district and these same students' scores from their 7th-grade year in 2015-2016 to determine if change over time existed. The samples for this study were chosen from one Northwest Arkansas school district. ACT Aspire Summative Science Assessment scores were used to provide the academic performance data for the dependent variable used in each hypothesis. During the Spring 2019, the ACT Aspire Summative Science Assessment was administered to 10th-grade students across Arkansas, including students from the selected district. For Hypothesis 1, a significant interaction effect between gender and time existed. Males and females, on average, significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), with females displaying a larger, significant increase. The effect size was interpreted as small. For Hypothesis 2, the main effect for SES was significant, with the not eligible for free or reduced lunches group significantly outscoring the eligible group, with a large effect size. Also, the main effect for time was significant, with both groups combined

increasing from Time 1 (Grade 7) to Time 2 (Grade 10). The effect size was also large. For Hypothesis 3, a statistically significant interaction effect existed between race and time. White and non-White students, on average, significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), with the White students displaying a larger, significant increase. The effect size was interpreted as medium.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Every school day, students arrive in classrooms with their unique sets of circumstances: family dynamics, cultural background, social structure, and living conditions. These factors can be assets or disadvantages to learning and academic performance. Gender, socioeconomic status (SES), and race often play a definitive role in affecting students' access to learning, ability to learn, and academic performance, particularly in Science, Technology, Engineering, and Mathematics (STEM) subjects (Adamuti-Trache & Sweet, 2014; Ali et al., 2005). Mathematics- and science-related course selection patterns are strongly associated with ethnicity, qualified by gender, prior mathematics and science achievement, and the student's SES (Adamuti-Trache & Sweet, 2014; Rozek et al., 2019). For example, recent ACT Aspire Summative Assessment scores indicated that achievement gaps existed associated with a student's gender, SES, and race. In science, females slightly outscored males; students from low socioeconomic backgrounds performed more poorly; and European Americans and Asians significantly outscored African Americans and minorities in general (Bureau of Legislative Research, 2017). Those gaps perpetuate post-high school. Students with low SES tend to attend less prestigious colleges, work during college, and financially support their families back home, at least to some degree (Bessette, 2016).

High schools were not traditionally designed to prepare the majority of students for college. Historically, most who went to college were from affluent families, and preparation was more about integrating into socioeconomic norms (Bessette, 2016). Communities and local colleges could commit to providing dual credit and Advanced Placement courses in high school to interested students, not just those from affluent, predominantly White backgrounds. Although state and local school officials have been addressing gaps with focused interventions, the need persists in incorporating a theoretical framework to improve students' academic achievement and performance. Learning could be viewed as ongoing construction, engaging students with the material that effectively transports students from where they are, regardless of gender, SES, race, and enabling them to move to academic success.

Students who are engaged in learning are more likely to experience academic success than those who are lectured. Learning is better facilitated than taught in the traditional sense. Students need engagement and participation in the learning for knowledge to be beneficial (Driver, 1983). How students think and act are learned behaviors acquired from their environments. Students' learning can be shaped and molded regardless of gender, SES, and race. Piaget used *accommodation* and *assimilation* to describe one's mind's interplay with one's environment (Gleitman, 1987; Piaget, 1953). Learning is a process that involves active construction and not merely passive acquisition. Learning involves active assimilation and accommodation of new material (Duffy & Cunningham, 1996). Science is constructed within the individual by the individual reacting to environmental stimuli. For example, hands-on science activities such as labs and small group activities allow students to interact with their peers as they assimilate the learning by engagement with the activity. Student engagement with the learning enhances the student's opportunity for successful learning.

The key to bridging gaps in science scores due to demographics lies in early elementary school intervention. A greater number of highly-trained instructors teaching science at the elementary level who facilitate and engage students in learning could improve student science scores (Bentancur, 2018; Han et al., 2015). Just as students' gender, SES, and race create an environment that constructs a unique set of circumstances that they bring into the classroom, the classroom environment should engage the learning. Engagement with the learning helps construct the students' understanding and ability to apply attained knowledge resulting in better academic performance. According to social constructivism theory, learning is intertwined with students' interactions with surroundings socially, culturally, and educationally (Erdrogen & Stuessy, 2015; Lynch, 2016; "Social constructivism," 2001). Expanding the quality of students' exposure to STEM courses and how these courses are taught can be crucial in understanding how to address gaps in science scores related to students' gender, SES, and race. Students' exposure to STEM courses encourages academic growth, problem-solving skills, and increased interaction with peer collaboration and, subsequently, peer critique.

Encouraging students to pursue STEM fields in college or postsecondary training programs or take STEM courses in high school is insufficient; students should be appropriately prepared for STEM studies before reaching those destinations. Increased preparation is especially urgent for underserved learners. Underserved learners expressed interest in STEM at the same levels as their peers, but underserved learners' preparedness lagged far behind those same peers (Hayes, 2017). A lack of preparedness is especially indicative for students with multiple underserved characteristics, including belonging to certain racial or ethnic groups, living in low-income households, and having parents who have not attended educational institutions beyond high school (Hayes, 2017; Malin et al., 2017). The Every Student Succeeds Act (ESSA) is an example of the government attempting to address deficiencies in STEM scores among students throughout the United States. Under ESSA, states are allowed to decide their schools' education plans within a federal government framework. State-adopted curriculums prepare students to succeed in college and career, and these standards apply to all students, including those with thinking and learning differences (Tomlinson, 2008). ESSA requires states to hold each school and district accountable for student achievement and emphasizes graduating students who are STEM prepared and ready for post-high school STEM-related professions. District resources are available within the ESSA scope to increase STEM courses and adequately prepare students for college or career readiness. STEM courses prepare all students, including those historically underserved by higher education (Malin et al., 2017). STEM preparedness is directly related to increased exposure to and participation in STEM courses. If students receive adequate exposure and can participate in STEM courses throughout high school, college career choices in STEM become more likely.

Exposure to various teaching strategies in science at the elementary level and continuing through high school could allow students to acquire the necessary science skills and knowledge, resulting in a newly constructed academic mindset. Learners could then use their newly found constructs as a tool of *adaptation* (Piaget, 1954), enabling them to compete academically, despite their demographic status. The responsibility should fall upon state educational agencies and the local school districts to equip teachers to present collaborative learning and hands-on experiences in STEM classes such as science (Bentancur, 2018). Collaborative learning and hands-on experiences challenge students to accommodate and assimilate new learning into their preconceived notions formed due to the environments from which they arrive in the classroom. Variety in teaching strategies translates into a variety of teaching methodologies and schools of thought. Exposure to various teaching methodologies exposes the student to new ideas and new ways of receiving information. Helping students develop an open mind by exposure to various teaching methods and strategies promotes acceptance of new ideas and knowledge that enables them to explore disciplines such as science using their newly developed constructs.

Statement of the Problem

Three purpose statements guided this study. First, the purpose of this study was to determine the effects by change over time between males versus females on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district. Second, the purpose was to determine the effects by change over time between students receiving free and reduced lunches versus regular paid lunches on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district. Third, the purpose was to determine the effects by change over time between Whites versus non-White students on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district. Change over time was defined as scores from students in Grades 7 and 10 in each statement.

Background

Theoretical Framework: Social Constructivism Theory

The human mind is not simplistic, and how people learn and acquire knowledge is complex. From birth and continuing throughout life, the mind seeks, as an active agent, knowledge (Siegel, 2004). Learning knowledge is a process that involves active construction and not merely passive acquisition (Duffy & Cunningham, 1996). The process of learning science or any subject involves active assimilation and accommodation of newly discovered information to existing cognitive structures. Discovery is the emphasis. From birth to death, learning involves discovering knowledge through experiences acquired and engagement in people's social environment, including their gender, SES, and race (Vygotsky, 1978). Learning and subsequent knowledge are not merely passed from teacher to learner but constructed brick by brick through a person's interaction and involvement in the surrounding social environment. The teacher serves as a facilitator, guiding students to the learning (Apple, 1982; Driver, 1983). Learners take new knowledge and add this knowledge to their cognitive constructs. Piaget used accommodation and assimilation to describe one's mind's interplay with one's environment (Gleitman, 1987). How an individual thinks and acts is a developed behavior stemming from social learning on the individual. Vygotsky (1986) emphasized the social origin of cognition and the effect of social interaction on learning. Students learning science bring an approach to learning based on their gender, SES, and race and how those variables have been influenced by interaction with the social environment throughout maturation. The human mind is a complex process of active engagement with the person's environment that accommodates and assimilates knowledge discovery.

Learning is constructed within social contexts through interactions with a learning community. According to the social constructivism theory, learning results directly from individuals' interactions with their cultures and societies (Lynch, 2016). Learning evolves through the processes of social interaction, social negotiation, and subsequent evaluation of the viability of human understanding. Students accommodate and assimilate new learning based on their learning constructs extending from cognitive structures developed through living life as male or female; European American, African American, or Hispanic; and from experiences afforded through SES (Ali et al., 2005; Vygotsky, 1978). However, constructivism should not be used to excuse students stubbornly clinging to unfounded belief systems instead of opening their minds to acquiring new ideas and learning as maturation continues. To grow in their learning and be able to critique and transform current social conditions, students must gain an understanding of what those conditions are, how the conditions developed, what possible alternatives exist, and how social and political institutions might be used to reshape those conditions (Hyslop-Margison & Strobel, 2008). Martin Luther King, Jr. embodied social constructivism as a Black male from meager socioeconomic conditions. However, King's knowledge of American society's central cultural artifacts, such as the Bill of Rights, enabled him to couple learning with cultural knowledge, accounting for those cultural artifacts falling short of their promised ideals and principles as applied to him and his fellow citizens (Lynch, 2016). Vygotsky argued that individuals acquire knowledge via two types of activity: inter-psychological or among people and intra-psychological or within people (Wink & Putney, 2002). Humans interface with new learning and knowledge with an evolving construct based upon their gender, SES, and racial background. Human interfacing is simultaneously open to discovery and willing to amend their philosophy accordingly.

One of the keys to learning science is for students to open their minds to new ideas and knowledge as they interact with other students. Vygotsky (1986) claimed that an analogy could be drawn between human children and chimpanzees in that they have natural biological abilities that enable them to react to stimuli. The science skills and knowledge learned can then be readily turned into a socially constructed and negotiated product. Learners use their cognitive construct as a tool of intellectual adaptation (Duffy & Cunningham, 1996; Piaget, 1954). The teacher's responsibility is to present collaborative learning and hands-on experiences that challenge students to accommodate and assimilate new learning into their preconceived notions about the learning. Through engaging in this type of dialogue with the learning, students construct a base of information and knowledge that helps them develop an informed and personal understanding of the subject (Hyslop-Margison & Sears, 2006). Science is constructed using environmental stimuli. The significant contribution of constructivism becomes the process of learning and not just the gaining of knowledge (Siegel, 2004). Science becomes an interwoven tapestry that incorporates people as individuals—their gender, SES, and racial background—with the social, environmental stimuli that influence individuals' perception and philosophy of those variables. Learners engage in the learning process, develop higher mental functions, and permit culture and environment to determine the type of memory strategy embraced (McLeod, 2018). Social constructivism views cognitive functions, such as learning, as affected by the beliefs, values, and tools of intellectual adaptation of the culture or environment in which people develop and are therefore socio-culturally determined. As learners interact with their respective cultural environments, they construct cognitive functions that reflect the cultural environment they live and function in daily.

Gender and Science Achievement

A STEM degree can lead to a career in science, technology, engineering, mathematics, and other technical fields, whether male or female. STEM careers tend to be high-paid with great benefits worldwide (Stockwell, 2017). Females are less likely to study STEM in high school and college (United States Department of Education, 2016). Subject choice in high school is the main predictor of the gap between females and males in STEM courses and STEM careers (Delaney & Devereux, 2019). As a result, females are often missing out on potentially lucrative and exciting career choices. Only 6.7% of females graduate college with a STEM degree, while more than twice as many males graduate college with a STEM degree (Choney, 2018). A disconnect exists between the number of females and males entering college to obtain a STEM degree and those who graduate with the degree. Females do not pursue STEM careers as often as their male peers. Subsequently, females miss out on STEM careers with good to lucrative pay and benefits.

Bias and prejudice are often at the juncture of females' participation in STEM careers and science achievement. Unfortunately, the underlying sociological and anthropological aspects that lead to real solutions regarding gender gaps in STEM careers are not addressed at K-12 levels (Brown, 2011). Sociological and anthropological aspects must be identified and addressed if underrepresented student populations such as females increase participation and preparedness in science. The remedy lies in a multi-contextual approach rather than an affirmative action strategy to help solve problems (Brown, 2011). An approach that fails to address bias and prejudice regarding female representation in STEM careers and science achievement also fails to promote female achievement in science. The support for gender equity in STEM must begin at home, with parental encouragement. Then, help must continue with the teacher and institutional encouragement for females to take Advanced Placement college preparatory courses in high school and courses related to STEM to pursue a STEM career beyond college (Ash, 2020). However, mere encouragement from parents and teachers is not enough. Females who have positive contact with a STEM role model, particularly females, are more likely to be more STEM prepared and achieve in science than those who do not have such contact (Choney, 2018; Herrmann et al., 2016). Female exemplars in STEM careers interacting with female students at the earliest possible juncture (elementary school) could provide females with the role models necessary to desire the same or similar STEM career as that exemplar. Further, such exemplars could provide females with the encouragement and strength to overcome bias and prejudice regarding female participation in the STEM career world.

Gender equality interventions, as early as elementary school, are needed to overcome bias and prejudice that causes females to lose interest in STEM careers and science achievement. Women with positive STEM role models make higher grades, fail less, and have fewer withdrawal rates in high school and college pursuit of a STEM career (Hermann et al., 2016). However, positive STEM role models are but a singular intervention to promote female STEM success. The lack of STEM readiness, preparedness for college, and participation in STEM careers are not due solely to a lack of interest in females (Choney, 2018; Iasevoli, 2018). Stereotypes, such as the perception that women are not good at mathematics and science or lack the mental capabilities to solve complex issues in STEM careers, present females with yet another roadblock in pursuing STEM education and careers. Engaging in a dialogue between people's cognitive framework and the learning experience, people construct a base of information and knowledge that assist them in developing an informed and personal understanding of the subject matter, in this case, science (Hyslop-Margison & Sears, 2006). Females must understand the stereotypes and how to deal with these effectively. In addition, females must recognize those who persist in using stereotypes to keep females outside specific careers and seek to overcome such continued discrimination proactively.

Equal access to STEM and STEM-related opportunities can overcome and transform social conditions that negatively impact gender equality. Hyslop-Margison and Strobel (2008) suggested that females, to mature in their learning and be able to critique and transform current social conditions, must gain a substantial understanding of what those conditions are, how those conditions developed, what possible alternatives exist, and the social and political institutions that might be used to reshape these. Determination and grit are not limited to one gender but form the foundation for overcoming obstacles and experiencing success in STEM careers. ESSA (2020) promoted equality in education, beginning at the earliest levels of public education. ESSA has effectively removed the barrier of gender inequality and enabled females to have equal access to all education facets, including STEM courses and STEM careers. Equal access equips females with the opportunity to bypass bias, prejudice, and stereotyping and choose an educational pathway through STEM courses and careers.

Socioeconomic Status and Science Achievement

As technology increases, so does the need for students to succeed in STEM courses in high school and college and STEM careers beyond college. However, many students face low SES barriers, which prevent them from success in STEM courses and hinders their opportunities to pursue STEM careers. During the Obama presidential administration, a report was commissioned and published that identified low SES as a mitigating factor in student success in STEM and a barrier to STEM careers (The Executive Office of the President, 2014). The Obama Era report supported research that identified SES as a primary limiting factor among students taking STEM courses and being underprepared to pursue STEM careers through a college education. Low SES has the most substantial effect on whether secondary students choose to engage in science courses in high school and beyond (Cooper & Berry, 2020). The equality of access exists for students to pursue STEM courses and STEM careers. However, students from low-SES backgrounds lack the necessary exposure to STEM courses and struggle to comprehend complex science issues. Their struggle to comprehend these issues stems from a lack of access to technology, stable home environments, and parental lack of education (Mealins, 2019; Means et al., 2016; Ross, 2009). The birth environment also warrants consideration in determining low SES and a lack of science achievement throughout school. Children born into a low SES environment can begin a cycle for each succeeding generation; children born into poverty tend to remain in poverty because they lack the resources and interventions that could enable them to rise above their low SES (Bates, Lewis, & Weis, 2013). Low SES translates into poor science achievement and, often, no college education or trade school certificate. Socioeconomic barriers hinder vocational development, particularly among the sciences. Low SES correlates with low educational achievement. Low SES, coupled with gender disparities in STEM careers, can lead to the underdevelopment of human resources and capital at the societal level (Toglia, 2013). Students from low-SES backgrounds find difficulty competing in today’s economy and therefore contribute to the shortage of technology workers available for the technology industry. Consequently, the need to excel in science and other STEM courses to pursue college educations bridges the gap in STEM careers beyond college.

The key to increased student participation and achievement in science and other STEM courses are interventions that begin early in students’ academic careers that address their specific needs created by low SES. SES was identified as a barrier to STEM success among students, and officials mandated that school districts implement interventions to address student struggles in STEM courses (The Executive Office of the President, 2014). One such intervention was recognizing that interventions work best on students early in their educational careers. Science achievement's imbalance surfaced as early as the elementary level (Bentancur, 2018; Bessette, 2016). Early interventions for students with low-SES increase their chances of liking science and STEM courses by excelling in science courses. Interventions at the elementary level increase student preparation and enhance students’ chances for science and STEM achievement. Increased science and STEM achievement builds confidence and results in low-SES students’ participation in STEM courses.

Low SES correlates with lower academic achievement, which indicates a lack of preparedness. Many low-SES students express an interest in science and other STEM-related courses, but their preparedness in science and STEM lags behind their peers

(Adamuti-Trache & Sweet, 2014; Hayes 2017). Students with low SES, beginning in elementary and continuing through high school, need ever-increasing exposure to science and STEM courses and teaching methodologies that engage students with low SES in learning. Improving teacher quality and teaching pedagogies are necessary interventions, but schools also need to make STEM courses, such as Advanced Placement, available to all students. Increasing exposure to science at the elementary level and consistently increasing exposure to STEM courses throughout high school could create a proper foundation for increased science achievement success. The challenge then for educators is the implementation of STEM programs that begin in elementary and carry through high school that incorporates diversity in teaching methods along with making the programs accessible to all students regardless of their SES (Cooper & Berry, 2020; Rozek et al., 2019; Sublett & Plasman, 2017). Increasing access to STEM courses can enhance science achievement and create career opportunities regardless of gender or SES. Many students, especially those from lower socioeconomic backgrounds and those whose gender is female, seem to underperform in STEM courses and compromise their abilities to advance in STEM careers. Consistent interventions can be the difference between students with low SES being prepared for STEM course progression from grade to grade.

Race and Science Achievement

Along with gender and SES, race may also play an essential role in science and STEM preparedness. Significant gaps exist between White and non-White students regarding performance in science and STEM courses in general (Jaschik, 2017). In the United States, Civil Rights laws made an indelible impact on education and opened the door for underserved students to experience equity in education and exposure to science and STEM courses. During the 1960s and 1970s, with the passage of laws such as Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, and Section 504 of the Rehabilitation Act of 1973, which collectively prohibited discrimination based on race, sex, and disability, the footprint of the federal government became even more noticeable on public education throughout the United States (Office for Civil Rights, 1999). Therefore, the federal government has intervened in public education for students to have equal access to quality education. Ensuing legislation such as ESSA has continued to ensure equity in education. However, despite these efforts, significant gaps remain between the preparedness of White students and non-White students.

STEM preparedness is directly related to certain factors that, if implemented, negate poor student performance. Regardless of their SES, students can increase their chances of performing well in college by taking college preparatory courses, developing successful study habits, and increasing their efforts through preparatory classes. (Micari et al., 2016; Noble et al., 2006). Theoretically, proper classroom instruction, successful study habits, and adequate effort should prepare students to succeed in science and other STEM courses. A direct correlation exists between academic-preparedness diversity and positive learning outcomes (Houser & An, 2015). Elementary through high school and college classroom activities should be academically, socially, and racially diverse to benefit all students. Academically, less-prepared students derive greater benefit and fare better when they are not alone in a group of highly prepared students. Teachers at all academic levels should include group activities in their curriculum and create diversity within those groups by pairing diverse academic, social, and racial individuals to promote and enhance academic preparedness in science and STEM courses.

Student and teacher interaction is essential, even more so for non-White students who find themselves in the minority in many classrooms across the United States, especially in science and STEM courses. Non-White students rarely see people of color teaching science and STEM courses (Micari et al., 2016). However, low self-esteem perpetuated through a lack of parental support, low societal expectations, and lack of teacher interaction and relationship building is equally a factor in the under-representation of students of color in science and STEM courses (McCave, Gilmore, & Burg, 2014; White & Rotermund, 2016). Teacher encouragement to take STEM courses and excel in STEM courses can positively affect minority students. Such a reaction is especially true when the teacher is from the same ethnic or minority background as the students. Non-White students' self-esteem is encouraged, and the learning is more engaged when STEM participation is diverse, including student-teacher interaction.

The student-teacher rapport and teacher support and encouragement in STEM courses is an essential factor regarding student success. Students, particularly those of color, SES, and underserved status, need college prep courses in high school for science and other STEM course preparedness (Jaschik, 2017). In particular, African Americans, Latinos, and low-SES students need college prep interventions in high school to prepare for success in science and other STEM courses in college. Teacher encouragement to engage in science and STEM courses leads to student and teacher relationship building (Noble, Roberts, & Sawyer, 2006; White et al., 2016). Creating a relationship of trust, understanding, and mutual respect can equally contribute to student success in science and STEM courses for White and non-White students. Interaction between teachers and students in diverse classrooms and diversity in group activities has enhanced interest among minorities in science and other STEM courses (Gray et al., 2020). Disrupting past racial inequities in teaching pedagogies and establishing constructive rapport between teacher and student can overtly bring diversity into the classroom. The teacher and student can embark on an academic relationship based on encouragement to achieve, inspiring minority involvement and success in STEM courses.

Factors Affecting Change over Time and Science Achievement

Teacher preparation and qualification, or lack thereof, can mitigate students' performances in science between Grades 7 and 10. Some elementary and middle school teachers who teach science subjects do not hold science degrees (Humphrey & Luna, 2019). An elementary or middle school teacher in Arkansas can achieve Grades 4-8 language arts, social studies, mathematics, and science certification by passing the appropriate Praxis exam required for state certification (DESE, 2019). The person must first attain a teaching certificate in a Grade 4-8 discipline and possess a bachelor's degree from an accredited university. These teachers often teach science at the elementary through the eighth-grade level yet possess no educational background or training in the science disciplines or have a limited amount of college hours in the field of science. Conversely, high school science teachers hold a bachelor's degree in science and are certified to teach specific science courses by successfully passing the corresponding Praxis science exam. The result can be a lack of engagement and preparation in hands-on science experiments at the elementary level only to experience increased rigor and engagement at the secondary level (Schneider et al., 2016). The effect can be that a student matriculates through elementary and middle school, having experienced no teachers who have formal science training of which science is their specialty. A lack of formal, collegiate academic teacher preparation in science can affect student performance and negatively impact STEM preparedness.

While mid-career teacher training, also known as professional development, may focus on the content and pedagogy of science courses, the conveyance of such knowledge has no foundational basis for learning if the teacher has not experienced science courses in their collegiate academic training. The teacher then lacks the necessary background in science disciplines to create a learning atmosphere in the classroom that is rigorous and inclusive of methodologies conducive to science learning (Bendix, 2017; Gordon, 2017). Students suffer because these teachers' content and methodologies do not necessarily convey the depth of learning and learning types necessary for the students to progress in scientific knowledge from grade to grade academically. Subsequently, the student has a more difficult time excelling on the ACT Aspire as the student progresses from elementary to middle school and from junior high to high school (Means et al., 2016). Traditional classroom lecturing, for example, is appropriate in certain circumstances, but the teacher must see themselves as a facilitator of the learning and expose students to a variety of pedagogies. High expectations for learning, close relations with teachers, and real-world STEM role models and experiences enhance students’ success in STEM readiness.

Another factor affecting change over time can be the lack of priority to science at the elementary level. Content, standards, and pedagogy are essential aspects of teaching science, but only if schools spend time teaching science. Unfortunately, about 50% of the fourth-graders in the United States do hands-on science activities at least once a week, and only 25% of those students have teachers who focus on inquiry and problem-solving skills (Education Commission, 2021). The emphasis at the elementary level in Arkansas, like many other states, is on reading and mathematics due to standardized testing (David, 2011). While these disciplines are essential, each can serve as a tool to support overall learning, including mastery of big ideas found in science instruction (Camins, 2017). In essence, elementary-age students need more time to learn science than many elementary schools appropriate across the United States. To improve student performance in science, only suitable qualified teachers and adequate time allotted to teach science will potentially increase student performance (Camins, 2017; Van Damme, 2016). A sound elementary school curriculum provides sufficient time and flexibility to provide students' autonomous learning of disciplines such as science. The relative rigor of science increases as students progress from elementary to high school, with science gaining equal educational time as a core subject.

Historically, the relative importance of core subjects such as science in elementary schools has been contentious. Contentious in that many varied social interests and political opinions converge in the decision-making process as to which subjects are the most important to emphasize, often resulting in curriculum overcrowding (Bauer, 2019; Van Damme, 2016). The result is often curricula prioritizing expected social outcomes to the detriment of students' educational needs and potential. Science instruction and social studies are often sacrificed by yielding precious educational time to reading and mathematics because the state- and federal-mandated testing focuses heavily on these latter disciplines. Schools and teachers are thereby judged on those test scores that are exclusive of science and social studies. Because of social and political interests, the affirming experiences afforded to students in science, such as hands-on activities, critical thinking skills, and problem-solving skills, have become less emphasized. Thus, teachers have little time to fit science into the curriculum (Camins, 2017). In such instances, students, regardless of their gender, SES, or race, are denied the opportunity to learn science alongside other disciplines. Perhaps with the recent increased emphasis placed on science by federal mandates such as ESSA, the history of neglect can be negated, and students can discover the necessity of learning science and how science affects their everyday lives.

Hypotheses

The following hypotheses guided this study. Each hypothesis defined *change over time* as student scores from Grades 7 and 10.

1. No significant difference will exist by change over time between males versus females on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district.
2. No significant difference will exist by change over time between students receiving free and reduced lunches versus regular paid lunches on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district.
3. No significant difference will exist by change over time between Whites versus non-White students on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district.

Description of Terms

ACT Aspire Summative Science Assessment. The ACT Aspire Summative Science Assessment is one of four summative exams adopted by the Arkansas Department of Education in 2015 and is aligned with the most commonly used college entrance exam, the ACT Test (Arkansas Department of Education, 2017). The ACT Aspire Summative Assessment measures reading, English, mathematics, and science readiness for Grades 3-10 in Arkansas public schools.

Arkansas Department of Education (ADE). The Arkansas Department of Education added a division, commonly referred to as the Division of Elementary and Secondary Education (DESE), in 2019 (Division of Elementary and Secondary Education, 2019). Therefore, citations before Fall 2019 will be designated as the Arkansas Department of Education and, after the fall of 2019, denoted as DESE.

Change Over Time. Change over time was defined as scores from students in Grades 7 and 10 on the ACT Aspire Summative Science Assessment.

Gender. Gender was used herein to refer to an individual's identity as either male or female.

Race. Race was divided into two categories: non-White designated persons who were not European American, and White designated persons who were European American and neither Hispanic nor Latino (Harbin et al., 2019).

Socioeconomic Status (SES). Socioeconomic status was defined by school lunch status per the guidelines set forth by the United States Department of Agriculture (2020). Students were identified as qualified to participate in the free or reduced school lunch program or not qualified.

Significance

Achievement in science requires students to gain appropriate knowledge about science through the process of learning. Learning involves discovering knowledge through experiences acquired or discovered due to social environment encompassing gender, SES, and race (Piaget, 1953; Vygotsky, 1978). Students bring to learning a construct shaped by their gender, SES, and race through interactions with their social environments. In social constructivism applied to education, teachers should be facilitators of knowledge (Apple, 1982). Therefore, teachers must transition from the dispensers of knowledge to the facilitators of learning for their students. This transformation is especially true in science classrooms. Students need to be engaged and participatory in the learning for knowledge to be beneficial. Students engaged in learning learn more than those who are only spoken to or lectured (Almarode, 2018; Driver, 1983; Weyer, 2019). Teachers should, therefore, discover and implement research-based strategies to facilitate the learning of science. Learning is a process that involves active construction and not passive acquisition and thus involves active assimilation and accommodation of new material (Duffy & Cunningham, 1996). Gender, SES, and race are factors of students' cultures and environments. Therefore, gender, SES, and race directly influence students' learning and achievement in science.

Research Gaps

Only a few studies have attempted to consider all three variables of gender, SES, and race to determine the effects on science achievement alone as measured by the ACT Aspire Summative Science Assessment. Most studies have focused on one of these variables and their effects on student achievement and preparedness in science and other

STEM-related subjects (Herrmann et al., 2016; Houser & An, 2015; Iasevoli, 2018). These studies help educators determine the teaching strategies necessary for students to have the proper knowledge and skills to succeed in high school and college. Science preparation can be one component that increases science achievement (Ellerton et al., 2016; Hayes, 2017). To be adequately ready and excel in science achievement, a focus should be placed on using teaching strategies that account for the cultural and environmental constructs from which students learn. As a result, gender, SES, and race variables can be considered to construct those strategies and implement such strategies for students.

Possible Implications for Practice

A competition for students exists between public schools, charter schools, and private schools. School administrators and teachers are looking for every advantage to provide their students with the learning strategies that could enable them to succeed academically (Noble et al., 2006). As a result, serious thought should be given to the influences that gender, SES, and race have on student achievement and science achievement (Bureau of Legislative Research, 2017). Strategies should include teacher encouragement, hands-on activities for students, and increased student preparation in K-12 STEM classes. Increased preparation is especially urgent for underserved learners who express interest in STEM at the same levels as their peers but whose preparedness lags. Increased preparation is needed for students with multiple underserved characteristics, including coming from a low-income household, belonging to certain racial or ethnic groups, and having parents who have not attended educational institutions beyond high school (Hayes, 2017; Mattern et al., 2015). Such factors can limit students' achievement due to a lack of support at home and social environment. Therefore, a student's gender, race, and SES can be potential variables that affect student achievement in science (White et al., 2016). Lack of support from parents and the surrounding environment can create gaps in students learning as they attempt to progress through grade levels. As a result, gender, SES, and race can indicate gaps in student achievement in science and STEM-related subjects (Bentancur, 2018). School administrators and teachers can develop teaching strategies that use these data to address students' science achievement gaps. Teaching strategies incorporating gender, SES, and race data can be individualized and can address each student's unique learning style.

The ACT Aspire Summative Assessment assesses student readiness in reading, mathematics, English, science, and writing. The summative assessment is administered to students in Grades 3 through 10 each school year. Differential performance on the ACT Aspire among student demographic groups is primarily attributable to differential preparation academically, for example, the number of Advanced Placement classes taken, school characteristics, and SES (ACT Research Report Series, 2015). Notable differences exist between male and female students regarding STEM subjects, and when all other factors were considered, SES also produced negative results (Card & Payne, 2017). A direct correlation exists between gender, SES, race, and ACT Aspire achievement, including science. Links between these variables and student performance suggest that teaching strategies can be developed to address such gaps and improve student achievement in science, beginning in elementary school (Adamuti-Trache & Sweet, 2014; Almarode, 2018; Ashford et al., 2016; Bessette, 2016). This study's results could help school administrators, counselors, and teachers make informed decisions regarding gender, SES, race, and science achievement. Competent use of research can support teaching strategies that increase student achievement in STEM courses and corresponding assessments.

Process to Accomplish

Design

A quantitative, causal-comparative strategy was used for this study. A 2 x 2 mixed factorial design with a repeated measure on the second factor was used for each hypothesis. The trait independent variables for Hypotheses 1-3 were gender (male versus female), SES (free and reduced lunch eligibility versus no eligibility), and race (White versus non-White), respectively. Change over time was coupled with each trait independent variable as the within-subjects factor. The dependent variables for Hypotheses 1 through 3 included student achievement on the ACT Aspire Summative Science Assessment for 7th-grade students and 10th-grade students in a public school district located in Northwest Arkansas.

Sample

The sample was the 2018-2019 ACT Aspire Summative Science Assessment scores from 10th-grade students in a Northwest Arkansas school district and these same students' ACT Aspire Summative Science Assessment scores from their 7th-grade year in 2015-2016 to determine if a change over time existed. The 7th- and 10th-grade students' scores were collected and stratified by gender, SES, and race. The test score data were then analyzed using the *IBM SPSS Statistics 25* program. Scores were analyzed by gender, SES, race, and change over time to determine if these variables significantly affected student science achievement.

The school district used was a Northwest Arkansas school district. Data were collected from the district's two junior high schools and the high school the junior high schools fed. The district's population consisted of European American (68%), Hispanic-Latino (12%), African American (10%), Asian/Pacific Islander (4%), and Native American (0.5%). The gender demographic of the district was male (49%) and female (51%). SES was determined by eligibility or no eligibility in the free and reduced lunch program. The average for the district was 39% who were eligible for free or reduced lunch status. The teacher-to-student ratio for the district was 15:1.

Instrumentation

The ADE adopted the ACT Aspire Summative Assessment in the spring of 2015. The ACT Summative Assessment measures reading, mathematics, English, science, and writing readiness for Grades 3-10 (ACT Research Report Series, 2015). The ACT Aspire Summative Science Assessment is a part of the ACT Aspire Summative Assessment. The system of assessment adopted by the ADE is connected to the most commonly used college entrance exam, the ACT Test, and can be used to predict a future score on the ACT (Edwards, 2015). Scores from the ACT Aspire Summative Science Assessment were used to measure the dependent variable of science achievement provided by the same students from their 7th-grade and 10th-grade years in a Northwest Arkansas school district.

Data Analysis

A 2 x 2 mixed factorial design with a repeated measure on the second factor was conducted using gender, SES, and race as the independent variables to address each of the three hypotheses, respectively. Change over time was the second independent variable for each hypothesis. The three hypotheses' dependent variable was student achievement in science measured by the 2015-2016 and 2018-2019 ACT Aspire Summative Science Assessment scores. A two-tailed test with a .05 level of significance was used to test the null hypotheses.

Summary

In the preliminary literature review, gender, SES, and race appear to affect student learning and achievement in general, specifically in science. The crucial claim of social constructivist theory is that a sociological analysis of science and scientific knowledge is advantageous to each student and reveals the social and environmental nature of learning and achieving in science (Detel, 2015; Vygotsky, 1978). The development of scientific knowledge and the effect on student achievement appears to be determined by each student's social and environmental forces. The roles of others, such as parental influence and teacher encouragement, create a social framework that mediates or filters science or any discipline (van der Veer & Valsiner, 1991). Equally, students' gender identity, SES, and racial ethnicity serve as a lens through which they filter the input of knowledge, such as scientific learning facilitated by the teacher. Knowledge is not mechanically acquired but actively constructed within students' learning environments of which their gender, SES, and race are an indelible part and influence how they learn science and subsequently perform on science assessments. Gender, SES, and race served as the variables examined and tested to discover if a change over time occurred in students' science achievement between Grades 7 and 10. Chapter II will include a literature review examining the available research regarding gender, SES, and race on student science achievement.

CHAPTER II

REVIEW OF RELATED LITERATURE

Recent decades have witnessed the emergence of the concept of lifelong learning. The idea of an individual being a lifelong learner is firmly embedded in the changing forms of social structure, and in particular, the effect globalization has fostered upon the world economy and its effects on the flexibility of employment (Gould, 1993). Students in America's classrooms bring a social construct resulting from their environments, shaping and molding their abilities to think and learn. Constructivist learning theory functions on the principle that students construct knowledge based on their prior knowledge (Hyslop-Margison & Sears, 2006; Piaget, 1954). The learners create knowledge obtained from the world around them. The learners create knowledge as they encounter learning throughout their lives. Therefore, social constructivists observe instruction and schooling as a communal social experience within which meanings are collectively and vigorously fashioned and where more experienced others such as instructors, students, or adults assist in the building and developing of students' understandings (Duffy & Cunningham, 1996; Watson, 2001). Learning becomes an ongoing, active process for each student. Each student integrates the new learning into past communal social experiences resulting in a fabric of knowledge reinforced with experience.

The student becomes an active participant in the development of learning. Students essentially learn via synergy with their fellow students and their unique social surroundings (Apple, 1982; Driver, 1983; Gleitman, 1987; Hyslop-Margison & Sears, 2006). With learning being profoundly dependent on mutual interaction with one's peers and environment, the student, regardless of the subject matter learned, is unavoidably influenced by gender, SES, and race (Jaschik, 2017; Vygotsky, 1986). The students' knowledge evolves from their social world, which develops out of their social constructs. The social construct includes gender, SES, and race and how those factors affect students' surroundings and how their surroundings affect their ability to succeed in science classes. The interrelationship between gender, SES, and race and the individual connects as much significance to the learning technique as to obtaining new learning (Lynch, 2016; Vygotsky, 1986). The learning is not merely passed from the teacher to the student originating in kindergarten and culminating 13 years later with graduation. Instead, learning is a lifelong discovery. Vygotsky (1978) argued that individuals acquire knowledge through two types of activities: *interpsychological* (among people) and *intrapsychological* (within ourselves). The learning process encapsulates all aspects of the person: gender, race, and SES, along with stimuli from the environment (Siegel, 2004; Wink & Putney, 2002). Students are exclusively able to learn by using the preceding and current community environment present in their lives. The key to learning for each student becomes having teachers who can facilitate learning by consolidating the previous and present learning and incorporate new learning in association with that learning.

Piaget's and Vygotsky's theories are, indeed, more complimentary than oppositional to each other. However, not everyone agrees that their theories of social interactions play a significant role in an individual's cognitive development. Chaiklin (2003) contended that each was relatively unclear in accounting for the precise landscape of people's learning needs, their capability levels at any one juncture of their development, their motivation to learn, or those factors that influence people's motivation. Interestingly, Piaget was judged to be misunderstood by Vygotsky in some of his ideas, especially for downplaying the role of social influences in people's cognitive development (Carpendale & Muller, 2014). Conversely, Vygotsky's sociocultural theory is often seen as disregarding the role of individuals by refusing to recognize that individuals can, and often do, rise above social norms based on their abilities to bring about their understanding (Lui & Matthews, 2005). Individuals such as gifted and talented students and child prodigies lend proof that while social influences are important, the development of individuals and how that development occurs is not always relative to the environment in which individuals find themselves. In social constructivism applied to education, the teacher should be a facilitator of knowledge (Apple, 1982). The teacher then uses a variety of methodologies and activities that spur creativity and engagement within each student. However, strict adherence to such an idea eliminates the reality that individuals can often facilitate learning for themselves, creating inequality for each learner.

Vygotsky's sociocultural theory does not appear applicable to every social and cultural group of people. For example, social or cultural groups may not be whole and equal, with all individual learners acquiring the same understanding from engagement and interaction (Duffy & Cunningham, 1996). In reality, collaboration and engagement or participation vary from one learner to another, therefore creating the inequality of each learner due to differences in skills for each learner, which produces constraints (Lui & Matthews, 2005). These inequalities are never more present than when observed in learners with learning difficulties or learning disabilities. Such students, for example, might be unable to assimilate the same input or derive the same meaning from group interactions as those students without learning difficulties or learning disabilities (Lui & Matthews, 2005). How an individual thinks and acts is often learned behavior from one's environment; students who have learning difficulties, especially those with learning disabilities, can misinterpret or not cognately understand social signals that are norms in personal interaction with others. These students often fail to understand social signals resulting in inconsistent actions with the conveyed social signals (Stanberry, 2009). Social collaboration and engagement are problematic for individuals who possess learning difficulties or learning disabilities that impede the individual's ability to cognitively process verbal and nonverbal social cues, thus inhibiting that individual's ability to learn what is, and is not, socially acceptable.

In addition, Vygotsky downplayed the role of imagination in learning. Vygotsky believed that the individual's ability to adhere to rules or structure is the primary key to school preparedness rather than the individual's capacity to imagine (Chaiklin, 2003). Engagement in collaborative learning experiences incorporates the whole person, which includes one's imagination. For example, collaborative engagement such as play with implicit, internalized rules that can be negotiated among the participants requires a greater level of cognitive, social, and verbal functioning than adherence to following explicit, external, and immutable rules (Lui & Matthews, 2005). The use of imagination in learning involves more complex and deeper thinking over a more extended period. The use of imagination in collaborative play or engagement in collaborative learning experiences occurs at a higher cognitive level than using imagination during rule-based play such as board games and sports (Saifer, 2010). For Vygotsky, and Piaget to an extent, learning involves the lifelong discovery of knowledge through experiences the individual acquires due to one's social interaction with one's environment. Learning is a social construct built over time according to specific rules (Vygotsky, 1978). The individual learns according to a predictable pattern of assimilation of social and cultural stimuli. Overall, regarding learning and engagement in learning activities, Vygotsky's argument was governed by rules, whereas imagination played no significant part (Saifer, 2010). For others, imagination coupled with knowledge produces creativity. Einstein (2009) stated, "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution" (p. 32). Systematic rules of cognition may govern the ability of the individual to gain knowledge. However, the imagination factor is essential, mainly how individuals process their knowledge through social and cultural environments.

Theoretical Framework: Social Constructivism Theory

A Brief History

Social constructivist theory affects the classroom through teaching. Effective teachers actively engage students in the learning process (Roberts, 2020). The origin and subsequent foundations of constructivism lie with two individuals, Swiss psychologist Jean Piaget and the Russian psychologist Lev Vygotsky (Piaget, 1954; Siegel, 2004; Vygotsky, 1978). American psychoanalyst Jerome Bruner and American theorist and psychoanalyst John Dewey have also contributed to constructivism (Brunner, 1996). Vygotsky's theory is considered the most authoritative constructivist theory because the theory conveys many essential ideas, including the perspective that social interaction establishes the basis of the learning procedure and characterizes a student's integral learning progress (Gleitman, 1987; Wink & Putney, 2002). A key component of Vygotsky's theory is the sociocultural theory, which views a student's human development as a socially mediated process. In a socially mediated process, a student acquires cultural perspective, conviction, and diagnostic methodologies through collaborative communication alongside experienced civilization representatives such as teachers and adults (Lynch, 2016; McLeod, 2020). Knowledge acquisition, therefore, occurs in social and cultural surroundings. As a result, a student's gender, SES, and race play significant roles.

A significant aspect of Vygotsky's idea of constructivism historically emphasized social elements, subsidizing intellectual progress and learning. Learning is an outgrowth from social interactions that result from regulated learning; therefore, environments in which students grow up and their experiences at school influence how they think and what they think about (McLeod, 2019; White et al., 2016). Vygotsky (1986) developed a concept known as the zone of proximal development that referenced the difference between what the learner could and could not do, contending that social interaction leads to the student's advancement because learning competencies were underscored by pedagogy. The constructivist theory asserted that students have individual ways of thinking. The teacher's role is to stimulate their thinking by treating students as individuals and facilitating opportunities to work with others (Apple, 1982; Williams, 2018). Students learn through observation and participation in a collaborative environment.

Collaboration with peers increases students' ability to support and defend their respective learning positions intellectually.

The constructivist theory of education was first advanced by Vygotsky and refined later by others to evolve into each student learner's concept as integral to the overall learning process. Bruner (1996) connected Vygotsky's theories to Piaget, a cognitive theorist who viewed students as learners, regarding those who learned through life experiences. However, Vygotsky's ideas, integrated among those of Piaget, evolved into a widely influential theory that challenged education's status quo. Before the rise of social constructivism, teachers would teach using a behaviorist approach, instilling ideas and knowledge into students' minds by getting them to conduct rote memorization (Abramson, 2013; Siegel, 2004). Essentially, students would sit in a classroom and regurgitate answers by repeating what the teacher said. Vygotsky's theory became popular and an influential child-centered theory of the 1960s that imposed a more definitive pedagogy (Williams, 2018). Constructivism argued that students use cognitive mental processes to arrive at logical conclusions. Students needed to consider what was taught to grasp the desired learning intellectually. Students contemplate what they have heard and compare and contrast the new knowledge with what they already understand to formulate their conclusions through the teaching. As a result, the constructivist model espoused by Piaget, Vygotsky, and Bruner has subsequently influenced contemporary classroom pedagogy, replacing the simple conveying of knowledge with encouraging the art of learning.

Application Science Education

A key aspect of the constructivism theory is that of collaborative learning. Collaborative learning allows students to work with teachers one-on-one and with other students in group settings (Zambrano et al., 2019). Collaborative learning is an integral part of creating a deeper and more lasting understanding (Vygotsky, 1962). The idea is that students from various socioeconomic and racial backgrounds have much to offer one another. When the students master collaboratively designed activities, the internalization of knowledge occurs differently according to each student's personal experience (Fosnot, 1996; Vygotsky, 1986). The constructivist theorist's embedded goal in the classroom is to create an inquiring and accepting atmosphere that is engagingly dynamic and encourages students to reach their fullest potential. Through teacher facilitation, the community created in the classroom incorporates the outside community that affects *making meaning* from the learning (Vygotsky, 1978; Wegener & Eccles, 2019). As a primary responsibility, the teacher has a position as a facilitator that originates from a synergetic analytic atmosphere where students evolve into effective partners in their learning. Teachers should migrate mentally from persons who lecture to persons who facilitate learning (Apple, 1982). The teacher can also ensure an accurate understanding of the students' preexisting comprehension and guide activities to recognize these. Meshing the students' preexisting knowledge and experiences with guided activities enable them to construct their learning further (Gleitman, 1987; Hyslop-Margison & Sears, 2006; Oliver, 2000). The learning takes on a real-world application that combines the learning activity with experience from the students' environmental framework. The students' abilities to recall the learning are enhanced by associating the learning with application to life experiences.

Teachers expose students to hands-on experiences and then observe students' learning, providing gentle guidance and prompts. The teacher's guidance and prompts create instructional scaffolding that suffices as temporary support, enabling the learner to complete the task (Bruner, 1996; Castagno-Dysart et al., 2019). Scaffolding becomes an essential item of practical constructivist instruction wherein the adult constantly regulates assistance in response to the learner’s achievement. If the classroom pedagogy is well-designed and structured for the proper developmental level, the students should learn through the experiences alone (Archer & Hughes, 2011). Scaffolding enables students to transition from receiving the instructor’s direct instruction to independent problem solving and collaboration among their peers. The necessity for instructional scaffolding is vital if students construct skills that enable them to direct their learning (Castagno-Dysart et al., 2019). Scaffolding requires students to evolve into highly independent, problem-solving individuals. As such individuals, students can effectively communicate and contribute collaboratively, resulting in cognitive skill development.

The field of science easily yields to incorporate constructivist theory in the practice of the scientific method, which is a construct designed to bring students through a step-by-step process, forming conclusions based on where the experiment-driven data take them. Beginning in elementary school and proceeding throughout secondary school, the process of learning in the realm of science demands that the students engage in creative activities such as lab experiments that promote self-organization and problem-solving skills (Almarode, 2018; Lynch, 2016). The motivated constructivist teacher allows the students to originate their investigations and construct their theories. The teacher also challenges students to perform open-ended investigations, decipher problems with rational and valuable contexts, and investigate and discover supporting or conflicting potentialities (Archer & Hughes, 2011). Independent thought and problem-solving skills are encouraged. Contradictions can, therefore, be inspected, delineated, and debated as each student is a scientist (Gould, 1993). Open-ended investigations are inquiry-based opportunities for students to learn through trial and error within the classroom's safe confines. Inquiry-based learning uses systemic and scientific methodology to collect data, evaluate, and formulate answers to problems (Tawfik, Woei, & Giabbanelli, 2020).

The students' overall effect is a developing dialogue between what they have experienced growing up in their respective communities as affected by their gender, SES, and race with the new learning from the classroom community, including constructive input from peers and teachers. Community stakeholders should consider the classroom environment for dialogue and interchanging ideas (Apple, 1982; Espinola, 2019; Lynch, 2016). Science learning then becomes an act of hearing, seeing, sharing, investigation, interpretation, and dialogue. These respective actions effectively construct students' perceptions and experiences of the world beyond their framework of reference.

Advantages and Disadvantages of Constructionist Learning Theory

Constructivist learning theory functions on the principle that students construct learning positioned upon prior learning and experience. Constructivism theory states that no learning is independent of the learners; only the students' learning is built upon the knowledge obtained from the surrounding environment (Detel, 2015; Piaget, 1953; Vygotsky, 1978). Instead of possessing concrete answers, constructivism teaches that learners formulate the answer as they view the answer based upon their environmental frame of reference. One of the benefits of this method is that teachers acting as facilitators can be more inclusive of different cultures and encourage diversity rather than other learning theories (Hyslop-Margison & Strobel, 2008; Lynch, 2016). Constructivist instruction lends more credence to sensory input, a facet neglected by various lecture-oriented educators. Constructivism is often juxtaposed to behaviorism, which is less concerned with the complexity in the learner's mind (Abramson, 2013). Behaviorism relates to the student's ability to pay enough attention to memorization and repeat information. Historically, students listened to a teacher lecture, took appropriate notes, and regurgitated the information on a subsequent exam. While some of this process still occurs, and a time and place for such pedagogy exist, education is discovering that students need total engagement in the acquisition of learning, using all their senses, not merely their eyes and ears but also social interactions from guided learning (Eggen & Kauchek, 2013). Students need to offer and receive constructive input from peers. Offering and receiving constructive feedback from peers increases students' comprehension and ability to support and defend their positions on a subject effectively.

Students often respond more favorably to constructivist learning environments because they find engagement in learning more enjoyable than sitting idly and performing rote memorization. Learning is better facilitated than taught in the traditional sense (Driver, 1983; Vygotsky, 1978). Students need to be engaged and participatory in the learning process for knowledge to be beneficial. Therefore, the social constructivist theory benefits students by permitting them to be engaged in their learning environment instead of passive participants. Constructivism acknowledges learners as possessing the capability to process learning and exercise creative, independent, critical thinking. Culture determines the type of memory strategy a person develops (McCleod, 2018; Vygotsky, 1986). Through interaction within the sociocultural environment, higher mental functions are developed. Constructivist learning environments allow students to exercise and implement their cognitive abilities without fear of rejection.

The most significant disadvantage to social constructivist theory is a shortage of formal structure. Some students need very structured learning environments and teacher encouragement to succeed academically (Davidson, 2016; Kahlenberg, 1996). Constructivism admonishes the instructor to discard the traditional or standardized curriculum for a more personalized academic pursuit system that students already comprehend. Constructivism requires differentiation so that students can learn at an optimal cognitive level. Personalizing instruction through differentiation can be painstaking and often impractical for teachers (Tomlinson, 2008). Social constructivism challenges the teacher to acquire and maintain best practices that enable differentiation. Adeptly adapting learning to students' cognitive frameworks requires skills obtained through interaction with students over an extended period and understanding their cognitive and academic levels (Bentancur, 2018; Raffan, 2001). Therefore, experienced teachers possess a distinct advantage over novice teachers. In addition, school districts may not be equipped to train teachers accordingly nor possess the funding to provide teachers professional development to obtain the needed expertise to differentiate learning.

Another disadvantage of the constructivist theory is eliminating grading in the traditional sense and instead emphasizing students measuring their progress, which could lead to students lagging academically. Teachers, without standardized grading and evaluations, may not realize that the students are struggling. Since no measurement tool exists in the conventional sense, students may not be constructing knowledge as the theory professes but instead imitating what other students are doing (Scheurman, 1998). Such a pedagogy could lead to some students falling behind their peers and requiring remediation. Students may indeed prosper from selective constructivism principles integrated into the learning environment; however, most students require significant structure and constructive feedback in the form of tangible grades (Means et al., 2016; Sprouls, Mathur, & Upreti, 2015). Personal feedback could be challenging to achieve for students due to continuously working in small groups. The teacher could maintain vigilance and facilitate feedback by becoming well-versed in constructivist classroom management and permitting students to measure their progress.

Learning through trial and error may also be a time-consuming process. Teachers are often pressed for time to organize sustainable problem-based learning lessons in constructivist pedagogy effectively (David, 2008; David & Green, 2007; Kauffman et al., 2002). An intense focus on problem-based lessons to exclude other pedagogy exposes another disadvantage to constructivist theory in the classroom. The disadvantage can surface by students becoming confused and frustrated because they may not possess the competencies to form relationship associations and synopsis between their learning and the learning they are obtaining for themselves (Bruner, 1996). For example, a lack of social awareness or a particular learning disability could impede learning via a constructivist pedagogy. If learning evolves through the process of social negotiation and evaluation of the viability of individual understanding, then the amount of cognitive development may be absent due to biological or environmental issues (Lynch, 2016). A lack of cognitive and social progress could prevent students from thinking or reacting appropriately to cognitive and social stimuli. The students' learning progress could become stunted and require remediation.

The ACT Aspire Summative Science Assessment

Description and Benefits

ACT released the first ACT Aspire Summative Assessment in April of 2014. In June of that same year, ACT discontinued the prior exams, ACT Explore and the ACT Plan assessments. However, as with the prior two exams, ACT Aspire aims to prepare students to succeed on the ACT Test to enter their colleges or universities of choice. While the ACT Test and the ACT Aspire are different exams that use different formats, ACT promotes the ACT Aspire to predict students' success. In addition, the ACT Aspire provides information about a student's progress in school and a possible future ACT score

(Vitale, 2016). The ACT Aspire Summative Assessment is a widely-used tool for ACT practice, assessing common core standards and meeting state testing requirements.

One of the ACT Aspire benefits that appeal to state departments of education and local school districts is that the ACT Aspire is delivered on a computer. While paper copies are available, the shift to computer delivery reflects society's increasingly digital nature and the importance of computer literacy in higher education and the workforce (ACT Research Report Series, 2015). The electronic format includes graphics and interactive elements that ACT believes may further engage students and increase their likelihood of success on the exam. Before 2014, the ACT Explore and ACT Plan existed in a paper-only format. The electronic format also enabled the ACT Aspire to move away from solely relying on selected-response (multiple-choice) questions and asking students to answer three problem types: constructed response, selected response, and technology-enhanced. Students must explain and justify their answers to questions and compare, create, and critique with constructed responses while demonstrating critical thinking skills and problem-solving skills suited for science disciplines and promoting academic growth (Allen, 2019; Gewertz, 2016). ACT refocused the assessment to further enhance student skills and influence pedagogy in ways that ACT and universities generally require. Computer delivery requires technological literacy on students' part and enables scores to be transmitted more efficiently to state departments of education and school districts.

Pedagogy

In relationship to pedagogy, the increased interest in teaching STEM has expanded from elementary throughout high school. The ACT Aspire measures student preparedness in reading, mathematics, English, science, and writing by administering the summative assessment to Grades 3 through 10 once a school year. The differential performance on the ACT Aspire among student demographic groups is primarily attributable to differential preparation academically (ACT Research Report Series, 2015). The more exposure to STEM-related courses and learning engagement in classes such as science, the increased likelihood that the student will succeed on the ACT Aspire and the ACT Test. Adopting the ACT Aspire Summative Assessment can improve academic growth, with the most significant effects demonstrated in English and science (Allen & Fang, 2017). The ACT Aspire extends the preparation timeframe to 8 years in the third grade, surpassing the ACT Explore and Plan's 3-year window. The 8-year timeframe also equips guidance counselors, parents, and teachers with data that may enable them to recognize gaps in students' knowledge earlier in their academic careers and make appropriate academic interventions (Allen, 2019; Arkansas Department of Education, 2020). By enabling students to achieve more success in STEM-related courses beginning in elementary and consistently through the middle, junior, and high schools, the chances for continued success through college and career could be enhanced. The ACT Aspire assists students in preparation for the ACT by testing the same content with the same benchmarks (Allen & Fang, 2017). In essence, the ACT Aspire reveals to students if they are learning enough content to perform well on the ACT. The ACT then could be an essential indicator of college readiness and potential success.

Factors Affecting Scores

Various factors affect student performance on the ACT Aspire and ensuing ACT. Achievement gaps exist in the ACT Aspire scores between students of different genders, SES, and races (Bureau of Legislative Research, 2017). ACT Aspire lists the criterion of ready and exceeding as the benchmarks for student achievement and readiness at each grade level (ACT Research and Report Series, 2015). Asian and European American students had the highest percentage of students scoring ready (at grade level) or exceeding (beyond grade level) in each section of ACT Aspire, and Black and Native Hawaiian/Pacific Islander students had the lowest percentage. Among male and female students, females slightly outscored males in the English section. Students with low SES (a designation usually attributed to students eligible for free or reduced lunches in schools) scored lower than students from higher SES levels, with the gap being most significant in English with 65% of non-SES students scoring ready or exceeding compared to 37% of SES students. SES is a reliable and consistent indicator of environmental and mental health and is relevant to behavioral and social science aspects, including investigation, methodology, teaching, and assistance (American Psychological Association, 2020). Low SES correlates with lower educational achievement. Children from low-SES groups possess meager cognitive development, vocabulary, recall, and social spontaneity processing as risk factors. Improving school instruction and early intervention curriculum may assist in reducing risk factors. Expanded investigation and interaction between SES and education is fundamental. The achievement rate of SES students in science, technology, engineering, and mathematics is much more diminished than that of students from more affluent backgrounds.

Socioeconomic disparities in science skills are prevalent and noticeable during the early years of schooling. The importance of seeing the benefits of multiple SES measures reveals that SES inequalities in science achievement appear early in education and indicate STEM success (Ali et al., 2005; Bentancur, 2018). Possible educational policies can, therefore, be aimed at addressing these gaps in the early school years. Early childhood teaching approaches that concurrently address science instruction with reading and mathematics instruction will likely improve overall science performance. Arkansas's response to the ESSA was to use federal dollars and resources toward meeting the educational and academic preparation necessary for low-SES students to succeed on the ACT Aspire Summative Assessment (Arkansas Department of Education, 2017). Arkansas believed that students in low SES could be supported on the ACT Aspire by allotting money and resources that addressed their needs academically, beginning in the lower grades. ESSA can progress equity by targeting higher-order cognitive skills for students, examining school performance and progress, requiring that schools/districts report equitable resource usage, and implementing evidence-based interventions for school improvement (Fusarelli & Ayscue, 2019). However, ESSA places confidence in states adhering to all aspects of the Act, including addressing inequities. ESSA provided numerous opportunities and pathways for states to generate more equitable school systems and, if coupled with using ACT Aspire data efficiently, may overcome gender, SES, and racial gaps in performance in subjects such as science.

Effect of Gender on Science Achievement

Equality of Access

Suppose science and technology will drive the human workplace experience now and in the future. In that case, schools and school districts' responsibility could be to ensure that students have the freedom to accomplish and assimilate science. The disagreement over equality of access to science rests within social justice that seeks the common good for all persons, regardless of gender (Hanson, 2012). In the United States, numerous acts and laws ensured that gender could not be discriminated against in the workplace or the classroom. The common good is attributed to the number of social life circumstances that permit social groups and their reasonable and accessible access to personal realization (Reich, 2018). Science degrees and occupations occupy a place of prestige among societies across the world that are technologically advanced. Creating equality of access and opportunity for persons can create an environment wherein access and opportunity work for society's common betterment (Hanson, 2012). The demand for well-trained workers, engineers, and scientists by the United States' economy makes science training critical to that economy. The argument can be posited that society cannot possess adequate science outside science talent, disregarding gender and race.

Gender was a significant component of conducting scientific endeavors in the United States and across the globe. Gender influenced student learning and impacted student outcomes, such as ACT Aspire STEM readiness (United States Department of Education, 2016; Iasevoli, 2018) due to the disparity of males versus females pursuing STEM courses and careers. For the first time, ESSA demanded that every student in the United States be taught high scholastic specifications to prepare them for academic success in college and careers, emphasizing STEM courses (ESSA, 2020). The Act promoted evidence-based and place-based interventions created by local teachers and educators. ESSA can progress fairness by targeting higher-order cognitive skills for students, various assessments of school performance and progress demands that school districts accurately report resource equity, and the Act's attention to evidence-based remediation for school improvement (Fusarelli & Ayscue, 2019). However, despite advances, opportunity equality and accessibility in science have not been achieved. Achievement gaps remain evident in ACT Aspire scores between students of different gender, SES, and race (Bureau of Legislative Research, 2017). Despite equal access to STEM courses, an imbalance between males and females remains regarding STEM preparedness for higher learning institutions and post-high school careers in STEM fields. Interest in STEM courses and STEM careers are equal among females and males. However, females lagged behind males in actual degrees and STEM jobs (Delaney & Devereaux, 2019; Iasevoli, 2018). An association existed, therefore, between gender and STEM preparedness and participation in STEM careers. Despite females and males exhibiting a similar interest in STEM courses and fields of study, females consistently chose fewer STEM courses in high school and college. Gender inequalities, more males than females choosing STEM-related courses and fields of study, resulted in more males being involved in science universally.

Bias, Prejudice, and Gender Representation

Charitable behavior can enhance the atmosphere of classrooms and schools across America by promoting equity and avoiding bias and stereotyping. Data from the Early Childhood Longitudinal Study revealed that teachers and parents rated females as more likely to comfort, assist, and empathize with other students than males (Chapin, 2007). Females tended to forego stereotyping and bias more so than males in social interaction. Culture determines the type of memory strategy the person develops. Through interaction within the sociocultural environment, higher mental functions are developed (McLeod, 2018). Empathy denotes a higher mental function and interpersonal awareness. STEM careers and science require higher mental functions that are more sophisticated and effective mental processes. Such interpersonal sensitivity may explain why research called attention to disparities regarding gender across STEM fields. Females are over-represented within the social sciences and underrepresented in STEM careers. Only a fraction of engineering careers is occupied by females (Card & Payne, 2017; Su & Rounds, 2015). However, stereotypes continue to block encouragement for females participating in STEM-related fields. For example, the gender gap in computer science is partly caused by the misconception that computers are too complicated for females to use and understand (Coger et al., 2012). Bias was found to also play a role in gender discrepancies. Teaching and engineering are among the unequal disciplines in academician's gender split.

STEM fields are inclusive of both males and females. However, females are significantly underrepresented in STEM fields due to bias (Mangan, 2012). Employers, less today than in the past, view females with children as a risk because females cannot devote adequate time to the job because of motherhood (Delaney & Devereaux, 2019). Males tend to score more advanced in spatial competencies necessary in engineering. Such bias, dichotomized alongside stereotyping, pushes men away from teaching while stereotypical prejudices deter women from STEM careers. Students who encountered gender bias throughout their educational careers had lower STEM self-concepts than students who did not (Robnett, 2016). However, the opposite can be true. Teachers' encouragement and positive female role models can prompt females into STEM courses and careers (Hermann et al., 2016; Kahlenberg, 1996). All students need teacher encouragement and gender role models. The earlier in the academic career of a female that encouragement toward STEM occurs, particularly coupled with female STEM role models, the greater the likelihood that STEM's self-esteem will take root in female students (Hermann et al., 2016). Positive peer connections may be invaluable for females as they progress through the educational process into the STEM-career pipeline. Female role models in STEM fields are an important aspect that encourages females to enter STEM careers, making STEM fields more inclusive.

Support for Gender Equality

With proper support, females can perform just as well as males in STEM courses and career positions in science. Potential causes for non-White student under-representation in STEM are preparedness deficiencies, stereotype threats, familial or societal expectations, or low self-esteem (McCave, Gilmore, & Burg, 2014; Rozek et al., 2019). Preparedness and low self-esteem can be addressed through teachers in the classroom. The lack of interest in STEM fields and teacher encouragement to pursue STEM careers can adversely affect student progression throughout K-12 and play an essential role in student outcomes on the ACT Aspire (Allen & Fang, 2017; Kahlenberg, 1996). Conversely, teacher encouragement, particularly toward females, can positively affect those students pursuing STEM classes and careers. High school students' enrollment reveals that females enroll in science and mathematics classes at the same percentage as their male peers to enroll in science and mathematics classes (Allen, 2019; Almarode, 2018). The interpersonal dialogue and interaction within the classroom can make a substantive difference in students' self-esteem and encourage attention to preparedness. Engaging in a dialogue between people's cognitive construct and the learning experience, people construct a foundation of knowledge and learning that helps them develop a personally informed perception of the subject matter (Hyslop-Margison

& Sears, 2006). By reacting to stimuli, students of either gender can willingly construct learning of the subject matter. Constructed learning was shown to increase their ability to become prepared and succeed in science disciplines.

Building rapport with students fosters interpersonal relationships that afford students positive role models whom to emulate. Females who have had positive contact with a STEM role model are more likely to be more STEM prepared than those women who do not have such contact (Hermann et al., 2016; Wegener & Eccles, 2019). Women with positive STEM role models made higher grades, failed less, and had fewer withdrawal rates in STEM careers. For both genders, learning science is a development that comprises active structuring and not merely apathetic procurement (Duffy & Cunningham, 1996). Learning science involves active assimilation and accommodation of new material enhanced by teacher facilitation and role-modeling. Students' thoughts and actions are learned from their environment (Duffy & Cunningham, 1996; Gleitman, 1987; Hyslop-Margison & Sears, 2006; Lynch, 2016). Positive teacher interaction is one intervention that can bridge the gap between females and males regarding increased female participation and performance in STEM courses. Female teachers in STEM courses also enhance female STEM readiness for post-high school endeavors.

Gender Equality Interventions

Interventions, such as project-based learning that engages students of either gender could inspire and prepare females for STEM success. However, interventions should occur in the lower elementary school (Bentancur, 2018; Quinn & Cooc, 2015). Science achievement gaps progressively worsen as students advance from lower elementary through junior high and high school. The gender inequalities begin in the third grade and continue throughout post-secondary school as fewer and fewer females choose to pursue careers in STEM employment (Iasevoli, 2018). School and teacher quality and educational programs can play a role in either increasing or decreasing achievement gaps between males and females in science (Griffith, 2010; Perry, 2019; Weyer, 2019). An absence of STEM gender diversity adversely affected female students, from mathematics self-concept to science self-concept. For example, while female students' general achievements in mathematics were equivalent to males', female students reported reduced mathematics self-confidence levels in environments where males outnumbered females in occupational diversity (Niepel, Stadler, & Greiff, 2019). Regarding this data, the conventional wisdom that pervaded society until recent decades was that males were naturally gifted with mathematical and scientific abilities, whereas females struggled in these areas. This erroneous belief was long used to justify discouraging and even preventing women from studying mathematics and science and subsequently pursuing jobs in those fields (Frantz, 2007). Persons with intellectual integrity refuted such bias and pointed to women who now constitute one-half of all bachelor's degrees in mathematics and represent an ever-growing employment rate in science careers. Discrepancies in course-taking tendencies and a predilection for STEM courses conditional on readiness contribute to male-female inequalities in the number of students entering STEM (Card & Payne, 2017). Elementary intervention can include pedagogy best practices that simultaneously address science instruction with mathematics instruction, promoting gender equity from the early stages of cognitive development (Hanson, 2012). The effort to end the increasingly fewer females taking STEM courses that originates in third grade and culminates in gaps between genders in science careers can be accomplished through consistent attention given to erasing bias, stereotypes, and lagging preparedness. However, such consistent attention should be addressed early in the students' educational experience.

Effect of Socioeconomic Status on Science Achievement

Effect of Socioeconomic Status

An ever-growing need exists for students to excel in STEM-related subjects. Although countries worldwide have accentuated the significance of science teaching for technological advancement and international economic competition, correlative conclusions from standardized global student assessments revealed a growing gap in science scores between advanced and developing countries (Perera, 2014). The United States, considered a developed country, is no exception. SES is a significant indicator in determining the level of achievement that students can expect and was a contributing factor in determining career objectives, career direction, and performance. Socioeconomic obstacles impede career development, particularly among the sciences (Ali et al., 2005; American Psychological Association, 2020; Mealins, 2019). SES had an effect on students as to whether they chose STEM careers. Students from a lower SES generally had less self-confidence in career ambitions. Students from higher SES backgrounds tended to be more prepared to establish career ambitions. They were commonly better qualified for the workplace due to access to means such as employment offices, guidance counselors, preferred institutions of learning, distinguished social factors, family experience with higher education, and STEM-related courses beginning in elementary and extending through high school (Ali, McWhirter, & Chronister, 2005). Identifiable links existed between students' abilities to be STEM-ready based on preparedness. Investigative researchers established links between teaching strategies and intellectual learning in science (Almarode, 2018; Mealins, 2019). Unfortunately, students with lower SES were often not able to attend schools with highly qualified teachers. Their schools were also fettered with budgets that did not allow for advanced STEM courses such as pre-Advanced Placement and Advanced Placement science classes. Students lacked the preparation to excel in STEM-related areas such as science and subsequently chose not to pursue STEM-related careers, thus exacerbating the world population's lack of participation in science careers.

While the equality of educational opportunities may have been present, other SES-related factors create academic issues for students. A relationship exists between classroom coverage of science concepts and student achievement (Schmidt et al., 2009). The achievement gap in science often stemmed from students having trouble comprehending various conceptions because of their SES circumstances (Mealins, 2019). Moreover, students from underprivileged backgrounds appeared to be disadvantaged at home because both parents worked minimum wage jobs and could not provide tangible benefits such as laptops and internet access. These same parents were generationally low SES and most likely did not attain a high school education, let alone a post-secondary degree. These parents often did not see the impact education could have on their children and therefore lacked encouraging attitudes toward school. SES ceased to become the mitigating factor when low-SES students have parental involvement and encouragement to succeed academically (Mealins, 2019; Means et al., 2016; Perera, 2014). The causes of low SES reached beyond mere aesthetics and involved genetic heritability, being born into poverty. Intelligence measured in children revealed significantly greater intelligence among groups with higher SES than lower SES groups (Bates, Lewis, & Weiss, 2013). Higher SES is associated with high intelligence scores whenever the magnitude of hereditary significance on intelligence was equivalent to SES. Genes multiplied natural inputs, such as increased exposure to STEM classes that support intellectual growth (Bates, Lewis, & Weiss, 2013; Noble et al., 2006). The indicated result implied that increasing SES might elevate mean intelligence. An increase in SES could also influence respective discrepancies in intelligence. SES can be impactful.

Interventions

Students of low SES attend less prestigious colleges, work during college, and financially support their families back home to some degree. High schools were not traditionally designed to equip the preponderance of students for post-secondary education (Almarode, 2018). Most who attended higher learning institutions originated from affluent families, and preparedness was about desegregating into social models of a bygone era (Bessette, 2016). Communities and local colleges could commit to offering dual credit and Advanced Placement courses in high school aimed at interested students and not just students from affluent, predominantly White backgrounds. School context variables of higher dropout and mobility rates signaled more significant risk factors directly associated with SES (Hogrebe & Tate, 2010; Noble et al., 2006). Elevated dropout rates were often directly proportional to low SES. These underlying sociological and anthropological aspects needed real solutions with permanent results; however, these same aspects were not addressed uniformly across American communities at K-12 levels.

One way of addressing sociological and anthropological needs would be to focus on socioeconomic inequalities in science competencies through classroom and individualized interventions during the early years of schooling. The significance of contemplating various socioeconomic situations' benefits by showing that socioeconomic imbalances in science achievement surfaced early in education life (Bessette, 2016). School districts could explore policies aimed at addressing achievement gaps in early school years. One suggestion promoted fundamental pedagogies that synchronously addressed science instruction with reading and mathematics instruction to improve overall science performance. The key to producing better science scores on ACT Aspire was an early intervention for students of low SES in the elementary grades (Bentancur, 2018; Weyer, 2019). Students with low SES require teachers to recognize their plight and align teaching strategies and interventions specific to the students' needs to address the impact of low SES on their learning. Beginning at the elementary level, such interventions could provide the impetus for students with low SES to gain the knowledge and preparedness necessary to reach ready or exceeding status on the ACT Aspire in ensuing grades.

The more highly trained science teachers at the elementary level and the more significant exposure students have produced more successful student science scores. Schools with more students from low-SES and minority backgrounds accomplished increased science proficiency scores when more science classes were taught by exceptionally experienced instructors (Hogrebe & Tate, 2010). Instructor competency in high-poverty and high-minority classrooms persisted as a vital administrative objective for revision and enhancement. The learning was better facilitated than taught in the traditional sense (Driver, 1983). Students needed to be engaged and participatory in the learning for the receipt of knowledge to be beneficial. The more highly qualified the teacher, the greater engagement on the student's part because highly qualified teachers employed research-based pedagogies and proven to engage students.

A viable intervention promotes fundamental teaching methodologies that simultaneously assist students in science instruction with reading and mathematics to improve science performance. Students from low SES may require highly skilled teachers beginning at the elementary level. Schools with a greater percentage of low SES and minority students had shown that increased science proficiency is possible when students had greater exposure to classes taught by highly trained and exceptionally experienced teachers (Hogrebe & Tate, 2010; Niu, 2017). Highly trained and experienced teachers understand the necessities of diverse teaching methods, personal interaction with students, consistent student encouragement in the classroom, and the need to facilitate the learning versus lecturing the students. Engagement with the learning is necessary for students with low-SES, resulting in increased science achievement and STEM participation (Driver, 1983). The highly qualified teacher, due to appropriate training, creates learning environments that are inclusive and engaging. Using research-based pedagogies, highly qualified teachers assist students in skills necessary for learning applicable to science and other disciplines such as mathematics and reading.

Increased Student Preparation

Early intervention and increased preparation are necessary for increased ACT Aspire science scores. Heightened teacher training was particularly imperative for minority students, who expressed enthusiasm for STEM learning at the same levels as their classmates but whose preparation trailed behind their peers, especially those under-resourced students (Adamuti-Trache & Sweet, 2014; Hayes, 2017). Students not receiving sufficient interventions included persons belonging to various racial or ethnic groups, those originating from low SES households, and students whose parents have not received an education beyond high school. SES was a reliable and consistent environmental and mental health indicator relevant to all aspects of observable behaviors, social disciplines, and education. Low SES correlated with lower educational achievement.

Increased exposure to K-12 science knowledge and STEM preparedness for college may depend upon interventions at the K-12 level. For example, interventions such as cooperation between school districts and local community colleges or universities to offer college prep courses can enhance student STEM readiness (Bessette, 2016; Ellerton, Naydu, & Tsimounis, 2016). Cooperative agreements between local colleges and universities can help bridge the SES gap by providing qualified professors to teach advanced science subjects such as Advanced Placement physical or biological sciences. Students, to mature in their learning and be able to assess and revolutionize current social conditions, gain understanding in a significant way as to what constitutes those conditions, how the conditions evolved, the possible alternatives, and the civil and bureaucratic entities used to change the conditions (Hyslop-Margison & Strobel, 2008). Students with low SES need exposure to science as they mature. Typically, the amount of STEM instruction increases with a student's age. Science is taught much less frequently in K-6 than in other disciplines (Hayes, 2017). Only about 74% of high schools offered Advanced Placement courses in science (Fisher, 2020). The trend of teaching science less frequently in K-6 should be reversed for students with determining factors such as low SES to compete with their peers and succeed in science. Advanced Placement and Pre-

Advanced Placement courses can be an avenue toward improved ACT Aspire scores in science. Equally, increased exposure to science and learning interventions in elementary grades could create a foundation for building science knowledge in the middle grades and beyond, improving ACT Aspire student achievement.

Effect of Race on Science Achievement

Social and Educational Course Correction

Learning is a process that encapsulates all aspects of the person: gender, SES, and race stimuli from the environment. Vygotsky (1978) contended that individuals acquire learning through two types of activity: interpsychological (with people) and intrapsychological (inside ourselves). A direct relationship existed between the diversity of students who were academically prepared and positive learning outcomes. Small group activities in K-12 and college could be academically, socially, and racially diverse for students' benefit (Micari et al., 2016). However, historically, racial prejudice prevented non-White students from an equitable education in academic fields. Before the 1950s, non-White students were kept away from White children, and the better-quality White schools prevented non-White students from learning interpsychologically. Non-White students' understanding was limited to their respective culture and environment, which was usually disadvantaged.

The Supreme Court decision *Brown vs. the Board of Education* in 1954 made it unconstitutional for public schools to prevent non-White students from attending White schools. The footprint of the United States Federal Government widened in the 1960s with the enactment of laws such as Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, and Section 504 of the Rehabilitation Act of 1973, which collectively outlawed discrimination based upon race, sex, and disability (Office for Civil Rights, 1999). The enactment of the Civil Rights Laws made an indelible impact on education in the United States by making education free and available to all citizens. Today, the necessity of creating a community educated in science originates from the demands of living and working in a technologically sophisticated international economy (DeBoer, 2000; Muller et al., 2001). Diversity in learning constitutes a moral and ethical necessity, as well as an economic benefit. All races can bring benefits and attributes to enhance learning.

Racial Gaps in Science Achievement

As persons react to environmental stimuli, the internal construction of science begins to occur. Gender, SES, and race have played a significant role in STEM preparedness (Houser & An, 2015). The engagement in the dialogue between the person's cognitive construct and the learning experience constructed a framework of information and learning that helped develop an educated and personal conception of the subject matter (Hyslop-Margison & Sears, 2006). However, despite the United States government and the Department of Education's efforts, significant gaps existed by race and ethnicity (Brown, 2011; Jaschik, 2017). These gaps were not confined to minority areas such as inner-city schools. Achievement gaps in science, for example, occurred in racially diverse schools as well (Bali & Alvarez, 2004). Ethnic, non-White students were particularly susceptible to low interest, low aspiration, low admission, retention, and low persistence in STEM courses such as science (Prime, 2019). Many non-White students did not have the support at home, nor did they necessarily have successful role models in science careers. Non-White students lacked tangible frames of reference to draw inspiration to enter STEM-related classes and pursue STEM-related careers beyond high school, mainly due to poverty. Motivation factors, especially satisfaction and involvement, were critical predictors of STEM career goals even after controlling for SES, STEM career awareness, and science achievement (Ahmed & Mudrey, 2019). Generational poverty can deter a person's ability to have hope for a better future. The lack of hope stunts a person's ability to find a reason and cause for self-motivation and achievement. The lack of hope that results from generational poverty as an environmental stimulus can stunt the internal construction of science within an individual.

The issue of motivation toward STEM careers among minorities was two-fold. Some racial groups and ethnic groups performed better on the ACT if they took core courses in high school to prepare for college; and a lack of peer motivation, encouragement, and stimulation to take STEM courses and excel existed among minorities, particularly African Americans and Latinos (Jaschik, 2017). First, Asian students who did not take college prep did better on the ACT than African American and Latino students who did take college prep courses. Generally, Hispanic and African American secondary school graduates meet ACT's College Readiness Benchmarks in English, reading, mathematics, and science at decidedly reduced percentages compared to Asian and European American graduates. Second, high expectations for learning, close relations with teachers, real-world STEM role models, and positive environmental stimuli enhanced students' chances for success in STEM readiness and entering a STEM career regardless of status (Means et al., 2016; White et al., 2016). Students can be products of their environment. A student's cognition is the product of social interaction in learning (Vygotsky, 1986). If this is true, the issue was not the color of the students' skin nor their genetic or ethnic makeup (Moore, 2015; Prime, 2019). Instead, the issue entailed the absence of positive environmental interaction due to poverty and dysfunctional family structures brought on by the effects of poverty such as divorce and single-parent households wherein the parent must work numerous jobs to provide necessities such as food and housing. Students born into low SES and minority circumstances may lack the same opportunities to succeed academically, unlike their higher SES and non-minority peers. The principle determent appeared to be centered on poverty and a lack of peer exemptors to follow, coupled with the absence of sufficient STEM courses in high school to prepare students for college and career readiness in STEM.

Importance of Student and Teacher Interaction

The 21st-century American educational system's demographics are in a constant state of flux as the system attempts to address issues that face an ever-increasing percentage of minority students within the system's confines. Attempting to consider race and ethnicity as problematic in America's educational system and creating an effective system to counteract those issues are challenges that must be overcome (Morgan & Demir, 2016). One disparity facing America's educational system is teacher education programs graduating primarily White female teacher candidates who express hesitancy, even fears, of teaching students from diverse populations, creating higher student-to-teacher ratios in low SES communities. Minority student under-representation in STEM courses and careers is due to preparedness deficiencies, stereotype threats, familial or societal expectations, or low self-esteem (McCave, Gilmore, & Burg, 2014; White & Rotermund, 2016). Put succinctly, minority students do not often see people of color or ethnic background standing in front of the classroom, encouraging and facilitating learning. The apparent absence of peers in STEM teaching fields in and of itself discourages minorities from taking STEM courses and pursuing STEM careers.

The lack of interest in STEM fields and teacher encouragement to pursue STEM careers can adversely affect student progression throughout K-12. Lack of interest in STEM fields and a lack of teacher encouragement to take STEM courses can play an essential role in student outcomes on the ACT Aspire (Kahlenberg, 1996; White et al., 2016). Teacher encouragement, particularly toward females, minorities, and students with low SES, can positively affect those students pursuing STEM classes and careers. Such encouragement and inspiration from teachers from the same minority and ethnic backgrounds increase the chances of students experiencing success in taking STEM courses and performing well on exams such as ACT Aspire. However, ACT research indicated that ACT scores and high school GPAs are significantly better predictors of success in a STEM major than interests in STEM (Allen, 2019; Hayes, 2017). Simply encouraging students to take STEM courses such as science throughout their K-12 years, major in a STEM field, or enter a STEM career is insufficient. Students must prepare for STEM studies to succeed in STEM studies. Equally important, students need encouragement to take STEM courses and pursue STEM careers while experiencing minority exemplars providing students with said encouragement.

Exposure to Diversity in STEM

Ethnic diversity and exposure to broad academic programs enhance students' chances for STEM preparedness and subsequent success in STEM courses such as science. Data indicated that science- and mathematics-related subject choice tendencies were firmly linked to ethnicity, certified not solely by gender or previous mathematics and science performance but by the grade level of the student at the entrance into the school and enrollment in English as Second Language courses (Adamuti-Trache & Sweet, 2014). The minority and ethnic students' exposure to science and other STEM courses, beginning in elementary and continuing through high school, created STEM preparedness to succeed beyond high school and college. A direct relationship existed between academic-preparedness diversity and positive learning outcomes (Hayes, 2017; Micari et al., Van Winkle, & Pazos, 2016). Small group activities throughout K-12 and college should be academically, socially, and racially diverse for all students' benefit. Students who are less prepared academically gain more significant benefits and perform best when not isolated within a group of academically accomplished students. For example, before entering college, STEM exposure increased the likelihood of Latinos developing an interest in STEM careers in college. Ethnic diversity and more extensive exposure to education can play a vital role in altering the gender make-up of science lecture halls, university research, and STEM-related careers.

Students who were more prepared academically in high school were generally more successful in college. GPA and test scores among high school graduates who excelled in STEM courses support the conclusion that academic preparedness in high school translates into academic success in college (Mattern et al., 2015; Noble et al., 2006). Students were more engaged when learning opportunities were communal. Acculturation in STEM courses and intentional partnerships in small groups enhanced interest and participation among minority students in K-12 (Gray et al., 2020). When appropriate academic and social support was provided to minority students, their preparedness was enhanced, resulting in improved test scores and STEM participation

(Weyer, 2019). Interventions that focus on academic support and social development could enhance minority involvement in STEM courses and result in greater diversity in STEM courses. Such involvement could enable students to be more academically prepared, resulting in possible improved success in college.

Factors Affecting Change over Time and Science Achievement

College preparation and qualification via Praxis exams for teachers' acquisition of science skills can significantly affect students' performances on the ACT Aspire science assessment between Grades 7 and 10. Some teachers who teach science subjects do not hold science degrees (Humphrey & Luna, 2019). For example, in Arkansas, a teacher can become certified in Grade 4-8 language arts, social studies, mathematics, and science by passing the appropriate Praxis exam required for state certification (DESE, 2019). The person must first hold a teaching certificate in a Grade 4-8 discipline and possess a bachelor's degree from an accredited university. These teachers often teach science at the elementary through the eighth-grade level yet possess no educational background or training in the science disciplines, or have a minimum of college science credits. Conversely, high school science teachers hold a bachelor's degree in science and are certified to teach specific science courses. The difference is that high school teachers may have as many as 38 or more core hours of preparation at the college level in science. Teachers at the elementary level may only have eighteen or fewer. The effect is a lack of engagement and preparation in hands-on science experiments and methodologies at the elementary level to a student having increased engagement at the secondary level (Schneider et al., 2016). The result can be that a student matriculates through elementary and junior high school, having experienced few or no formal science training in which science is their specialty. A lack of formal, collegiate academic teacher preparation in science can affect student performance and preparedness and negatively impact STEM preparedness.

Required teacher professional development primarily focuses on the content and pedagogy of science courses. However, the conveyance of such knowledge has no foundational basis for learning if the teacher has not experienced science courses in their collegiate academic training. The teacher may lack the necessary background in science disciplines to create a learning atmosphere in the classroom that is rigorous and inclusive of methodologies conducive to science learning (Bendix, 2017; Gordon, 2017). Students suffer because these teachers' content and pedagogy do not necessarily convey the depth of learning and learning methodologies necessary for the students to progress in scientific knowledge and preparedness academically from grade to grade. Subsequently, the student has a more difficult time excelling on the ACT Aspire as the student progresses in the grade level (Means et al., 2016). Traditional classroom lecturing and accompanying methodologies, for example, are appropriate in certain circumstances, but the teacher must see themselves as a facilitator of the learning and expose students to, and engage the students in, a variety of pedagogies. High expectations for learning, close relations with teachers, and real-world STEM role models and experiences enhance students' success in STEM readiness.

Another factor affecting change over time can be the lack of priority of science at the elementary level. Content, standards, and pedagogy are essential aspects of teaching science, but only if schools spend time teaching. Unfortunately, about 50% of the fourth-graders in the United States do hands-on science activities at least once a week, and only

25% of those students have teachers who focus on inquiry and problem-solving skills (Education Commission of the States, 2021). The emphasis at the elementary level in Arkansas, like many other states, is on reading and mathematics due to standardized testing (David, 2011). While these disciplines are essential, each can serve as a tool to support overall learning, including mastery of big ideas found in science instruction (Camins, 2017). Essentially, elementary-age students need more time to learn science than elementary schools appropriate across the United States. To improve student performance in science, only suitable qualified teachers and adequate time allotted to teach science will potentially increase student performance (Camins, 2017; Van Damme, 2016). A sound elementary school curriculum provides sufficient time and flexibility to provide students' autonomous learning of disciplines such as science. The relative difficulty of science increases as students progress from elementary to high school, with science gaining equal educational time as all core subjects.

Historically, the relative importance of core subjects such as science in elementary schools has been contentious. Contentious in that many varied social interests and political opinions converge in the decision-making process as to which subjects are the most important to emphasize, often resulting in curriculum overcrowding (Bauer, 2019; Van Damme, 2016). The result is often curricula prioritizing expected social outcomes to the detriment of students' educational needs and potential. Science instruction and social studies are often sacrificed by yielding precious educational time to reading and mathematics because state-and federal-mandated testing focuses heavily on these latter disciplines. Schools and teachers are thereby judged on those test scores that are exclusive of science and social studies. Because of social and political interests, the affirming experiences afforded to students in science, such as hands-on activities, critical thinking skills, and problem-solving skills, have become less emphasized. Thus, teachers have little time to fit science into the curriculum (Camins, 2017). In such instances, students, regardless of their gender, SES, or race, are stymied in their opportunity to learn science and other core subjects. Perhaps with the recent increased emphasis placed on science by federal mandates such as ESSA, the history of neglect can be negated, and students can discover the necessity of learning science and how science affects their everyday lives.

Summary

In essence, learning is a process that encapsulates all aspects of the person, including gender, SES, race, and the stimuli from the social and cultural environments and engages in either collaboratively or by existing. Vygotsky argued that individuals acquire knowledge through two types of activity: inter-psychological or among people and intra-psychological or within ourselves (Wink & Putney, 2002). Individuals are, in effect, products of their environments. Students bring to learning a construct shaped and molded by their gender, SES, race, and interactions with their social and cultural environments (Vygotsky, 1978). Knowledge, therefore, evolves through the processes of social negotiation and evaluation, engagement with one's environment. Social worlds develop out of personal interaction with one's culture and society (Lynch, 2016). Engaging in a cognitive dialogue between people's cognitive construct and each learning experience, individuals build a basis of information and knowledge that assists them in developing an informed and personal understanding of the knowledge, or for the students, the respective subject matter such as science (Hyslop-Margison & Sears, 2006). Science, or any learning, is constructed within the individual, by the individual, as a cognitive reaction to environmental stimuli.

Therefore, how one thinks and acts is a learned behavior derived from environmental interaction and engagement. Piaget used the terms *accommodation* and *assimilation* to describe this interplay between one's mind and environment (Gleitman, 1987). Individuals' gender, SES, and race and how their environment responds to each play a significant role in shaping their knowledge. Adopting instruments such as the ACT Aspire Summative Assessment leads to academic growth for students (Allen, 2019). Such an instrument can identify links between a student's ability to be STEM-ready based on preparedness. Data from student scores allow educators to investigate links between teaching strategies and surface versus deep learning in science (Almarode, 2018). Such investigations can lead to implementing interventions such as group activities that enhance the learning environment and enable students to interact and engage with the learning. Collegial collaboration among students creates a learning environment that maximizes knowledge acquisition by individual students within those activities. According to Vygotsky's way of thinking, learning becomes a social construct wherein the learner benefits from social and cultural interaction (Duffy & Cunningham, 1996). To mature in their learning and be able to critique and transform current social conditions, students must understand substantially what those conditions are, how they developed, what possible alternatives exist to them, and the social and political institutions that might reshape them. Such cognitive interplay with fellow students enables the group as a whole and the individuals within the group specifically to interpret stimuli and data so that each person's cognitive abilities are encouraged to flourish (Hyslip-Margison & Strobel, 2008). Students feel free to bring their perceptions based on their gender, SES, and race to interact with ideas and learning within this context. Chapter III includes the research design of determining the effects of gender, SES, and race by change over time on science achievement measured by the ACT Aspire Summative Science Assessment for students in a Northwest Arkansas school district. Change over time was defined as scores from students in Grades 7 and 10.

CHAPTER III

METHODOLOGY

A literature review demonstrated that students in today's classrooms in the United States arrive possessing a social construct that is a product of their environments that shape and mold their abilities to think and learn. Constructivist learning theory functions on the premise that students construct subject matter knowledge based on their prior knowledge of that subject matter (Hyslop-Margison & Sears, 2006; Piaget, 1954; Vygotsky, 1978). Therefore, students create knowledge they obtain from the world around them. The students or learners create knowledge as they encounter learning opportunities throughout their lives. As a result, social constructivists consider teaching and learning as a communal social experience within which meanings are collectively and vigorously fashioned and where more experienced others, such as teachers, students, or adults, assist in the ongoing construction and evolution of students' understandings of subject matter (Duffy & Cunningham, 1996; Vygotsky, 1962; Watson, 2001). Learning for each student emerges as an ongoing, active life process. Each student integrates the new learning into past communal social experiences resulting in the weaving of knowledge reinforced existentially.

Each student becomes an effectual contributor in learning by experiential and natural engagement with the learning. Students essentially learn through interactive collaboration with their fellow students within their communal surroundings (Apple, 1982; Driver, 1983; Gleitman, 1987; Hyslop-Margison & Sears, 2006; Vygotsky, 1978). Learning dependent on mutual interaction with one's peers and environment, regardless of the subject matter being learned, is unavoidably influenced by gender, SES, and race (Jaschik, 2017; Vygotsky, 1962). The students' knowledge evolves from their social world, which develops out of their social constructs. Each student constructs learning within the individual learner. The significant contribution of constructivism becomes the process of learning and not just the acquiring of knowledge (Siegel, 2004). The social construct influences one's perceptions and beliefs, and one's gender, SES, and race influence learning. To what degree those factors affect students' surroundings and how their surroundings affect students' abilities to succeed in science classes are two critical questions to address. The correlation between the individual's gender, SES, and race connects as much significance to the learning technique as the obtainment of new learning (Lynch, 2016; Siegel, 2004; Vygotsky, 1986). The knowledge is not merely effectuated from the teacher to the student originating in pre-kindergarten and culminating 13 years later with high school graduation. Instead, learning is a lifelong discovery (Vygotsky, 1978). The acquisition of knowledge encapsulates all aspects of the person: gender, SES, and race, in conjunction with stimuli from the environment (Siegel, 2004; Wink & Putney, 2002). Students uniquely learn by taking advantage of the preceding and current collective environment present in their lives. The literature suggested that each student's strategic aspect of learning becomes an engaging interaction with teachers who can advance the learning by integrating the students' preceding and existent learning while accommodating new learning in coalition with that mastery.

A literature review revealed that a limited number of studies have attempted to consider all three variables of gender, SES, and race to determine the effects on science achievement alone as measured by the ACT Aspire Summative Assessment for science. Most studies have focused on only one of these variables and the effects on student achievement and preparedness in science (Herrmann et al., 2016; Houser & An, 2015; Iasevoli, 2018). Such studies assist educators in determining the appropriate teaching strategies necessary for students to acquire the necessary science knowledge and skills to succeed in high school and college. Research-based teaching pedagogy that enhances students' science preparation can be one component that increases science achievement (Ellerton et al., 2016; Hayes, 2017). To be adequately ready and excel in science achievement, a deliberate emphasis should be placed on teaching strategies that elucidate the cultural and environmental constructs from which students learn. As a result, gender, SES, and race variables can be calculated to construct those instructional strategies and those strategies can be implemented to benefit students learning science.

This research project examined the effects of change over time between gender, SES, and race on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. Change over time was defined as scores from students in Grades 7 and 10 in each statement. The following hypotheses guided this study.

1. No significant difference will exist by change over time between males versus females on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district.

2. No significant difference will exist by change over time between students receiving free and reduced lunches versus regular paid lunches on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district.
3. No significant difference will exist by change over time between Whites versus non-White students on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district.

This chapter described the research design, the process of obtaining a sample, and the sample population. The instrument used to measure student achievement was discussed, and the data collections and statistical analysis processes were detailed. Finally, the limitations were examined.

Research Design

A quantitative, causal-comparative strategy was used. A 2 x 2 mixed factorial design with a repeated measure on the second factor was used for each hypothesis. The trait independent variables for Hypotheses 1-3 were gender (male versus female), SES (free and reduced lunch eligibility versus no eligibility), and race (White versus non-White) as the between-groups variables. Change over time was coupled with each trait independent variable as the within-subjects factor. The dependent variables for Hypotheses 1 through 3 included student science achievement measured by the ACT Aspire Summative Assessment for science for 7th-grade and 10th-grade students in a public school district located in Northwest Arkansas.

Sample

The sample consisted of the 2018-2019 ACT Aspire Summative Assessment for science scores from 10th-grade students in a Northwest Arkansas school district and these same students' scores from their 7th-grade year in 2015-2016 to determine if a change over time existed. The 7th- and 10th-grade students' scores were collected and stratified by gender, SES, and race. The test score data were then analyzed using the *IBM Statistical Packages for the Social Science (SPSS) Version 25* program. Scores were analyzed by gender, SES, race, and change over time to determine if these variables significantly affected student science achievement.

The school district used was a Northwest Arkansas school district. Data were collected from the district's two junior high schools and the high school the junior high schools fed. The district's population consisted of European American (68%), Hispanic-Latino (12%), African American (10%), Asian/Pacific Islander (4%), and Native American (0.5%). The gender demographic of the district was male (49%) and female (51%). SES was determined by eligibility or no eligibility in the free and reduced lunch program. The average for the district was 39% who were eligible for free or reduced lunch status. The teacher-to-student ratio for the district was 15:1.

Instrumentation

The ADE adopted the ACT Aspire Summative Assessment in Spring 2015. The ACT Summative Assessment measures reading, mathematics, English, science, and writing readiness for Grades 3-10 (ACT, 2015). The system of assessment adopted by the ADE is connected to the most commonly used college entrance exam, the ACT Test, and can be used to predict a future score on the ACT Test. The ACT Aspire Summative

Assessment for science scores were used to measure the dependent variable of science achievement provided by the same students from their 7th-grade and 10th-grade years in a Northwest Arkansas school district. The ACT Summative Assessment for science consists of multiple-choice questions and open-ended response questions. Each assessment is 60 minutes in length, with three subsections. Chronbach's internal consistency reliability for the 2016 7th-grade ACT Aspire Summative Assessment for science is between 0.78-0.80, with a scale score range of 400-443. Chronbach's internal consistency reliability for the 2019 10th-grade ACT Aspire Summative Assessment for science is between 0.78-0.82, with a scale score range of 400-449. The 7th-grade and 10th-grade assessments meet or exceed the acceptable range for coefficiency (Tavakol & Dennick, 2001).

Data Collection Procedures

In the Spring 2020, upon the Institutional Review Board approval, one Northwest Arkansas school district was invited to participate. The superintendent accepted the invitation and arranged for the 2015-2016 and 2018-2019 ACT Aspire Summative Assessment for science scores to be obtained, removing any identifiable student information to avoid a breach of confidentiality. ACT Aspire Summative Assessment for science data arrived within two weeks following the formal request. Once all information was received, the data were coded to identify each student's gender, SES, and race and then entered into an Excel spreadsheet in preparation for analysis. During data collection and upon competition of data entry, ACT Aspire Summative Assessment information was stored in a secured location on a personal computer that was password protected.

Analytical Methods

I used *IBM Statistical Packages for the Social Science (SPSS) Version 25* to analyze the acquired data. *IBM SPSS for Intermediate Statistics* was consulted to determine the correct test to use in the analysis (Leech et al., 2015). Data collected for the three hypotheses were coded according to gender, SES, and race. A 2 x 2 mixed factorial design with a repeated measure on the second factor was conducted using gender, SES, and race as the independent variables to address the three hypotheses. Change over time was the second independent variable for each hypothesis. The three hypotheses' dependent variable was student achievement in science measured by the 2015-2016 and 2018-2019 ACT Aspire Summative Assessment for science scores. A two-tailed test with a .05 level of significance was used to test the null hypotheses.

Limitations

The identification of limitations that may have an unfavorable effect on the results of this study was imperative. Identification of these limitations provides the reader with the discretion as to how to interpret the results. The following were limitations affiliated with this study. First, only one school district in Northwest Arkansas was considered and used to gather data regarding students' gender, SES, and race and their scores on the ACT Aspire Summative Assessment for science in 7th- and 10th-grade years. Economic disparities exist between one geographical region of Arkansas and other such regions of Arkansas (Borden & Madori-Davis, 2019). The geographical and economic environment in which the district is located is the most affluent region of Arkansas. These facts limit the readers' ability to compare and relate the results of this study with some Arkansas school districts that could be considered for comparison. Estimating the differences in performance between the students in one Northwest Arkansas school district and those students in other districts would be problematic using only this study as a reference.

Second, only limited research compares the change over time of achievement of Arkansas students who participated in the ACT Aspire Summative Assessment for science using the three factors of gender, SES, and race. Many studies have focused on one of these variables and the effects on student achievement and preparedness in science and other STEM-related subjects (Herrmann et al., 2016; Houser & An, 2015; Iasevoli, 2018). Gender, SES, and race were used to explore the effect each could have on science achievement, particularly the impact of SES. Learning involves discovering knowledge through experiences acquired or discovered due to social environment encompassing gender, SES, and race (Piaget, 1953; Vygotsky, 1978). To discover a way to deliver science content and develop a more prepared and knowledgeable science student, school administrators explore various avenues of instructional pedagogy. School administrators and teachers are looking for advantages to provide students with learning strategies that could enable them to succeed academically (Noble et al., 2006). The idea of choosing the appropriate science curriculum and delivery of science content resulting in increased performance on the ACT Aspire Summative Assessment for science over time may lead school administrators to investigate the data from this study. Whether gender, SES, and race positively or adversely affect students' scores on the assessment as the students' progress from 7th to Grade 10 may be relational to other factors.

A third limitation was that the research consisted of student scores from the ACT Aspire Summative Assessment for science. The ACT Aspire Summative Assessment for science has been designed to align with the ACT Test; however, this assessment may not have aligned with the Arkansas State Standards for the science content area tested. Differential performance on the ACT Aspire Summative Assessment among student demographic groups is primarily attributable to differential preparation academically, for example, the number of Advanced Placement classes taken, school characteristics, and SES (ACT Research Report Series, 2015). The local school district also determined how the Arkansas State Standards were interpreted and the content delivered. The alignment of the ACT Aspire Summative Assessment to each school district's delivery of Arkansas State Standards was not guaranteed.

Further, the fourth limitation was that the years of experience, educational levels, and specialized training or professional development of the science teachers in the school district was not considered. Teacher preparation and qualification can mitigate factors affecting students' performances in science between Grades 7 and 10. Some teachers who teach science do not possess science degrees (Humphrey & Luna, 2019). In Arkansas, a teacher can become certified in Grade 4-8 language arts, social studies, mathematics, and science by passing the appropriate Praxis exam required for state certification (DESE, 2019). Teaching experience and training varied by science teacher within the district used for data. In addition, teaching experience and training varied from junior high to high school in the district used for data collection.

The fifth limitation involved the inability to factor in the culture or climate in the schools. The culture or climate in a school or district is influenced by the teachers, principals, and district administration (Owens & Valesky, 2015; Stefkovich & Begley, 2007). The two junior highs and one high school selected were similar in the demographic categories of gender and race. However, the immeasurable variables of teacher/student relationships, teacher/student motivation, and the culture or climate were not considered. Nor was the absence of or implementation of a school-wide or district-wide intervention program for students at risk of poor performance on the ACT Aspire Summative Assessment for science.

Finally, the research design was causal-comparative, not experimental, which established a limitation. A quantitative, causal-comparative strategy combined with a 2 x 2 mixed factorial design with a repeated measure of each hypothesis's second factor was implemented. The trait independent variables for Hypotheses 1-3 were gender (male versus female), SES (free and reduced lunch eligibility versus no eligibility), and race (White versus non-White), respectively. Change over time was coupled with each trait independent variable as the within-subjects factor. The dependent variables for Hypotheses 1 through 3 included student achievement on the ACT Aspire Summative Assessment for science for 7th-grade students and 10th-grade students in a public school district located in Northwest Arkansas.

Summary

As well as highlighting the main effect relationships between variables, the factorial design of the study allows the interaction effects of combined variables to be analyzed. The main disadvantage or limitation of the causal-comparative strategy was the inability to manipulate the variables (Salkind, 2010). A factorial design should be planned meticulously, as an error in one of the levels or general implementation will compromise a significant amount of work. Other than these slight detractions, a factorial design is a mainstay of many scientific disciplines, delivering usable results in the field.

The design of a study and influences or uncontrollable characteristics may impact the research outcome or data interpretation. The limitations identified did not seem to surpass the ordinary circumstances often experienced by researchers when schools were used for research studies. Though limitations existed, the findings of this study supplied information for school districts faced with improving academic results in science students' preparedness for the ACT Aspire Summative Assessment for science.

CHAPTER IV

RESULTS

Three purpose statements guided this study. The trait independent variables for Hypotheses 1-3 were gender (male versus female), SES (free and reduced lunch eligibility versus no eligibility), and race (White versus non-White), respectively. Change over time was coupled with each trait independent variable as the within-subjects factor, defined as student scores in Grades 7 and 10 in each of the statements. The dependent variables for Hypotheses 1 through 3 included student achievement on the ACT Aspire Summative Assessment for science for 7th-grade students (2016 scores) and 10th-grade students (2019 scores) in a public school district located in Northwest Arkansas.

Analytical Methods

Data were collected and coded for the three hypotheses: gender (0 = male, 1 = female), SES (0 = no eligibility, 1 = free and reduced lunch eligibility), and race (0 = non-White, 1 = White). Using *IBM Statistical Packages for the Social Sciences (SPSS) Grad Pack 25*, three hypotheses were analyzed using a quantitative, causal-comparative strategy. A 2 x 2 mixed factorial design with a repeated measure on the second factor was used for each hypothesis. Scores from 540 students enrolled in one Northwest Arkansas school district from 2016 and 2019 were collected. The gender categorization of the sample population consisted of 280 males and 260 females. The SES categorization of the sample population consisted of 160 who had free and reduced lunch eligibility and

380 who had no eligibility; therefore, a random sample of 160 no eligibility scores was selected for the analysis. The race categorization of the sample population consisted of 471 White students' scores and 69 non-White; therefore, a random sample of 70 White students' scores was selected for the analysis.

Hypothesis 1

Hypothesis 1 stated that no significant difference will exist by change over time between males versus females on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. A 2 x 2 mixed factorial design with a repeated measure on the second factor was conducted to test this hypothesis. Before conducting the analysis, data were screened for entry errors and missing values, with none found. Data were also screened for outliers, assumptions of normality, and homogeneity of variances. Descriptive statistics and inferential results were also reviewed. Table 1 displays the group means and standard deviations for science achievement by gender and time.

Table 1

Means, Standard Deviations, and Numbers for ACT Aspire Summative Science Assessment Achievement Scale Scores as a Function of Gender and Time

Time	Gender						Total		
	Male			Female					
	M	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*
1	426.70	7.44	280	427.33	6.90	260	427.00	7.19	540
2	429.62	10.89	280	431.62	9.02	260	430.58	10.07	540
Total	428.16	(0.48)	560	429.47	(0.50)	520			

Note. 1 = Testing 1 in Grade 7; 2 = Testing 2 in Grade 10.

An examination of the box and whisker plots for each set of science scores revealed no extreme outliers within the samples. The Shapiro Wilks test was used to test for normality in the four groups (male-Time 1, $W(280) = 0.91$, $p < .001$; female-Time 1, $W(260) = 0.97$, $p < .001$; male-Time 2, $W(280) = 0.95$, $p < .001$; female-Time 2, $W(260) = 0.97$, $p < .001$). All groups violated the assumption of normality. Histograms were used to provide a better test for normality due to the large sample size. The histograms revealed slight negative skewness in three groups, with the male-Time 1 scores revealing a more significant negative skewness. Despite these violations of the assumption of normal distribution, analysis of data using ANOVA was deemed appropriate as ANOVA is considered robust to mild violations of the assumption (Leech et al., 2015). Additionally, the Box's *M* value was associated with a *p* value of less than .001, which was interpreted as significant. However, the Box's *M* test is sensitive to larger sample sizes. Levene's test of equality of variance for the two groups of Time One scores, *F*(1,

538) = 1.33, *p* = .249, indicated that the assumption of homogeneity of variances for the 7th-grade assessment was not violated. However, Levene's test of equality of variance for the two groups of Time Two scores, *F*(1, 538) = 19.82, *p* < .001, indicated that the assumption of homogeneity of variances for the 10th-grade assessment was violated. The results of the mixed factorial ANOVA analysis are displayed in Table 2.

Table 2

Mixed Factorial ANOVA Results for Gender and Time Measured by ACT Aspire Summative Science Assessment Scale Scores

Source	*SS*	*Df*	*MS*	*F*	*p*	*ES*
Between Groups						
Gender	464.38	1	464.38	3.64	.057	0.007
Error	68650.16	538	127.60			
Within Subjects						
Time	3500.27	1	3500.27	141.72	.000	0.208
Gender*Time	125.26	1	125.26	5.07	.025	0.009
Error	13287.61	538	24.70			

Results of the mixed factorial ANOVA were examined. The between-groups main effect for gender was not significant, *F*(1, 538) = 3.64, *p* = .057, *ES* = 0.007. According to Cohen (1988), the effect size for gender was considered small. Regardless of time, females (*M* = 429.47, *SE* = 0.50), did not score significantly different compared to the males, (*M* = 428.16, *SE* = 0.48). Thus, the null hypothesis for the main effect of gender was retained. In contrast, the results regarding the within-subjects main effect for time were significant, $F(1, 538) = 141.72$, $p < .001$, $ES = 0.208$, which was considered a large effect size. Regardless of gender, the Time 1 scores, on average, ($M = 427.00$, $SD = 7.19$) were significantly lower compared to the Time 2 scores ($M = 430.58$, $SD = 10.07$). Thus, the null hypothesis for the main effect of time was rejected. However, the results of both significant main effects needed to be interpreted by the significant interaction between gender and time, $F(1, 538) = 5.07$, $p = .025$, $ES = 0.009$, which is considered a small effect size. Given that the interaction effect was significant, a simple main effects analysis was performed. Figure 1 shows the means for science achievement as a function of gender and time.

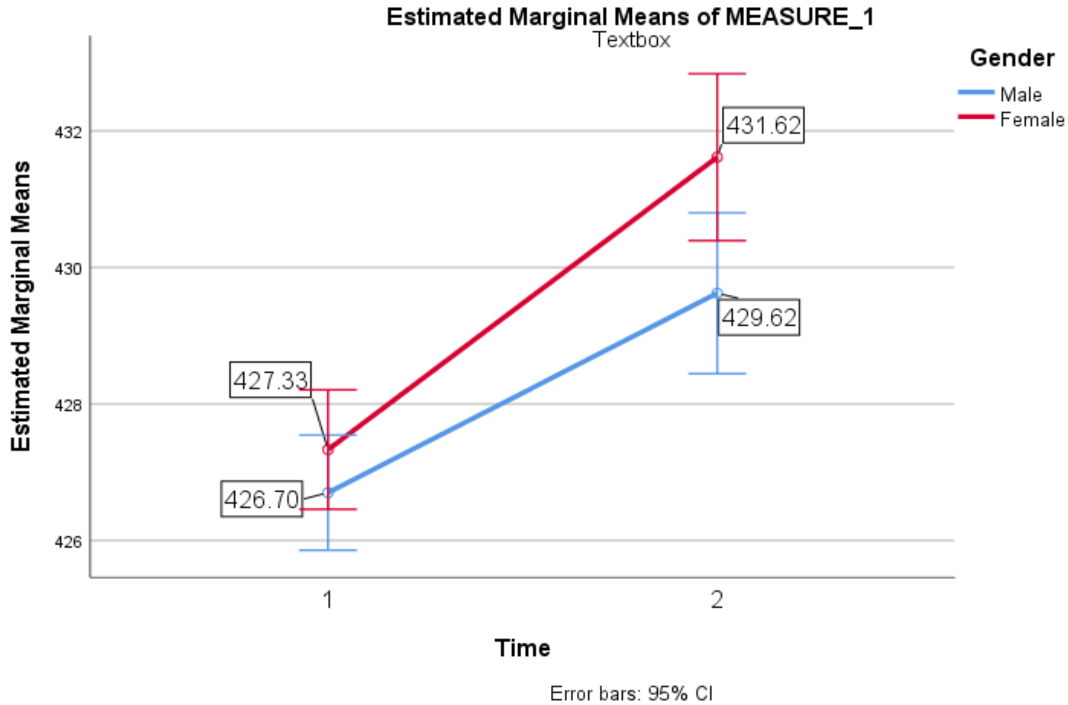

Figure 1. Means with error bars for ACT Aspire Summative Science Assessment achievement as a function of gender and time.

When examining gender by each level of time, the male-Time 1 students' mean for science achievement ($M = 426.70$, $SD = 7.44$) was significantly lower compared to the male-Time 2 students' mean ($M = 429.62$, $SD = 10.89$), $p < .001$. Males increased their scores significantly over the two testings by 2.92 points. Likewise, the female-Time 1 students' mean for science achievement ($M = 427.33$, $SD = 6.90$) was significantly lower compared to the female-Time 2 students' mean ($M = 431.62$, $SD = 9.02$). $p < .001$. Females increased their scores significantly over the two tests by 4.29 points. Of the two groups, the females significantly increased their scores from Time 1(Grade 7) to Time 2 (Grade 10).

When examining time by each level of gender, the male-Time 1 students' mean for science achievement (M = 426.70, SD = 7.44) was not statistically different compared to the female-Time 1 students' mean (M = 427.33, SD = 6.90), p = .308. Although females scored, on average, higher compared to the males, the 0.63-point difference was not statistically significant. However, the male-Time 2 students' mean for science achievement (M = 429.62, SD = 10.89) was significantly lower compared to the female-Time 2 students' mean (M = 431.62, SD = 9.02), p = .021. Females scored, on average, 1.99 points higher compared to the males at Time 2. Although males and females did not score significantly different at Time 1 (Grade 7), females increased the difference, on average, by over three times compared to the male students at Time 2 (Grade 10).

Hypothesis 2

Hypothesis 2 stated that no significant difference will exist by change over time between students receiving free and reduced lunches versus regular paid lunches on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. A 2 x 2 mixed factorial design with a repeated measure on the second factor was conducted to test this hypothesis. Before conducting the analysis, data were screened for entry errors and missing values, with none found. Data were also screened for outliers, assumptions of normality, and homogeneity of variances. Descriptive statistics and inferential results were also reviewed. Table 3 displays the group means and standard deviations for science achievement by SES and time.

Table 3

Means, Standard Deviations, and Numbers for ACT Aspire Summative Science Assessment Achievement Scale Scores as a Function of SES and Time

Time	SES						Total		
	Not Eligible			Eligible					
	M	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*
1	428.78	5.93	160	423.16	7.64	160	425.97	7.38	320
2	432.58	9.13	160	425.45	10.26	160	429.02	10.33	320
Total	430.68	(0.59)	320	424.31	(0.59)	320			

Note. 1 = Testing 1 in Grade 7; 2 = Testing 2 in Grade 10.

An examination of the box and whisker plots for each set of science scores revealed no extreme outliers within the samples. The Shapiro Wilks test was used to test for normality in the four groups (not eligible-Time 1, $W(160) = 0.94$, $p < .001$; eligible-Time 1, $W(160) = 0.97$, $p = .002$; not eligible-Time 2, $W(160) = 0.97$, $p = .001$; eligible-Time 2, $W(160) = 0.97$, $p = .003$). All groups violated the assumption of normality. Yet, histograms were used to provide a better test for normality due to a large sample size. The histograms revealed slight negative skewness in all four groups. Despite these violations of the assumption of normal distribution, analysis of data using ANOVA was deemed appropriate as ANOVA is considered robust to mild violations of the assumption (Leech et al., 2015). Additionally, the Box's *M* value was associated with a *p* value of .008, which was interpreted as significant. However, the Box's *M* test is sensitive to larger sample sizes. Levene's test of equality of variance for the two groups of Time 1 scores, $F(1, 318) = 13.84$, $p < .001$, indicated that the assumption of homogeneity of variances for the 7th-grade assessment was violated. Similarly, Levene's test of equality of variance for the two groups of Time 2 scores, $F(1, 318) = 4.05$, $p = .045$, indicated that the assumption of homogeneity of variances for the 10th-grade assessment was violated. The results of the mixed factorial ANOVA analysis are displayed in Table 4.

Table 4

Mixed Factorial ANOVA Results for SES and Time Measured by ACT Aspire Summative Science Assessment Scale Scores

Source	*SS*	*Df*	*MS*	*F*	*p*	*ES*
Between Groups						
SES	6502.50	1	6502.50	57.77	.000	0.154
Error	35795.48	318	112.56			
Within Subjects						
Time	1482.31	1	1482.31	52.06	.000	0.141
SES*Time	91.51	1	91.51	3.21	.074	0.010
Error	9054.19	318	28.47			

Results of the mixed factorial ANOVA indicated no significant interaction between SES and time, $F(1, 318) = 3.21$, $p = .074$, $ES = 0.010$, which was a small effect size. Therefore, SES and time did not combine to affect science achievement significantly, and the null hypothesis was retained. Given that no significant interaction between the variables of SES and time existed, the main effect of each variable was examined separately. The between-groups main effect for SES was significant, $F(1, 318) = 57.77$, $p < .001$, $ES = 0.154$. According to Cohen (1988), the effect size was considered large. Regardless of time, those eligible for free or reduced lunches ($M = 424.31$, $SE = 0.59$), scored significantly lower different compared to the group not eligible, ($M = 430.68$, $SE = 0.59$). Thus, the null hypothesis for the main effect of gender was rejected. Similarly, the results regarding the within-subjects main effect for time were significant, $F(1, 318) = 52.06$, $p < .001$, $ES = 0.141$, which is considered a large effect size. Regardless of SES, the Time 1 scores, on average, ($M = 425.97$, $SD = 7.38$) were significantly lower compared to the Time 2 scores ($M = 429.02$, $SD = 10.33$). Thus, the null hypothesis for the main effect of time was rejected. Figure 2 shows the means for science achievement as a function of SES and time.

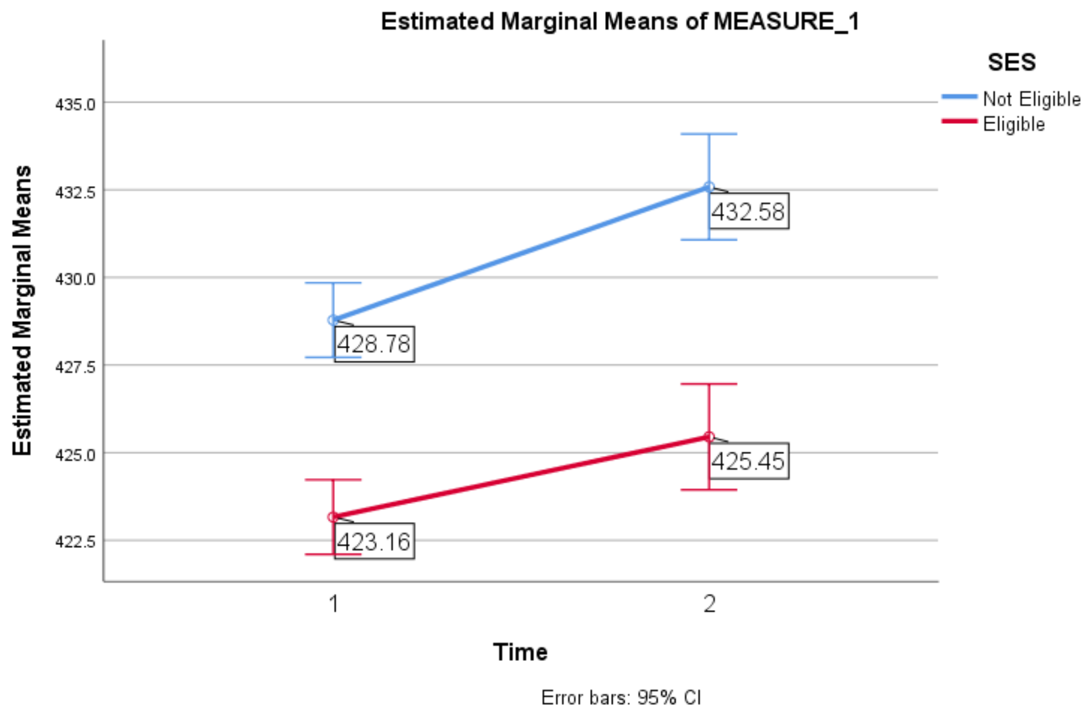

Figure 2. Means with error bars for ACT Aspire Summative Science Assessment achievement as a function of SES and time.

Regarding the main effect of time, both groups combined increased their score means from Time 1 (*M* = 425.97, *SD* = 7.38) to Time 2 (*M* = 429.02, *SD* = 10.33) significantly, with the not eligible for free or reduced lunches group increasing at a slightly higher rate between Time 1 (Grade 7) and Time 2 (Grade 10). Regarding the main effect of SES, the not eligible for free or reduced lunches group's mean (*M* = 430.68, *SE* = 0.59) was significantly higher than the eligible group's mean (*M* = 424.31, *SE* = 0.59). On average, the not eligible group scored 6.37 points higher than the eligible group. Although the difference between the groups increased from 5.62 at Time 1 (Grade 7) to 7.13 at Time 2 (Grade 10), the interaction effect was not significant.

Hypothesis 3

Hypothesis 3 stated that no significant difference will exist by change over time between White versus non-White students on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. A 2 x 2 mixed factorial design with a repeated measure on the second factor was conducted to test this hypothesis. Before conducting the analysis, data were screened for entry errors and missing values, with none found. Data were also screened for outliers, assumptions of normality, and homogeneity of variances. Descriptive statistics and inferential results were also reviewed. Table 5 displays the group means and standard deviations for science achievement by race and time.

Table 5

Means, Standard Deviations, and Numbers for ACT Aspire Summative Science Assessment Achievement Scale Scores as a Function of Race and Time

	Race								
Time	Non-White			White			Total		
	M	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*	*M*	*SD(SE)*	*n*
1	423.41	9.24	69	428.14	5.96	70	425.79	8.09	139
2	425.14	11.27	69	433.46	8.82	70	429.33	10.91	139
Total	424.28	(1.01)	260	430.80	(1.00)	140			

Note. 1 = Testing 1 in Grade 7; 2 = Testing 2 in Grade 10.

An examination of the box and whisker plots for each set of science scores revealed no extreme outliers within the samples. The Shapiro Wilks test was used to test for normality in the four groups (non-White-Time 1, $W(69) = 0.93$, $p = .001$; White-Time 1, $W(70) = 0.95$, $p = .004$; non-White-Time 2, $W(69) = 0.93$, $p = .001$; White-Time 2, $W(70) = 0.96$, $p = .035$). All groups violated the assumption of normality. Yet, histograms were used to provide a better test for normality due to the large sample size. The histograms revealed slight negative skewness in all four of the groups. Despite these violations of the assumption of normal distribution, analysis of data using ANOVA was deemed appropriate as ANOVA is considered robust to mild violations of the assumption (Leech et al., 2015). Additionally, the Box's *M* value was associated with a *p* value of less than .001, which was interpreted as significant. However, the Box's *M* test is sensitive to larger sample sizes. Levene's test of equality of variance for the two groups of Time 1 scores, $F(1, 137) = 21.42$, $p < .001$, indicated that the assumption of homogeneity of variances for the 7th-grade assessment was violated. Similarly, Levene's test of equality of variance for the two groups of Time 2 scores, $F(1, 137) = 9.60$, $p = .002$, indicated that the assumption of homogeneity of variances for the 10th-grade assessment was also violated. The results of the mixed factorial ANOVA analysis are displayed in Table 6.

Table 6

Mixed Factorial ANOVA Results for Race and Time Measured by ACT Aspire Summative Assessment for science Scale Scores

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Between Groups						
Race	2958.52	1	2958.52	21.12	.000	0.134
Error	19194.94	137	140.11			
Within Subjects						
Time	864.37	1	864.37	38.65	.000	0.220
Race*Time	222.07	1	222.07	9.93	.002	0.068
Error	3064.20	137	22.37			

Results of the mixed factorial ANOVA were examined. The between-groups main effect for race was significant, $F(1, 137) = 21.12$, $p < .001$, $ES = 0.134$. According to Cohen (1988), the effect size for the main effect of race was considered between medium and large. Regardless of time, White students ($M = 430.80$, $SE = 1.00$) scored significantly higher compared to the non-White students ($M = 424.28$, $SE = 1.01$). Thus, the null hypothesis for the main effect of race was rejected. Similarly, the results regarding the within-subjects main effect for time were significant, $F(1, 137) = 9.93$, $p = .002$, $ES = 0.068$, which was considered a medium effect size. Regardless of race, the Time 1 scores, on average, ($M = 425.79$, $SD = 8.09$) were significantly lower compared to the Time 2 scores ($M = 429.33$, $SD = 10.91$). Thus, the null hypothesis for the main effect of time was rejected. However, the results of both significant main effects needed to be interpreted by the significant interaction between race and time, $F(1, 137) = 9.93$, $p = .002$, $ES = 0.068$, which is considered a medium effect size. Given that the interaction effect was significant, a simple main effects analysis was performed. Figure 3 shows the means for science achievement as a function of race and time.

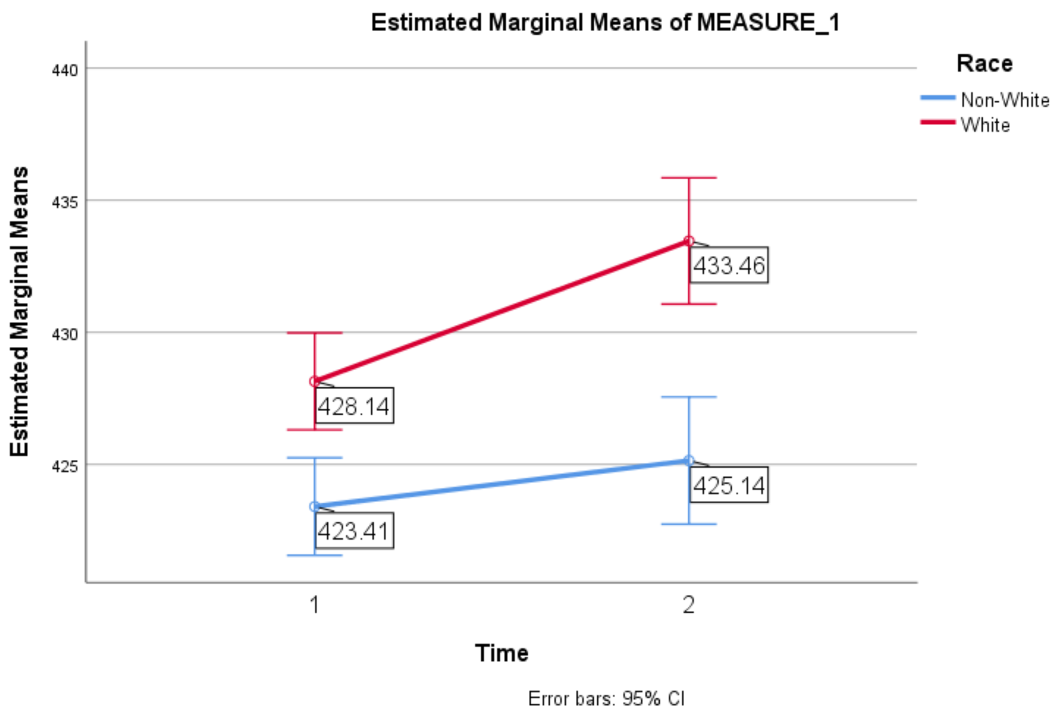

Figure 3. Means with error bars for ACT Aspire Summative Assessment for science achievement as a function of race and time.

When examining race by each level of time, the White-Time 1 students' mean for science achievement ($M = 428.14$, $SD = 5.96$) was significantly lower compared to the White-Time 2 students' mean ($M = 433.46$, $SD = 8.82$), $p < .001$. White students increased their scores significantly over the two testings by 5.31 points. Likewise, the non-White-Time 1 students' mean for science achievement ($M = 423.41$, $SD = 9.24$) was significantly lower compared to the non-White-Time 2 students' mean (M = 425.14, SD = 11.27). p = .033. non-White students increased their scores significantly over the two testings by 1.74 points. Thus, the White and the non-White students significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), with White students displaying an increase three times larger than non-White students.

When examining time by each level of race, the White-Time 1 students' mean for science achievement (M = 428.14, SD = 5.96) was statistically higher compared to the non-White-Time 1 students' mean (M = 423.41, SD = 9.24), $p < .001$. White students, on average, scored 4.74 points higher than non-White students at Time 1 (Grade 7). In addition, the White-Time 2 students' mean for science achievement (M = 433.46, SD = 8.82) was significantly higher compared to the non-White-Time 2 students' mean (M = 425.14, SD = 11.27), $p < .001$. White students scored, on average, scored 8.31 points higher compared to the non-White students at Time 2. Although both groups displayed significant gains between Time 1 (Grade 7) and Time 2 (Grade 10), the gap between the White and non-White students increased by approximately 1.75 times by the second testing.

Summary

The purpose of this study was to determine the effects of gender, SES, and race existing by change over time on the ACT Aspire Summative Science Assessment for 7th- and 10th-grade students in a Northwest Arkansas school district. Table 7 summarizes the results of the interaction and main effects of the three hypotheses.

Table 7

Summary of Statistical Significance of Gender, SES, Race, and Time on Aspire Summative Assessment for Science Achievement by Hypothesis

Variables by H_0	H1	H2	H3
Gender	.057		
SES		.000	
Race			.000
Time	.000	.000	.000
Gender*Time	.025		
SES*Time		.074	
Race*Time			.002

For Hypothesis 1, the main effect of gender was not statistically significant, but the main effect of time was significant. However, the results of both significant main effects needed to be interpreted by the significant interaction between gender and time. Males and females, on average, significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), with females displaying a larger, significant increase. The interaction effect size was interpreted as small. For Hypothesis 2, no significant interaction existed. The main effect for SES was significant, with the not eligible for free or reduced lunches group significantly outscoring the eligible group. The main effect size was large. Also, the main effect for time was significant, with both groups combined increasing from Time 1 (Grade 7) to Time 2 (Grade 10). This main effect size was large. For Hypothesis 3, the main effects of race and time were statistically significant. Again, the results of both significant main effects needed to be interpreted by the significant interaction between race and time. White and non-White students, on average, significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), with the White students displaying a larger, significant increase. The interaction effect size was interpreted as medium. Chapter V includes a discussion of the findings for each hypothesis, implications within the larger context of the literature, and recommendations for practice and further research.

CHAPTER V

DISCUSSION

Education leaders continuously search for specific criteria that are predictive of student achievement. In addition, educators seek to pinpoint specific effects that variables such as gender, SES, and race have on students' academic performance and achievement (Bentancur, 2018; White et al., 2019). As educators seek what variables affect student performance and achievement, research-based decisions regarding pedagogy are necessary. Regardless of the effects of variables, the goal for every school district is to increase student performance and achievement by providing an educational environment where students are allowed to learn and become equipped with the tools to succeed academically. This chapter presented a summary of the findings and implications connected to each hypothesis. Recommendations were provided for potential practice or policy and future research considerations.

Findings and Implications

Gender

Hypothesis 1 stated that no significant difference will exist by change over time between males versus females on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. For Hypothesis 1, the main effect of gender was not statistically significant, but the main effect of time was significant. However, the relationship between the two variables was better interpreted by the significant interaction between gender and time. The males and females combined significantly increased their scores from Time 1 (Grade 7) to Time 2 (Grade 10), but the interaction revealed that females displayed a more significant increase from Time 1 to Time 2 than males. The interaction effect size was interpreted as small.

The main effect of gender was not statistically significant, but the interaction effect of gender and change over time indicated a statistical significance. Females from 7th to Grade 10 significantly outperformed their male counterparts on the ACT Aspire Summative Assessment for science. The concept of gender as a variable that affects student achievement is not new. While research indicated that girls and boys are equally interested in STEM, girls lagged behind boys in preparedness for college courses in STEM and STEM careers (Iasevoli, 2018). Gender can affect STEM readiness in preparedness for STEM courses and career choices. The lack of females engaging in STEM careers coincides with their STEM readiness scores on the ACT Aspire Summative Assessment. Gender differences on the ACT exam existed as boys tended to score higher on mathematics and science, and girls scored higher on English and reading (Perry, 2019). Stereotypes are then inferred and perpetuated that boys are more genetically geared toward STEM courses and careers than girls. This belief, however, was not supported by this study's results.

Gender is but one variable that can be considered as affecting student learning and achievement. Learning is a process that encapsulates all aspects of the person's gender, along with other traits and stimuli from the environment (Wink & Putney, 2002). Students' differential performance on the ACT College Entrance Exam among student demographic groups is primarily attributable to differential preparation academically and includes the number of Advanced Placement classes taken and school characteristics. Realistically, subject choice in high school and resulting differences and preferences for STEM conditional on readiness contribute more to male-female differences regarding STEM preparedness and choosing STEM careers (Card & Payne, 2017; Delaney & Devereaux, 2019). Theoretically, students benefit from teachers who facilitate scientific knowledge and learning in a social constructivist manner (Apple, 1982). Learning is better facilitated than taught in the traditional sense. Students who engaged and participated in the learning retain more knowledge over time than those not engaged in this type of learning (Vygotsky, 1978; Wink & Putney, 2002). This study's results indicated no significant main effect existed for gender. However, females personified greater growth and preservation of knowledge regarding science than their male peers over time.

Socioeconomic Status

Hypothesis 2 stated that no significant difference will exist by change over time between students receiving free and reduced lunches versus regular paid lunches on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. Results indicated no significant interaction between SES and time. Therefore, SES and time did not combine to affect science achievement significantly, and the null hypothesis was retained. Given that no significant interaction between the variables of SES and time existed, the main effect of each variable was examined separately. The between-group main effect for SES was significant, with those eligible for free and reduced lunches scoring significantly lower than their counterparts. According to Cohen (1988), the effect size was considered large.

Similarly, the results regarding the within-subjects main effect for time were significant with a large effect size. Regardless of SES, the Time 1 scores, on average, were significantly lower compared to the Time 2 scores.

Educators have witnessed the varied effects of SES on students. Social class is a mitigating factor in determining career aspirations, trajectory, and achievement. Socioeconomic barriers hinder vocational development, particularly among the sciences. SES is a reliable and consistent indicator of physical and psychological health and is relevant to all behavioral and social science realms, including research, practice, education, and advocacy (Erdogen & Stuessy, 2015). Low SES correlates with lower educational achievement. Children from low-SES groups have poor cognitive development, language, memory, and socioemotional processing (Erdrogen & Stuessy, 2015). Improving school systems and early intervention programs may help to reduce risk factors. Increased research between SES and education could be invaluable. The success rate of SES students in science, technology, engineering, and mathematics is much lower than students from more affluent backgrounds (Ellerton et al., 2016). In this study, results indicated no significant interaction between SES and time, but the main effect for SES was significant. Regardless of time, those eligible for free or reduced lunches scored significantly lower than those not eligible.

Race

Hypothesis 3 stated that no significant difference will exist by change over time between White versus non-White students on science achievement measured by the ACT Aspire Summative Assessment for science for students in a Northwest Arkansas school district. Results of the between-group main effect for race were significant. According to

Cohen (1988), the effect size for the main effect of race was considered medium. Regardless of time, White students scored significantly higher compared to non-White students. Therefore, the null hypothesis for the main effect of race was rejected. Similarly, the within-subjects main effect for time was significant with a medium effect size. Regardless of race, the Time 1 scores, on average, were significantly lower compared to the Time 2 scores. Thus, the null hypothesis for the main effect of time was rejected. However, the results of both significant main effects needed to be interpreted by the significant interaction between race and time, with a medium effect size. Given that the interaction effect was significant, a simple main effects analysis was performed. White students, on average, scored significantly higher than non-White students at Time 1 (Grade 7). In addition, White students scored, on average, scored significantly higher compared to the non-White students at Time 2. Moreover, although both groups displayed significant gains between Time 1 and 2, the gap between the White and non-White students increased by approximately 1.75 times by the second testing.

The concept of race and the effects on student performance over time was explored. Students bring a construct into learning that is shaped by their race through interaction with their social environment (Vygotsky, 1986). Significant gaps exist by race and ethnicity. Jaschik (2017) found that all racial groups and ethnic groups performed better on the ACT if they took core courses in high school for college preparation. Therefore, engaged exposure to science and mathematics classes throughout K-12 helps students become STEM prepared at each grade level. Every K-12 curriculum should be enriched in science and mathematics courses (Houser & An, 2015). All students, particularly those of minority and underserved status, need exposure to college preparatory courses in high school for ACT preparedness.

Change Over Time

The concept of change over time on academic performance was the factor investigated in combination with each trait variable. The entire theoretical framework, the Social Constructivism Theory that served as a foundation for this study, operates on the premise that science or any learning is constructed by the individual reacting to environmental stimuli (Hyslop-Margison & Sears, 2006). The idea is that as any person is exposed to learning, regardless of subject, the person will construct knowledge about that subject as an ongoing dialogue between the person's cognitive construct and the learning experience. The result of students constructing a base of information and knowledge is that such a foundation will assist them in developing an informed and personal understanding of the subject matter. Increased exposure to science, and preparation resulting therein, is especially urgent for underserved learners, who express interest in STEM at the same levels as their peers, but whose preparedness lags far behind (Hayes, 2017). This exposure is especially true for students with multiple underserved characteristics, including belonging to specific racial and ethnic groups, coming from a low-income household, and having parents who have not attended educational institutions beyond high school. The key to producing better science scores on ACT Aspire Summative Assessment is early intervention for students beginning in the elementary grades and sustained throughout high school (Bentancur, 2018). This study revealed that, over time, students improved their scores on the ACT Aspire Summative Assessment for science regardless of gender, SES, or race. Therefore, the assumption can be made that time, coupled with continuous engaged learning in science, will improve students' scores.

Recommendations

Potential for Practice and Policy

This study examined the effect of gender, SES, race, and change over time on science achievement as measured by the ACT Aspire Summative Assessment for science on students' scores in a Northwest Arkansas school district. The results of this study could evolve into a direct influence on practices and policies of Arkansas school districts seeking to increase student performance and achievement in science between the 7th- and 10th-grades. Although this study focused on 7th- and 10th-grade students' ACT Aspire Summative Assessment for science scores, school districts should consider the continued and consistent exposure of K-12 students to engaging science learning.

The ACT Aspire Summative Assessment assesses student readiness in reading, mathematics, English, science, and writing. The summative assessment is administered to students in Grades 3-10 once per school year. Results from the ACT Research Report Series (2015) suggested that performance on the ACT among student demographic groups is attributed to differential academic preparation. In other words, students who are exposed to rigorous science classes throughout their academic careers score higher on the ACT Aspire Summative Assessment for science than their peers who do not have exposure to science classes. Differences existed between male and female students regarding science scores from the 7th-grade to the 10th-grade. In addition, when other factors were considered, SES produced significant results. Ethnic diversity and exposure to broad academic programs enhanced a student's chances for science preparedness and subsequent performance on assessments (Adamuti-Trache & Sweet, 2014). Therefore, links exist between a student's ability to be science-ready based on preparedness. One important facet of student preparedness is teacher pedagogy. Links exist between teaching strategies used in the classroom and whether students experience superficial learning or deep learning in science (Almarode, 2018). A course of action for school districts may be ongoing staff development that trains science teachers to engage students in the learning rather than lecturing to students. In addition, teacher development of lesson designs focused on delivering content based upon student engagement with the learning is critical and provides the skills necessary for students to complete the assessment promptly, representing their knowledge.

At-risk students, such as those from low SES backgrounds, need adequate interventions to succeed in education. States must have a plan that targets at-risk students and provide teacher training and teaching materials to assist these students toward success on the ACT Aspire Summative Assessment for science (Arkansas Department of Education, 2017). The State of Arkansas' official ESSA report to the United States Department of Education (2020) outlines how the Arkansas Department of Education will use money and resources toward meeting the educational and academic preparation necessary for SES students to succeed on the ACT Aspire Summative Assessment for science. Students with low SES can be helped toward successful scores on the ACT Aspire Summative Assessment with monies and resources allotted to school districts to address their academic needs in Arkansas.

Future Research Considerations

This research study did not provide sufficient evidence that gender influenced science achievement on the ACT Aspire Summative Assessment for science. However, the study did provide data to support the idea that SES and race influence student achievement on the ACT Aspire Summative Assessment for science, especially when coupled with change over time. The following recommendations were offered for future research considerations:

1. The present study used 2 years of achievement data to measure the same students' 7th-grade and10th-grade scores from one Northwest Arkansas school district. A longitudinal study could examine the students' scores over multiple grade levels and the interaction of the time distribution throughout the successive years.
2. The present study used only one Northwest Arkansas school district for data. Future researchers might consider including more public school districts and other types of schools such as charter school districts and schools of innovation to increase the sample size and the generalizability of the results. The economic environment of the district used in the study is the most affluent region in Arkansas. Future researchers might consider incorporating a more diverse number of school districts across Arkansas to compare and contrast student performance across the state effectively.
3. The ACT Aspire Summative Assessment for science used in the study might not truly align with the Arkansas State Standards for the subject assessed. A future study might examine how, or if any, alignment exists to the Arkansas

State Standards and how these standards are interpreted and content delivered by each school district.

4. The present study reported the student demographics for the school district involved in the research. Although the student demographics were considered, the years of teaching experience, the educational levels, and the specialized training in the content areas for the district's science teachers could be considered in a future study and student scores disseminated according to these teacher qualifications.
5. One variable for choosing the specific schools for the present study involved the examination of several demographic categories. Future research may also explore variables that reflect the school climate, including academic success, teacher and student relationships, and even the participation or nonparticipation of a school character development program.
6. The present study was not experimental but causal-comparative in design, which resulted in less conclusive findings. Using an experimental design might provide a more accurate depiction of whether an interaction exists among the trait variables.
7. The investigation in this study involved the inability to factor in the culture or climate in the school district studied. The two junior highs and one high school selected were similar in demographic categories of gender and race but not as similar regarding SES. The immeasurable variables of teacher and student relationships, teacher and student motivation, and the culture or climate were not considered. The absence of or implementation of a school or

district intervention program for students at risk of poor performance on the ACT Aspire Summative Science Assessment was not considered.

8. The present study explored the influence of gender, SES, race, and change over time on the ACT Aspire Summative Assessment for science scores. However, a future investigation may consider the grade-point averages of female students. Grade-point averages could provide a more suitable dependent variable compared to a single assessment.

Conclusion

The purpose of this study was to determine the effects by gender, SES, race, and change over time on science achievement as measured by the ACT Aspire Summative Assessment for science for 7th- and 10th-grade students' scores in a Northwest Arkansas school district. The overview of the results for the three hypotheses, implications, and recommendations for future practice and research have been included in Chapter V. Gender did not affect science achievement significantly in the test groups. However, the main effect of change over time indicated a statistical significance, revealing that as students increase their exposure to science, males and females increase their performance on the ACT Aspire Summative Assessment for science. The results for gender and change over time conflicted with the overall evidence from the literature review.

Regarding SES, SES and time did not combine to affect science achievement significantly. The between-group main effect for SES was significant. Regardless of time, those eligible for free or reduced lunches scored significantly lower than those not eligible. Similarly, the results regarding the within-subjects main effect for time were significant, indicating that regardless of SES, students scored higher on the 10th-grade assessment than the 7th-grade assessment. Students' continued exposure to science helped their scores. However, SES adversely affected students who were eligible for free and reduced lunches, which coincided with the results from the literature review.

In terms of race, the results were significant. Regardless of time, White and non-White students increased their scores significantly over the two tests. However, White students displayed an increase three times larger than non-White students. The gap between the White and non-White students' performances increased by approximately 1.75 times by the second testing. Therefore, the results reflected the evidence found in the literature review regarding the effect of race on student scores. The findings of this study have contributed to the body of knowledge regarding whether a significant difference in student achievement exists by gender, SES, race, and change over time as measured by the ACT Aspire Summative Assessment for science, between students' scores in the 7th-grade and those same students' scores in the 10th-grade. The results of this study are meaningful to educators and administrators concerned about closing student learning gaps in science.

REFERENCES

Abramson, C. I. (2013). Problems of teaching the behaviorist perspective in the cognitive revolution. *Behavioral Sciences, 3,* 55-71. doi:10.3390/bs3010055

ACT Research Report Series. (2015). A multidimensional perspective of college readiness: Relating student and school characteristics to performance on the ACT. Retrieved from ERIC database. (ED563774)

Adamuti-Trache, M., & Sweet, R. (2014). Science, technology, engineering and math readiness: Ethno-linguistic and gender differences in high-school course selection patterns. *International Journal of Science, 36*(4), 610-634. Retrieved from doi:10.1080/09500693.2013.819453

Ahmed, W., & Mudrey, R. R. (2019). The role of motivational factors in predicting STEM career aspirations. *International Journal of School & Educational Psychology, 7*(3), 201-214.

Ali, S. R., McWhirter, E. H., & Chronister, K. M. (2005). Self-efficacy and vocational outcome expectations for adolescents of lower socioeconomic status: A pilot study. *Journal of Career Assessment, 13*(40), 40-58. doi:10.1177/1069072704270273

Allen, J., & Fang, Y. (2017). *Updating ACT Aspire ELA and STEM readiness bench-marks for Grades 3-10*. Retrieved from www.act.org

Almarode, J. T. (2018). Perceptions of selective STEM high school graduates: Deep versus surface learning, college readiness, and persistence in STEM. *Research in the Schools, 25*(1), 72-84. Retrieved from ERIC database. (EJ1246952)

American Psychological Association. (2020, January). *Education and socioeconomic status*. Retrieved from https://apa.org/print-this

Apple, M. (1982). *Education and power*. London, UK: Routledge and Kegan Paul.

Archer, A. L., & Hughes, C. (2011). *Explicit instruction: Effective and efficient teaching*. New York, NY: Guilford Press.

Arkansas Department of Education. (2017, January). *Every Student Succeeds Arkansas State Plan September 2014*. Retrieved from http://www.ArkansasESSA.org

Ash, G. (2020). Why education is key to closing the STEM gender gap. *Education Technology.* Retrieved from https://edtechnology.co.uk/latest-news/stem-gender-gap-expert-insights/

Ashford, S., Lanchart, R., Kersaint, G., Lee R., & Kromrey, J. (2016). STEM pathways: Examining persistence in rigorous math and science course taking. *Journal of Science Education and Technology, 25*(6), 961-975. Retrieved from ERIC database. (EJ1122245)

Bali, V. A., & Alvarez, M. (2004). The race gap in student achievement scores: Longitudinal evidence from a racially diverse school district. *The Policies Study Journal, 32*(3), 393-415. doi:10.1111/j.1541-0072.2004.00072.x

Bates, T., Lewis, G., & Weiss, A. (2013). Childhood socioeconomic status amplifies genetic effects on adult intelligence. *Association for Psychological Science, 24* (10), 2111-2116. doi:10.1177/0956797613488394

Bauer, L. (2019). *What are the factors that affect learning at your school?* Retrieved from https://www.brookings.edu

Bendix, A. (2017). *Examining poor school performance in the U.S*. Retrieved from https://www.theatlantic.com/education/archive/2017/03/examining-poor-school-performance-in-the- us/520653/

Bentancur, L. (2018). Socioeconomic gaps in science achievement. *International Journal of STEM Education, 5*(38), 1-45. doi:10.1186/s40594-018-0132-5

Bessette, L. S. (2016). *"College readiness" versus "Ready for college."* Retrieved from https://hybridpedagogy.com/college-readiness-versus-ready-college/

Borden, T. & Madori-Davis, D. (December, 2019). The richest place in every state in the U. S. *Business Insider, December 4.* Retrieved from businessinsider.com/richest-small-town-or-place-in-each-of-the-50-us-states

Brown, E. (2011). A multi-contextual model for broadening participation in STEM related disciplines. *US-China Education Review, 8*(3), 323-332. Retrieved from ERIC database. (ED519571)

Bruner, J. (1996). *The culture of education.* Cambridge, MA: Harvard University Press Bureau of Legislative Research.

Bureau of Legislative Research. (2017). *Student Achievement Research Report, November 2017*. (Project No. 18-001-007). Retrieved from http://www.arkleg.state.ar.us

Camins, A. (2017). *Elementary school children need more time to learn*. Retrieved from https://www.huffpost.com/entry/post_5827_b_4059886

Card, D., & Payne, A. (2017). *High school choices and the gender gap in STEM*. Retrieved from https://www.nber.org/papers/w23769

Carpendale, J., & Muller, U. (2014). Social intervention and the development of knowledge. *Psychology Press, 2014*, 1-18.

Castagno-Dysart, D., Matera, B., & Traver, J. (2019). *The importance of instructional scaffolding.* Retrieved from www.teachermagazine.com.au/articles/the-importance-of-instructional-scaffolding

Chaiklin, S. (2003). *The zone of proximal development in Vygotsky's theory of learning and school instruction*. Retrieved from http://www.cles.mcl.edu.tw/~cerntu/099-curriculum/Edu_Psy/Chaiklin_2003.pdf

Chapin, J. R. (2007). The achievement gap in social studies and science starts early. *The Social Studies, 6*(10), 231-238.

Choney. S. (2018). *Why do girls lose interest in STEM? New research has some answers and what we can do about it*. Retrieved from https://news.microsoft.com/features/why-do- girls-lose-interest-in-stem-new-research-has-some-answers-and-what-we-can-do-about-it/

Coger, R. N., Cuny, J., Klawe, M., McGann, M., & Purcell, K. (2012). Why STEM fields still don't draw more women. (2012). *Chronicle of Higher Education, 58*(3), 3. Retrieved from ERIC database. (EJ989661)

Cohen, J. (1988). Statistical power analysis for the behavioral science. New York, NY: Lawrence Erlbaum Associates.

Cooper, G., & Berry, A. (2020). Demographic predictors of senior secondary participation in biology, physics, chemistry, and earth/space science: Students' access to cultural, social, and science capital. *International Journal of Science Education 42*(1), 151-166. doi:10.1080/09500693.2019.1708510

David, J. L. (2008). What research says about pacing guides. *Educational Leadership, 66*(2), 87-88. Retrieved from http://www.ascd.org/publications/educational-leadership/oct08/vol66/num02/Pacing-Guides.aspx

David, J. L. (2011). Research says…/High-stakes testing narrows the curriculum. *Educational Leadership, 68*(6), 78-80.

Davidson, C. (2016, December 5). *Introduction: How and why to structure a classroom for student-centered learning and equality* [Blog post]. Retrieved from http://hastac.org

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Science in Teaching, 37*(10), 582-601. doi:10.1002/1098-2736

Delaney, J., & Devereux, P. (2019). Understanding gender differences in STEM: Evidence from college applications. *Economics of Education Review, 72*(10), 219-238. Retrieved from https://ideas.repec.org/a/eee/ecoedu/v72y2019icp219-238.html

Detel, W. (2015). *International Encyclopedia of the Social & Behavioral Sciences* (Vol. 22). Frankfurt/Main, Germany: Elsevier.

Division of Elementary and Secondary Education. (2019). *About DESE*. Retrieved from http://dese.ade.arkansas.gov/about-ade

Driver, R. (1983). *The pupil as scientist*. New York, NY: Open University Press.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. *The Handbook of Research for Education and Technology.* New York, NY: MacMillan.

Education Commission of the States. (2021). *Will elementary science remain the forgotten stepchild of school reform?* Retrieved from https://www.ecs.force.com/studies/

Edwards, H. (2015). Is ACT Aspire an accurate predictor of your real ACT score [Blog post]? Retrieved from https://blog.prepscholar.com/is-act-aspire-an-accurate-predictor-of-your-real-act-score

Eggen, P., & Kauchak, D. (2013). *Educational psychology: Windows on classrooms.* Upper Saddle River, NJ: Pearson Education.

Einstein, A. (2009). *Cosmic religion and other opinions and aphorisms*. Mineola, NY: Dover Publications.

Ellerton, S., Naydu, C., & Tsimounis, A. (2016). Increasing science knowledge among high-risk student populations through a community college honors/service-learning program. *Journal of College Science Teaching, 46*(2), 11-16. Retrieved from http://www.jstor.org/stable/24892441

Erdogen, N., & Stuessy, C. (2015). Examining the role of inclusive STEM schools in the college and career readiness of students in the United States: A multi-group analysis on the outcome of student achievement. *Educational Sciences: Theory and Practice, 15*(6), 1517-1529. Retrieved from http://www.estp.com.tr

Espinola, M. (2019). *3 ways to integrate purposeful dialogue in the classroom*. Retrieved from www.gcu.edu

Every Student Succeeds Act (ESSA). (2020). Retrieved from https://www.ed.gov/essa

Fisher, J. F. (2020). Will the decline of AP course offerings spur the rise of course access? *Education Next, 20*(4), 52. Retrieved from https://www.educationnext.org/will-the-decline-of-ap-course-offerings-spur-the-rise-of-course-access/

Fosnot, C. T. (1996). *Constructivism: Theory, perspectives, and practice.* New York: NY: Teachers College Press.

Frantz, K. (2007). *Encouraging science*. Retrieved from www.thehumanist.org

Fusarelli, L. D., & Ayscue, J. B. (2019). Is ESSA a retreat from reality? *Phi Delta Kappan, 101*(2), 32-36. Retrieved from https://kappanonline.org/essa_retreat-from- equity-fusarelli-ayscue/

Gleitman, H. (1987). *Basic psychology*. New York, NY: W. W. Norton and Company. Retrieved from www.act.org/policy-advocacy

Gordon, L. (2017). *Teachers' training needs improvement so students benefit, new report says*. Retrieved from https://edsource.org/2017/teachers-training-needs-improvement-so-students-benefit-new-report-says/583028

Gould, N. (1993). Cognitive change and learning from practice. *Social Work Education, 12*(1), 77-78. Retrieved from https://researchportal.bath.ac.uk/en/publications/cognitive-change-and-learning-from practice-a-longitudinal-study

Gray, D. L., McElveen, T. L., Green, B. P., & Bryant, L. H. (2020). Engaging Black and Latinx students through communal learning opportunities: A relevance intervention for middle schoolers in STEM elective classrooms. *Contemporary Educational Psychology, 60*, 361-476. doi:10.1016/j.cedpsych.2019.101833

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*(3), 911-922. Retrieved from https://digitalcommons.ilr.cornell.edu/workingpapers

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education, 13*(5), 1089-1113. doi:10.1007/s10763-014-9526-0

Hanson, S. L. (2012). Science for all? The intersection of gender, race, and science. *The International Journal of Science in Society, 3*(2), 113-125. Retrieved from http://www.sciencepublishinggroup.com/j/ijsts

Harbin, M. Brielle; Thurber, Amie; and Bandy, Joe. (2019). Teaching Race, Racism, and Racial Justice: Pedagogical Principles and Classroom Strategies for Course Instructors. *Race and Pedagogy Journal: Teaching and Learning for Justice*, *3*(2), Article 1. Retrieved from https://soundideas.pugetsound.edu/rpj/vol4/iss1/1

Hayes, S. (2017). *Preparation matters most in STEM*. Retrieved from www.act.org

Herrmann, S. D., Adelman, R. M., Bodford, J. E., Graudejus, O., Okun, M. A., & Kwan, V. S. Y. (2016). The effects of a female role model on academic performance and persistence of women in STEM courses. *Basic and Applied Social Psychology, 38*(5), 258-268. doi:10.1080/01973533.2016.1209757

Hogrebe, M., & Tate, W. F. (2010). School composition and context factors that moderate and predict 10th-grade science proficiency. *Teachers College Record, 112*(4), 1096-1136. Retrieved from ERIC database. (EJ888472)

Houser, L., & An, S. (2015). Factors affecting minority student's college readiness in mathematics. *Urban Education, 50*(8), 938-960. Retrieved from ERIC database. (EJ1081792)

Humphrey, C. & Luna, P. J. (2019). The national STEM teacher shortage threatens future prosperity. Retrieved from www.realcleareducation/articles/2019/04/04/the_national_stem_shortage_threatens_future_prosperity_110320.html

Hyslop-Margison, E. J., & Sears, A. (2006). *Neo-liberalism, globalization, and human capital learning: Reclaiming education for democratic citizenship.* Dordrecht, Netherlands: Springer.

Hyslop-Margison, E. J., & Strobel, J. (2008). Constructivism and education: Misunderstandings and pedagogical implications. *The Teacher Educator, 43*(1) 72-86. Retrieved from https://www.researchgate.net/publication/233326590_Constructivism_and_education_misunderstandings_and_pedagogical_implications

Iasevoli, B. (2018, March 8). Despite equal interest in STEM, girls trail boys in readiness. Retrieved from www.edweek.org

Jaschik, S. (2017, September 7). ACT scores are up, but gaps remain by preparation and race/ethnicity. *Inside Higher Ed*. Retrieved from https://insidehighered.com/print/news/2017

Kahlenberg, R. D. (1996). *The Remedy: Class, race, and affirmative action*. New York, New York: New York Times Co.

Kauffman, D., Johnson, S. M., Kardos, S. M., Liu, E., & Peske, H. G. (2002). “Lost at sea”: New teachers’ experiences with curriculum and assessment. *Teachers College Record, 104*(2), 273-300. Retrieved from Research Gate database.

Leech, N., Barrett, K., & Morgan, G. (2015). *IBM SPSS for intermediate statistics.* New York, NY: Routledge.

Lui, C. H., & Matthews, R. (2005). Vygotsky’s philosophy: Constructivism and its criticisms examined. *International Educational Journal, 6*(3), 386-399. Retrieved from ERIC database. (EJ854992)

Lynch, M. (2016). *Social constructivism in education*. Retrieved from https://www.theedadvocate.org/

Malin, J. R., Bragg, D. D., & Hackmann, D. G. (2017). College and career readiness and the Every Child Succeeds Act. *Educational Administration Quarterly, 53*(5), 809-838. doi:10.1177/0013161X17714845

Mangan, K. (October, 2012). Despite efforts to close gender gaps, some disciplines remain lopsided. *Chronicle of Higher Education, 59*(10). Retrieved from ERIC database. (EJ989656)

Mattern, K., Radunzel, J., & Westrick, P. (2105). *Development of STEM Readiness Benchmarks to Assist Educational and Career Decision Making.* ACT Report. Retrieved from ERIC database. (ED558031)

McCave, E. J., Gilmore, J., & Burg, K. (2014). *Preparing minority students for undergraduate and graduate research*. Presented at 2014 ASEE Annual

Conference and Exposition, Indianapolis, IN. Retrieved from https://peer.asee.org/20383

McLeod, S. A. (2018). *Lev Vygotsky*. Retrieved from https://www.simplypsychology.org/vygotsky.html

McLeod, S. A. (2019). *Constructivism as a theory for teaching and learning*. Retrieved from https//www.simplypsychology.org/constructivism.html

Mealins, E. (2019). *Study: Socioeconomic status correlates with higher test performance in Alabama*. Retrieved from https://www.alereporter.com/2019/05/23/study-socioeconomic-status-correlates-with higher-test-performance-in-alabama/

Means, B., Wang, H., Young, V., Peters, V., & Lynch, S. (2016). STEM-focused high schools as a strategy for enhancing readiness for post-secondary STEM programs [Abstract]. *Journal of Research in Science Teaching, 53*(5), 1-38. Retrieved from ERIC database. (EJ1096580)

Micari, M., Van Winkle, Z., & Pazos, P. (2016). Among friends: The role of academic-preparedness diversity in individual performance with a small-group STEM learning environment. *International Journal of Science Education, 38*(12), 1904-1922. doi:10.1021/ed080p132

Morgan, G.A., Leech, N. L., Gloechner, G. W., & Barrett, K.C. (2013). *IBM SPSS for introductory statistics.* New York, NY: Routledge

Morgan, P. S., & Demir, K. (2016). *Toward a race-based understanding of culturally relevant pedagogy in the science classroom.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC. Retrieved from www.aera.net/Publications/Online-Paper-Repository/AERA

Muller, P. A., Stage, F. K., & Kinzie, J. (2001). Science achievement growth trajectories: Understanding factors related to gender and racial-ethnic differences in precollege science achievement. *American Educational Research Journal, 38*(4)*,* 981-1012. doi:10.3102/00028312038004981

Niepel, C., Stadler, M., & Greiff, S. (2019). Seeing is believing: Gender diversity in STEM is related to mathematics self-concept. *Journal of Psychology, 111*(6), 1119-1130. Retrieved from https://psycnet.apa.org/record/2019-05164-001

Niu, L. (2017). Family socioeconomic status and choice of STEM major in college: An analysis of a national sample. *College Student Journal, 51*(2), 298-312. Retrieved from Research Gate database.

Noble, J. P., Roberts, W. L., & Sawyer, R. L. (2006). Student achievement, behavior, perceptions, and other factors affecting ACT scores. ACT Research Report Series. Retrieved from ERIC database. (ED510477)

Office for Civil Rights. (1999). *Impact of Civil Rights laws*. Retrieved from https://www2.ed.gov/about/offices/list/ocr/docs/impact.html

Oliver, K. M. (2000). Methods for developing constructivism learning on the web. *Educational Technology, 40*(6), 5-16. Retrieved from https://www.jstor.org/stable/44428633?seq=1#metadata_info_tab_contents

Owens, R. G., & Valesky, T. C. (2015). *Organizational behavior in education: Leadership and school reform.* New Jersey: Prentice Hall.

Perera, L. D. H. (2014). Parents' attitudes towards science and their children's science achievement. *International Journal of Science Education, 36*(18), 3021-3041. Retrieved from ERIC database. (EJ1042648)

Perry, M. J. (2019). Gender differences on the ACT test: Boys score higher on math and science; girls score higher on English and reading. American Enterprise Institute. Retrieved from https://www.aei.org

Prime, G. M. (2019). *Centering race in the STEM education of African-American K-12 learners*. New York, NY: Peter Lang Publishing Group.

Piaget, J. (1953). *The origins of intelligence in children.* New York, NY: Basic Books.

Piaget, J. (1954). *The construct of reality in the child*. New York, NY: Basic Books.

Quinn, D. M., & Cooc, N. (2015). Science achievement gaps by gender and race/ethnicity in Elementary and Middle School: Trends and predictors. *Educational Researcher, 44*(6), 336-346. doi:10.3102/0013189X15598539

Raffan, J. (2001). A whirlwind tour of the major considerations for developing differentiation in the classroom. *Gifted Education International, 16*(1), 56-60. doi:10.1177/026142940101600108

Reich, R. (2018). *The common good.* New York, NY: Knoph Publishing Group.

Roberts, C. (2020). *Advantages and disadvantages of constructivism in teaching*. Retrieved from https://classrooms.synonym.com/advantages-disadvantages-constructivism-teaching-8634178.html

Robnett, R. D. (2016). Gender bias in STEM fields. *Psychology of Women Quarterly, 40*(1), 65-79. doi:10.1177/0361684315596162

Ross, R. B. (2009). *A study of socioeconomic status and performance on physical science assessments.* Retrieved from ERIC database. (ED531129)

Rozek, C. S., Ramirez, G., Fine, R. D., & Beilock, S. L. (2019). Reducing socioeconomic disparities in the STEM pipeline through student emotion regulation. *Proceedings* *of the National Academy of Sciences of the United States of America, 116*(5), 1553-1558. Retrieved from https://www.pnas.org/content/116/5/1553

Salkind, N. J. (2010). *Encyclopedia of research design.* Thousand Oaks, California: Sage.

Saifer, S. (2010). Higher order play and its role in development and education. *Psychological Science and Education, 2010*(3), 38-46. Retrieved from http://psyjournals.ru/files/31248/psyedu_2010_n3.Saifer.pdf

Scheurman, G. (1998). From behaviorist to constructivist teaching. *Social Education, 62*(1), 6-9. Retrieved from ERIC database. (EJ565801)

Schmidt, W. H., Cogan, L. S., Houang, R. T., & McKnight, C. (2009). *Equality of educational opportunity: A myth or reality in U. S. schooling.* Retrieved from ERIC database. (ED 537169)

Schneider, B., Krajcik, J., Lavonen, J., Salmelo-Aro, K., Broda, M., & Spicer, J. (2016). Investigating optimal learning moments in U.S. and Finnish science classes. *Journal of Research in Science Teaching, 53*(3), 400-421.

Siegel, H. (2004). The bearing of philosophy of science on science education, and vice versa: The case of constructivism. *Studies in History and Philosophy of Science, 35*, 185-198. Retrieved from https://www.cambridge.org/core/journals/episteme/article/

Social Constructivism. (2001). *Encyclopedia of the Social & Behavioral Sciences.* Frankfurt/Main, Germany: Elsevier.

Sprouls, K., Mathur, S. R., & Upreti, G. (2015). Is positive feedback a forgotten classroom practice? Findings and implications for at-risk students. *Preventing School Failure, 59*(3), 153-160. Retrieved from ERIC database. (EJ1061751)

Stanberry, K. (2009). *Learning difficulties and social skills: What's the connection?* Retrieved from www.greatschools.org/gk/articles/learning-difficulties-and-social-skills

Stefkovich, J., & Begley, P. (2007). Ethical school leadership. *Educational Management Administration and Leadership, 35*(2), 205-224.

Stockwell, C. (2017). *Women v. men in STEM degrees: Do we have a problem?* Retrieved from https://inside.collegefactual.com/stories/women-vs-men-in-stem-degrees

Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *Frontiers in Psychology, 6*(189), 1-29. Retrieved from www.ncbi.nim.nih.gov/pmc/articles/PMC4340183

Sublett, C., & Plasman, J. S. (2017). How does applied STEM coursework relate to mathematics and science self-efficacy among high school students? Evidence from a national sample. *Journal of Career and Technical Education, 32*(1), 29-50.

Tavakol, M. & Dennick, R. (2001). Making sense of Chronbach's alpha. *International Journal of Medicine Education, 2,* 53-55. Retrieved from https://10.5116/ijme.4dfb.8bfb

Tawfik, A. A., Woei, H., & Giabanelli, P. J. (2020). Comparing how different inquiry-based approaches impact learning outcomes. *Interdisciplinary Journal of Problem-based Learning, 14*(1), 25-40. Retrieved from ERIC database. (EJ1257973)

The Executive Office of the President. (2014). *Increasing opportunities for low-income students.* Retrieved from http://www.obamawhitehouse.archives.gov

Toglia, T. (2013). Gender equity issues in CTE and STEM education. *TechDirections, 72*(7), 14-18. Retrieved from ERIC database. (EJ1004588)

Tomlinson, C. A. (2008). Differentiated instruction. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education: What the record says* (pp. 167-179). Waco, TX: Prufrock Press.

United States Census Bureau. (2010). *Northwest Arkansas*. Retrieved from www.census.gov/geographies/reference-maps/2010/geo/2010-pumas/Arkansas.html

United States Department of Agriculture. (2020). Child nutrition guidelines: Income eligibility guidelines. *Federal Register, 85*(55)*,* 16050-16051. Retrieved from https://www.govinfo.gov/content/pkg/FR-2020-03-20/pdf/2020-05982.pdf

United States Department of Education. (2016). *Civil Rights data*. Retrieved from https://www2.ed.gov

United States Department of Education. (2020). *Every Student Succeeds Act* (ESSA). Retrieved from https://www.ed.gov/essa

Van Damme, D. (2016). *How much time is spent on maths and science in primary education?* Retrieved from https://oecdedutoday.com/how-much-time-is-spent-on-maths-and-science-in-primary-education/

van der Veer, R., & Valsiner, J. (1991). *Understanding Vygotsky: A quest for synthesis.* Cambridge, MA: Blackwell Publishing.

Vitale, D. (2016). *Including measures of student behavioral skills in accountability systems.* Iowa City, IA: ACT. Retrieved from https://www.act.org

Vygotsky, L. (1962). *Thought and Language.* Cambridge, MA: MIT Press.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Soubermann, Eds.). Cambridge, MA: Harvard University Press.

Vygotsky, L. (1986). *Thought and Language* (A. Kozulin, Trans. 1986). Cambridge, MA: The MIT Press.

Watson, J. (2001). Social constructivism in the classroom. *Support for Learning, 16*(3), 140-147. doi:10.1111/1467-9604.00206

Wegener, C. M., & Eccles, J. S. (2019). Gendered STEM choices: Altruistic values, beliefs, and identity. *Journal of Behavior, 110*(A), 28-42. Retrieved from https://www.sciencedirect .com/science/article/abs/pii/S0001879118301301

Weyer, M. (2019). *Early STEM education*. Retrieved from https://www.ncsl.org/research/education/early-stem-education.aspx

White, G. W., Stepney, C. T., Hatchimonji, D. R., Moceri, D. C., Linsky, A. V., Reyes-Portillo, J. A., & Elias, M. J. (2016). The increasing impact of socioeconomics and race on standardized academic test scores across elementary, middle, and high school. *The American Journal of Orthopsychiatry, 86* (1), 10-23. doi:10.1037/ort0000122

White, K., & Rotermund, S. (2019). Elementary and secondary mathematics and science education, Science and Engineering indicators 2020. National Science Foundation. Retrieved from ERIC database. (ED599383)

Williams, A. (2018). *What is a constructivist approach to teaching?* Retrieved from www.theclassroom.com

Wink, J., & Putney, L. (2002). *A vision of Vygotsky*. Boston, MA: Allyn and Bacon.

Zambrano, J., Kirschner, F., Sweller, J., & Kirschner, P. A. (2019). Effects of group experience and information distribution on collaborative learning. *Instructional Science, 47*, 531-550. Retrieved from https://link.springer.com/article/10.1007/s11251-019-09495-0