ADVANCED VERSUS REGULAR: THE RELATIONSHIP BETWEEN STUDENT ACHIEVEMENT IN SCIENCE AND CURRICULAR CHOICE

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ADVANCED VERSUS REGULAR: THE RELATIONSHIP BETWEEN STUDENT ACHIEVEMENT IN SCIENCE AND CURRICULAR CHOICE

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ABSTRACT

The purpose of this study was to examine the relationship between science curricular treatment and achievement in middle school. A repeated-measures ANOVA applied to standardized test score data from students, n = 3,135, determined relative growth from 5th to 8th grade. Findings show achievement scores from schools offering a choice of advanced and regular science was slightly higher. Gender played no significant role. Race was a significant factor in all scenarios as was free/reduced lunch status. Results showed no significant relationship between the type of science class and the category assigned by standardized achievement scores, and that curricular differentiation may not be the most effective way to enhance science education. Grit may have more impact on achievement than curriculum treatments.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Graduate Studies, have examined a dissertation titled "Advanced versus Regular: The Relationship between Student Achievement in Science and Curricular Choice," presented by Diane Fitzgibbons, candidate for the Doctor of Philosophy degree, and certify that in their opinion it is worthy of acceptance.

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CHAPTER 1

INTRODUCTION

The need to increase achievement in American schools has been a topic of many debates in recent decades. This demand for higher performance standards and achievement for pre-college education was exacerbated by the 1983 publication by the National Commission on Excellence in Education of a report entitled *A Nation at Risk.* This report stated many criticisms about American public schools, including the idea that American science and technology progress was being exceeded by students from other countries (National Commission on Excellence, 1983). Although national science scores on standardized tests show a slight overall improvement from 2006, 15-year-olds in the United States are still outperformed by students from several other nations on science tests (National Science Foundation, 2012a).

Early adolescence is a difficult stage for students as they transition from youth to adulthood. Students' grades can influence how a student feels about his or her ability to learn. Teachers and administrators have an imperative to strive to reach each student with instructional content that is both challenging and interesting. Although junior highs started as a vocational training ground many years ago (Alexander, 1995), the concept of teaching young adolescent students morphed into middle schools to address socio-psychological needs of students in this age group. Originally, middle schools were formed to decrease emphasis on competition, both in grades and athletics and foster collaboration among students (National Middle School Association, 2003), while supporting the students' social transition into their teenage years. To do this, many middle school formats began with every student taking similar classes without much choice in core classes. Junior high schools were similar, keeping core subjects the same at this age level for convenience. Eventually, reading and mathematics curricula offered more than one choice for students in hopes of improving achievement in those areas and to assist in grouping students by ability level in those subjects. Additional choices in school curricula involving reading and mathematics have been established for decades. However, some students may show more interest or aptitude in other subjects, such as science. Yet, at middle-level, most science classes traditionally offer only one type of science per grade level.

The Federal No Child Left Behind Act of 2001 (NCLB) required states to develop academic standards in mathematics and science by 2005, including learning assessments for science beginning in 2007, testing students at least once at both the elementary and middle levels to measure achievement (No Child Left Behind Act, 2001). These required state standardized tests usually offer four achievement categories that convey student learning: Advanced, Proficient, Basic, and Below Basic. According to the National Science Board report (National Science Foundation, 2012a), small improvements have taken place among science achievement scores of 15-year-olds, but they appear to be from those students in the lower categories receiving intervention strategies instead of increasing the numbers of students in the highest achievement categories.

Science is an abstract concept, and therefore is taught differently than other core subjects (Bronowski, 1956). Research shows that students need to be actively engaged before learning can occur (Danielson, 2002). In order for that engagement to happen more often, some middle and junior high schools in the past decade have adjusted their curricula so there is a choice in science classes at one grade level. The idea of curricular choice has been one that high schools have utilized for many years so students can earn a well-rounded education in subjects at varying challenge levels. However, some middle and junior high schools that have traditionally offered only one class for each core area per grade level are now offering options for those who desire more challenge at a younger age. Ebenezer and Zoller (1993) found that although students find science concepts interesting, they regarded their science class as boring. Schools reformed their curricula to meet the need for differing levels of mathematics skill in students before and during the onset of the requirements of NCLB, and mathematics achievement scores have shown some improvement (National Science Foundation, 2012a). Typically, eighth grade mathematics students have had the opportunity to choose their class through curricular differentiation offered in the form of Algebra and Pre-Algebra. Unfortunately, most middle-level schools did not adjust their curricular offerings for science students after the onset of NCLB, dismissing the need for variety in science. As research shows (Braddock, 1990), most middle-level schools in the U.S. have some subjects which are ability-grouped, although science is rarely differentiated until high school. In 2009, the American Recovery and Reinvestment Act was enacted, a part of which called "Race to the Top" included a contest for K-12 education systems to develop school reform to improve achievement. Part of those reforms involved the development of advanced classes and a more rigorous curriculum. From these efforts grew the idea of curriculum choices at middle-level instead of just at high schools, although many areas have not attempted this change due to inconsistent research results about the effects of differentiating the curriculum.

Historically, many attempts have been made to improve achievement of young adolescents, including the practice of ability grouping, which is the instruction of students of similar ability levels in a homogeneous classroom. Some teachers favor the practice of ability grouping because of the convenience of teaching students with similar skills (Lindle, 1994), or because it maximizes instructional resources (Tyner & Greene, 2005). There is significant research supporting ability grouping of higher-level students, showing gains in their achievement (Braddock, 1990; Kulik & Kulik, 1987; Lleras & Rangel, 2009; Steenbergen-Hu & Moon, 2011). However, other reports show that the effects of ability-grouped classes are inconclusive (Betts & Shkolnik, 2000). Another concern is shown in a study by Wang and Goldschmidt (2003), which claimed that the achievement gap between White and non-White students widens with course differentiation. Yet another study showed positive effects of non-homogeneous mixed-ability classes (Mastropieri et al., 2006), stating that lower performing students' achievement is increased when advanced students are present in the same class, going against the idea of segregating the top students. Clearly, there are different opinions about the results of the practice of grouping students together by skill level. As author and researcher Thomas L. Friedman stated, "The American education system from kindergarten through twelfth grade just is not stimulating enough young people to want to go into science, math, and engineering" (2005, p. 270).

In addition to mediocre standardized test scores when compared to some other countries, another disturbing statistic concerning science education is the decline in the number of American students training for careers in science. Even before the steady declines were reported, the aforementioned *A Nation at Risk* report stated that improvements in American education are urgently needed (National Commission on Excellence, 1983). In the National Science Board report (National Science Foundation, 2014), the number of 18- to 24-year-olds obtaining college degrees in a science field had fallen from a rank of third in the world three decades ago to seventeenth today. This trend could cause the U.S. to lose its competitive edge, with fewer people entering careers involving science, technology, engineering, and math (STEM) (Council on Foreign Relations, 2012). If this trend continues, there could be a shortage of scientists and engineers in our country, which could threaten the economic welfare and security of our nation (National Science Foundation, 2014). According to Griliches (1990), the number of patents in a country is a good indicator of innovation, which is connected to economics. The economic and technological advantage that the U.S. has held for so many years is slipping to other countries (Segal, 2004). Science in higher education has been affected as well, with a steady decline in doctoral scientists and engineers in America since 1993. In addition, the rate of published science and engineering articles from the U.S. is not keeping up with increased outputs from several other countries (National Science Foundation, 2012b). According to the National Science Board (National Science Foundation, 2012b), China is the world leader in the number of doctoral degrees in the natural sciences and engineering, surpassing the U.S. since 2007. This trend does not bode well for the future of science research and discovery in America. One corporation, Microsoft, stated in a company report that it has thousands of job openings that are going unfilled, and the U.S. educational system is failing to produce enough graduates in sciences, technology, engineering, and math disciplines. It wanted Congress to offer incentives to colleges to increase enrollment in these areas (Costa, 2013). As Freidman suggested, "We cannot hope to fight jobs lost to international competition without a well-trained and educated work force" (2005, p. 269).

Finally, another reason that science education reform is a worthy research topic is that all citizens should have an understanding of how science concepts affect their world. Citizens need to understand science to make informed decisions in their personal lives

(Council on Foreign Relations, 2012). Many actions in our daily lives have something to do with science, such as gardening, cooking, reading a map, storage of household chemicals, understanding weather, and so many more. Understanding the environment and how our actions affect it, as well as how our environment affects us, can be directly related to our understanding of science. Citizens who practice the right to vote should be informed about actions that affect the community, both in the short term and the long term. How well we understand the science behind those cause-and-effect relationships will determine how we vote, and ultimately how the environment is affected. Many actions, from choosing which type of vehicle to buy to knowing how to choose and properly handle food are connected to an understanding of basic science. Therefore, all students need a firm foundation of science concepts in order to function at higher levels. Yet, most Americans continue to answer incorrectly questions about basic factual science or the scientific inquiry process (National Science Foundation, 2012a), and the levels of science knowledge have not increased over the last decade. In a survey, Americans tended to have higher scores on factual knowledge of science when they reported that they had completed more science and math courses (National Science Foundation, 2012a). The importance of educating the populace in matters related to science is evident and can be accomplished with a strong foundation in science during their formative years.

Statement of Purpose

Significant gaps exist in the research of curricular treatments in science and their effect on achievement in middle-level students. The primary purpose of this paper is to compare the academic effects of science curricular choice on the science achievement scores of students at the middle level. This topic of research is important because it can help educators improve their instructional practice to effect positive outcomes for students in early adolescence, specifically in the area of science education. Positive experiences in science could lead to more interest in science for students' future studies. Also, this information can aid in attempts to design effective science curricula to improve science achievement overall. Due to the lack of science curricular differentiation in many areas, very little research exists that studies the effects of offering advanced science classes alongside regular science classes at this level, and how it impacts student achievement. With the increasing demand in the world for skills in STEM, the information in this paper can inform educators of middle-level students about ways to help those students perform better in science, as well as assist curriculum directors to make better decisions about the effects of differentiated curricula on student achievement.

Research Questions

There were six research questions in this study:

RQ1: What is the relationship between school districts that offer science curricular choice and those that do not as it affects relative growth in science?

RQ2: What is the relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it affects relative growth in science?

RQ3: What is the relationship between gender and relative growth in middle school science?

RQ4: What is the relationship between race and relative growth in middle school science?

RQ5: What is the relationship between free/reduced lunch (FRL) status and relative growth in middle school science?

RQ6: Is there a tendency of the science achievement categories assigned to students on state standardized tests to change over time?

Hypotheses

The research questions were designed to explore the relationship between curricular choice in middle level science classes and achievement outcomes over three years as measured by the Missouri Assessment Program (MAP) state standardized tests. The research questions addressed in this study were:

RQ1: What is the relationship between schools that offer science curricular choice and those that do not as it affects relative growth in science?

H1null: There is no relationship between schools that offer science curricular choice and those that do not as it affects relative growth in science.

H2alternative: There is a relationship between schools that offer science curricular choice and those that do not as it affects relative growth in science.

RQ2: What is the relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it affects relative growth in science?

H2null: There is no relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it affects relative growth in science.

H2alternative: There is a relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it affects relative growth in science.

RQ3: What is the relationship between gender and relative growth in middle school science?

H3null: There is no relationship between gender and relative growth in middle school science.

H3alternative: There is a relationship between gender and relative growth in middle school science.

RQ4: What is the relationship between race and relative growth in middle school science?

H5null: There is no relationship between race and relative growth in middle school science.

H5alternative: There is a relationship between race and relative growth in middle school science.

RQ5: What is the relationship between free/reduced lunch status and relative growth in middle school science?

H5null: There is no relationship between free/reduced lunch status and relative growth in middle school science.

H5alternative: There is a relationship between free/reduced lunch status and relative growth in middle school science.

RQ6: Is there a tendency of the science achievement category assigned to students on state standardized tests to change over time in middle school?

H6null: There is no tendency for science achievement categories assigned to students on state standardized test to change over time.

H6alternative: It is likely that science achievement categories assigned to students on state standardized test will change over time.

Definition of Terms

Student Achievement was measured by the Missouri Assessment Program (MAP) test, which divides students into four categories based on achievement (Advanced, Proficient, Basic, and Below Basic). Percentages of students in each of these achievement categories were compared among the groups.

Advanced is the highest of four result categories on the MAP test in which

> Students explain the physical and chemical properties of matter; apply knowledge of energy and energy transfer; demonstrate understanding of physical and chemical processes of organisms; evaluate the effects of balanced and unbalanced forces; predict the impact of environmental change in ecosystems; justify how adaptations help organisms survive; demonstrate understanding of the water cycle; compare and contrast weather and climate; explain the cause of seasons on Earth; demonstrate understanding of the solar system; apply the concept of light years; apply awareness of the influence of science and technology in society. (Missouri Department of Elementary and Secondary Education [MODESE], 2012, p. 9)

The MAP score range for the advanced category in eighth grade is 735-895.

Proficient is one of four result categories on the MAP test in which

> Students classify types of motion; calculate the speed of an object; demonstrate simple understanding of life processes; classify and/or show relationships between organisms; explain how adaptations help organisms survive; explain how species are affected by environmental change; understand and describe a food web; explain rock and fossil evidence of changes in the Earth; explain how Earth's systems interact; draw conclusions from tables or graphs; demonstrate basic understanding of the solar system; recognize the need for, and calculate, averages; use appropriate tools and methods to collect data; describe tools and discoveries that advance scientific knowledge. (MODESE, 2012, p. 9).

The MAP score range for the proficient category in eighth grade is 703-734.

Basic is one of four result categories on the MAP test in which

> Students identify an example of a force; demonstrate simple understanding of how traits are passed from one generation to the next; have a basic understanding of climate; identify a simple hypothesis; recognize a trend in a data table; demonstrate some awareness of how various factors influence and are influenced by science and technology. (MODESE, 2012, p. 9)

The MAP score range for the basic category in eighth grade is 671-702.

Below Basic is the lowest of four categories on the MAP test in which

> Students identify simple terms related to matter and energy; demonstrate beginning understanding of properties of light and how it travels; identify structures of plants and animals needed for survival; identify levels of organization in multi-cellular organisms; read simple graphs and make simple data comparisons. (MODESE, 2012, p. 9)

The MAP score range for the below basic category in eighth grade is 540-670.

Advanced Science is a curricular method that consists of the same topics covered in regular science but taught at a faster pace, with more outside reading, more writing, and with more required enrichment projects.

Curricular Differentiation is the practice of a school or district that offers two or more different levels of difficulty for the same grade and content area, and in some research is also referred to as within-school tracking.

Open Enrollment is the practice of allowing students (and their families) to choose between two types of classes in science without prerequisites of any kind.

Significance of the Study

The number of students choosing careers in science is dropping (National Science Foundation, 2012a). American students are performing lower than students in many other nations on standardized achievement tests in science. Research suggests that U.S. schools are falling from their former dominance, especially in the field of science (National Science

Foundation, 2012b). To remedy these trends, science education needs to improve so U.S. students can achieve as they did in the past, and so they can compete in a global society. Even before the publication of the 1983 report *A Nation at Risk*, schools in America have been put through many types of reform efforts in their attempts to raise achievement scores. One method of reform intended to raise achievement scores is to provide differentiated curricula for core classes, such as science. While some research (Spielhagen, 2006; Tieso, 2003) supported the practice of providing advanced and regular classes, some studies (Smith-Maddock & Wheelock, 1995) stated that the practice tends to "track" low-performing students, denying them meaningful learning opportunities. However, those studies dealt with students who met prerequisites in order to be placed into advanced classes.

This study examined the relationship between advanced science and regular science curricular offerings in an open enrollment format, so the effect of students who choose between entering a more rigorous science class or a regular science class could be studied. This study was intended to add to the body of knowledge concerning curriculum differentiation in middle-level science education as a reform effort and its effect on science understanding and achievement.

CHAPTER 2

LITERATURE REVIEW

Research in science achievement in middle-level students is almost absent when compared to other subjects such as reading and mathematics. Science education research is important because it can help educators and pedagogical leaders improve their instructional practices to effect positive outcomes for students in early adolescence in the area of science education. This study investigated whether offering open enrollment in middle school for science classes of different challenge levels would increase science achievement scores. With American science test scores lagging behind those of other countries, and with the current trend of fewer U.S. college students entering into science fields, research in the improvement of science education can be extremely beneficial. Also, this information may help to close the achievement gap that exists between ethnicities and genders as they pertain to science education. With the increasing demand in the world for skills in Science, Technology, Engineering, and Mathematics (STEM), the information in this study can inform educators of middle-level students about ways to help those students perform better in science.

This literature review shows a brief history of teaching and learning at middle-level grades. Science teaching is discussed, followed by factors that influence achievement and how it is measured. Current reform efforts, with attention focused on differentiated curricula, including benefits and drawbacks of the practice, are covered. Finally, the theoretical constructs on which this study was based are noted.

History of Science Instruction to Young Adolescents

Prior to the beginning of the 20th century, the format of American schools consisted of two divisions: A “common school” with kindergarten through eighth grades, and a “high school” with ninth through twelfth grades (Van Til, Vars, & Lounsbury, 1967). In those early times, attending high school was considered necessary only for those students who sought to attend college, while an eighth-grade education was sufficient for students who were needed on the farm. The early American eighth-grade drop-out rate was rising, so an attempt to keep students in school beyond eighth grade was enacted, which encouraged educators to introduce subjects that normally had been presented in ninth grade (Beane, 1993). Educators were hoping that this practice would influence students to stay in school through high school. Creating a unique level called a junior high school prompted many to stay in school (Beane, 1993). Junior high schools were developed in the middle of the 20th century to keep older students in school, and were mainly seen as a vocational training ground, although these junior high schools did begin the separate subject model of curriculum (Alexander, 1995). This traditional model of a junior high, usually consisting of grades seven through nine, continued through the 1990s.

Eventually, the junior high concept came into question during attempts to improve education in the 1960s. Researchers began to implement middle schools, which delivered content differently than departmentalized junior high schools. Middle schools tend to involve sixth through eighth grades, with the addition of programs such as advisories, interdisciplinary teaming, and exploratory courses that aspire to better meet the socio-psychological needs of young adolescents (Alexander, 1995). Middle schools sometimes consist of fifth through eighth grades, or just seventh and eighth grades. Not all junior high schools converted to middle schools, although most did eventually join the trend. Today, there are estimated to be about 13,000 middle schools and about 3,000 junior highs in the U.S. (National Center for Educational Statistics, 2009). Some junior high schools continue to convert to middle schools, while a few middle schools have converted back to junior highs. However, some schools that label themselves middle schools are not true middle schools in that they have no interdisciplinary teaming, or they lack advisories or integrated grade levels in classes.

Using either the middle school format or the junior high format, there is no significant difference in achievement rates among middle-level learners (Cuban, 1992). Other research (Rockoff & Lockwood, 2010) found that middle schools actually discourage motivation. The research conflicts on this point, some stating that middle schools make a positive difference in student achievement (MacIver & Epstein, 1993). The important idea for either format is to adequately prepare middle-level students for the future. Both types of schools implement a self-contained single-subject elementary style of information delivery, and most continue to departmentalize in the four core areas of language arts, mathematics, social studies, and science (Alexander, 1995). Because of the separation of these core subjects in middle schools, science instruction can be further studied and analyzed to investigate best practices for instruction.

Science Instruction in the Middle Levels

Teaching science concepts to middle-level students can be done with a variety of techniques, depending on the resources available to the instructor. Instruction of science at the middle levels in America varies from location to location. Some schools have designed a curriculum that matches standardized tests in their area in hopes that scores will improve

(Rosenmund, 2007). Because there is no one national standardized test, middle level science curricula that attempt to teach to a standardized test are vastly different from state to state. Some districts have instead remained with the traditional "spiral" of teaching physical, life, and earth sciences in alternating years until high school. Several initiatives have been developed by various groups, such as the Common Core State Standards Initiative (CCSSI), which seek to form a consistent set of national grade level expectations (Kendall, 2011). However, the CCSSI does not address science standards at this time. When it comes to science, a joint effort between the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve is underway to create national benchmarks for science, although these efforts will only guide curricula (Achieve, 2011) and will not set a national middle-level curriculum.

A current trend in public science education is to follow what mathematics education has done by adopting a differentiated curricular format. For example, a middle school student could enroll in a standard science class or an advanced science class depending on some criteria, such as teacher recommendations or standardized test scores. Middle-level mathematics classes have practiced this differentiation for decades, with both positive and negative results. For example, Wang and Goldschmidt (2003) showed in a four-year longitudinal study from an ethnically and linguistically diverse district, that course-taking patterns, even when controlling for prior achievement, played a prominent role in identifying performance differences among middle schoolers. The achievement gap between those taking advanced math and those who did not widened after the eighth grade. Although this study showed achievement levels rose with those in the advanced math group, it also exposed detrimental effects on those in the lower group.

A large body of work exists concerning mathematics and the effects of differentiated curricula, but studies for middle-level science are virtually non-existent. Some studies do connect advanced classes to higher achievement scores (Attewell & Domina, 2008; Kulik & Kulik, 1991; Slavin, 1990); however, they involve high school students or generic surveys of middle-level students not specific to science. Studies are greatly lacking concerning the effects of offering different middle-level science courses on students' science achievement. This is a pathway of needed future study. Differentiating science to incorporate an advanced class or a remedial class in addition to the standard class for a given grade level is relatively new to middle-level learners. It must be understood that the nature of teaching science is not linear like mathematics, in that all prior knowledge completely relates to what learning comes next. Science is not just a collection of facts and observations; it is a process that is more abstract (Bronowski, 1956). This abstract nature is what makes science teaching different than most core areas and its effects more difficult to research.

Not only do middle level curricula vary, but the methods used to impart that information do as well. In most cases, middle level science instruction involves direct instruction, which consists of teacher presentation, then drill or practice. In a national survey of over 10,000 American schools (McEwin, Dickinson, & Jenkins, 1996), about 87% of middle school science teaching consisted of this method of instruction. However, this study was not specific to science instruction alone. Evidence shows (Pearsall, 1992) that traditional methods of lecture and practice are less effective than once believed in developing students' understanding of science concepts.

One part of the abstract nature of science is the necessity for critical thinking skills. In mixed-ability group settings, critical thinking was encouraged when cooperative learning groups were used as an instructional method (Ennis, 1993). However, this study not only centered on science but also on social studies concepts together. Research in a future study specifically involving critical thinking concerning science concepts at the middle level would be beneficial.

Another commonly found method to impart science skills and knowledge is the use of hands-on science investigations in a lab setting. Studies show that research projects and science investigations, including inquiry learning, are done by high-achieving countries (Darling-Hammond & McCloskey, 2008). Although most science teachers use labs, it does not always produce all of the desired outcomes (Hegarty-Hazel, 1990). Too many middle school science teachers get caught up in the actions of science to entertain students while minimizing the importance of the learning objective. However, when learning objectives are clearly communicated, studies show that some lab activities have the ability to encourage critical thinking, demonstrate principles, and help students understand fundamental concepts (Hake, 1992). Similar to lab activities, project-based instruction can be engaging to middle-schoolers. One study shows that project-based methods can help students perform better on performance assessments than students who experienced traditional instruction (Kolodner, Gray, & Fasse, 2003). Lab activities and cooperative learning projects can be very popular motivators for middle-level students. Moore (1984) described science as a "way of knowing," specifically, a method that involves inquiry in the creation of new knowledge. Another study suggested that project-based middle school students achieved higher on statewide assessments, and the effects of participation in project-based classrooms were cumulative, with higher scores associated with more project-based instruction (Marx et al., 2004). According to the STEM Education Coalition, a "strong emphasis on hands-on, inquiry-based learning activities" (STEM Education Coalition, 2013, n.p.) are core policy recommendations to promote positive outcomes in science education. Although there are several methods of science instruction for middle-level students, studies fail to show evidence that one method is better than the rest. There are other methods known to educators as well which are not mentioned in this review that can be successful in teaching science, but the methods mentioned here have been researched for effectiveness.

Student Achievement Factors

Factors other than what is being tested in a research study may be variables that affect the achievement of students, especially if the students in question are early adolescents. Not only are they developing mentally, but physically, emotionally, and socially. Education professionals who work with middle-level students are aware of these challenges. As stated in Allison and Rehm (2007):

> As young adolescents confront a host of transitions associated with the emergence of puberty, including dramatic physical, social-emotional, and cognitive changes, they also undergo transformations in relationships with parents; encounter more emotionally intense interactions with peers, and struggle with personal identity issues. Middle school teachers, therefore, must become educated about and skilled in using pedagogy that is sensitive and responsive to the developmental and educational needs of young adolescents from diverse racial, ethnic, and cultural backgrounds. (p. 12)

Young adolescents are very dependent on peer relations, and it can affect their work-study habits. Wentzel and Caldwell (1997) found in a study of 213 sixth graders that there is a significant relationship between peer relations and school achievement at this age. Although the sample size was small, the results applied to both males and females.

In a study specific to female achievement, Reynolds and Juvonen (2011) showed that middle school girls who went through early physical maturation experienced more rumors and awkwardness than those who did not. In a multiple regression of over 900 girls, these results suggested that early maturation was associated with maladjustment and caused those girls to be at risk for rumors. However, that study did not specifically tie maladjustment to low achievement scores. In middle school it is especially important for learners to feel safe, accepted, and supported. In a study by Stewart and Suldo (2011), social support of peers, parents, teachers, and classmates affected academic achievement in that average and high achievers perceived themselves as supported. Also, in a recent study of sixth through eighth graders involving almost 3,000 adolescents using a hierarchical growth curve model, those students showed evidence of social bonding decreases as they got older (Oelsner, Lippold, & Greenberg, 2011). This study suggests that students with low social bonding are more likely to have delinquent behavior, show evidence of substance abuse, and have low academic achievement.

Socioeconomic status can be a factor on school achievement as well and can add to the stress of young adolescence. In a multilevel modeling longitudinal study by Fink (2010), attendance, race, whether the child was on free or reduced meal plans, and prior achievement were all factors that affected middle grade performance. In a similar study comparing affluent and disadvantaged populations of sixth through eighth grade students, it was found that disadvantaged urban youth who showed signs of emotional-behavioral difficulties were associated with poorer achievement, while data of affluent suburban youth did not hold significance in that association (Ansary, McMahon, & Luthar, 2012). However, the sample sizes were relatively small, and future studies could convey beneficial information if sample sizes are increased. One socioeconomic factor that can affect achievement in school is nutrition. Studies show that children who are well-nourished perform better in school (Glewwe, Jacoby, & King, 2001).

Some students do not make the transition between elementary and middle school as easily as others, as they adjust to the increased homework that often comes with higher grade levels. Homework levels tend to increase as students get older. Epstein (1984) suggested that parents who actively monitor homework have students with higher achievement rates. Students who do homework are more likely to have high academic achievement (Levin et al., 1997). Students of parents who tend to not to monitor homework efforts can be at a disadvantage when it comes to achievement in middle school. Also, some middle-level students do not put adequate effort into homework completion and show lower achievement rates (Levin et al., 1997). Motivation to learn science affects how a student performs.

Related to motivation is the concept of self-efficacy, which is a person's belief in his or her ability to succeed in a particular situation, and how people think, behave, and feel (Bandura, 1994). A study of 262 middle-schoolers showed that girls and White students in general reported stronger self-efficacy in science, and African-American students did not (Britner & Pajares, 2001). Although this study added important knowledge to what we know about self-efficacy and students' beliefs in science as a function of their gender and race, it dealt with a relatively small sample number and consisted of students in one area of the country. Future studies about this concept should involve larger numbers and student participants from many areas. Another study found that students significantly declined in grade point average when transitioning to middle school from elementary, but some of those students who felt more academically efficacious had higher grade point averages than their peers (Gutman & Midgley, 2000). This study involved 62 African-American families living in poverty and utilized qualitative surveys and quantitative grade averages in the data. A longitudinal study that lasted through high school would be a beneficial addition of knowledge in the future.

The correlation of gender and ethnicity to achievement has been studied. National and international comparisons of student achievement indicate that it is between fourth and eighth grade where U.S. students in general, especially minority students, fall behind in achievement (Alspaugh, 1998; Beaton et al., 1996). One study sought to examine the factors in gender differences in middle school science performance and found that boys tended to do better in physical science, which consists of several mathematical principles. The study (Lee & Burkham, 1996) came to the conclusion about gender differences being correlated to lab experiences:

> Explanations for these gender differences focus on laboratory experience. Only about 25% of eighth graders' science classes provide laboratory experiences at least weekly, and these experiences are more common in stand-alone middle schools enrolling more affluent students. Such laboratory experiences are especially beneficial for girls' achievement in physical science, but not boys'. We conclude that these results argue for increasing experiential and hands-on learning in middle school science classes—particularly in the physical sciences—as a means to promote gender equity in science achievement at this important educational level. (p. 16)

On a related note, a study attempting to find factors that affect equity in urban middle school science education (Hewson, Kahle, Scantlebury, & Davies, 2001) suggested that the culture and climate of schools involved in the case study differentially affected progress toward equitable reform in science education. The data in this study were analyzed using an equity metric, which allowed assessment of progress toward equity using a range of indicators. This study was conducted in two urban middle schools in the Midwest, but additional information could be gathered in the future if this experiment were repeated in other areas of the country.

English language learners (ELL) have a greater challenge when it comes to abstract concepts such as science. According to a study of ELL students, inquiry-based, hands-on science instruction helped those students to develop scientific understanding and acquire English language proficiency simultaneously (Amaral, Garrison, & Klentschy, 2002). However, ELL students varied in the way they participated depending on their prior experience with science.

Teacher disposition is another factor that can affect student achievement in a given subject area. Stronge (2007) stated that classroom success and student achievement was increased when teachers accommodated unique differences in students. In addition, Brophy (1986) suggested that any attempt to improve student achievement must include development of effective teaching behaviors, such as clear objectives and expectations and effective management strategies, and pace students through the curriculum in small steps. Similarly, longitudinal research suggested that neither teacher licensure test scores nor advanced degrees had an effect on student achievement, but it did show that student achievement increased with teacher experience (Buddin & Zamarro, 2009). Clearly, teachers can affect student performance, but the Buddin and Zamarro study involved reading scores in a relatively small sample size. It would be beneficial if future studies of this type would include science scores and investigate larger samples.

Measuring Student Achievement

Achievement is important to measure in many respects when it comes to studies pertaining to causation. Student achievement is easy to measure when looking at some quantitative data, but what pedagogues really seek is information on learning. Learning and achievement are not the same thing, but learning is difficult to quantify. Attempts should be made to distinguish learned intelligence from achievement scores (Rosenbach, 1973).

Achievement is usually measured by examining standardized test scores, teacher-given grades, or surveys of general trends. When scores of students taking state standardized tests are compared within a state, this achievement measurement holds more validity because all students in the same state are taking the same test. These measurements can be informative in subjects such as mathematics, in which an answer is either correct or incorrect. However, with the abstract nature of science, achievement measurement is more complex. Quantitatively, researchers can use standardized test scores as a measure of achievement, but those tests vary from state to state, causing questions about the validity of between-state comparisons. The question of authenticity also arises in the situation of a district that designs its curriculum to match the standardized test it is required to give. This is not an unusual occurrence, yet it seems to give those students an advantage when using standardized test scores as a measure of achievement. Likewise, grade point average is a measure that is easily quantifiable, yet its value is not completely valid in comparisons between teachers due to the variance in how the grades were assigned. However, both types of measures do give vague information and may show a trend in what affects achievement in a given situation.

Qualitatively, surveys and questionnaires are informational and can lead to information pertaining to achievement that is not as easily measured as a test score. In science specifically, performance events are a valid way to gather information on learned knowledge, but they are time-consuming. Another qualitative measure of achievement can come in the form of discussions involving critical explanations. Many times in the abstract area of science there are concepts for which knowledge cannot be easily measured by a multiple-choice test. The nature of science knowledge is unlike math in that it is harder to quantify into measures of achievement. STEM Coalition (2013) sources discussed the need for the use of formal and informal assessments in science that include both standardized tests as well as performance-based assessments. Funding for the extra manpower and effort to give and grade performance events as assessments will be difficult to come by in most situations.

NCLB requirements place pressure on school districts to perform, and another reform effort executed in many school districts across the nation, as well as in Missouri, is the practice of designing the curriculum to fit the test. Although doing so is more of a way to relieve pressure for higher test scores than a way to increase science knowledge, it is a practice that is presented as a way to increase science knowledge. However, when school districts adjust their curriculum to suit a standardized test, it weakens the inferences made from standardized test results (Haladyna & Nolen, 1991).

Recent Reform Efforts

Recently, the American Recovery and Reinvestment Act of 2009 provided funds for grants designed to encourage schools to create meaningful educational reform. There have been many school reform discussions, including topics such as teacher training, curriculum standards, and standardized assessments. With further research regarding middle-level science, researchers can get closer to finding what can promote positive student outcomes. Researchers need to measure student achievement in science with both formal and informal methods for greater understanding, not using just one or the other. From previous middle-level research, educators know that hands-on, project-based instruction is best for several different types of students. Educators also need to be aware of the many factors that can affect student motivation and accurate measurements of achievement, especially concerning young adolescents. Additionally, educators need to keep in mind all students in efforts to close the achievement gap.

Some of those efforts are those science teachers have control over, such as identifying core concepts and implementing effective instructional strategies to increase student achievement. However, some of those reform efforts are beyond the control of classroom teachers. One of those reforms beyond teacher control that is presently a popular trend is the implementation of differentiated science curricula. The efforts to research the effects of various teacher-initiated reforms are well documented, but research efforts to investigate the effects of different curricular choices in middle school science achievement are lacking. The information learned about improving young adolescents' science education is necessary for meeting NCLB requirements, as well as improving achievement in this abstract subject to middle-level students.

Types of Differentiation in Curriculum

Many schools now offer differentiated instruction, in which the teacher divides a classroom population into ability groups, so that different groups within a class of students have a more customized level of difficulty in topics covered. The objective of this practice is to reach more students at their level to enhance knowledge, to challenge those students who are prepared for higher levels, and to avoid frustration in learning for those who are not ready for higher levels within a topic. Differentiated instruction calls for teachers to adapt their methods to the learning needs of students, instead of using a one-size-fits-all approach for an entire class.

However, there is a trend in middle schools that takes differentiated instruction one step further, called course differentiation. Course differentiation includes the establishment of a course offering that targets students who perform at a given level within a subject area. This practice has been well established for years at the high school level in the United States, and with reading and mathematics at middle and elementary levels, but now this practice is making its way to science classes at middle level schools. For example, in mathematics courses at the eighth-grade level, it is common to find course differentiation in the form of a curriculum offering choice of either algebra one or pre-algebra, depending on the prerequisites and achievement in math prior to eighth-grade enrollment. This practice is not as prevalent in other curriculum areas, such as science, language arts, or social studies, yet some do exist. Although there is evidence (Reis, McCoach, Little, Muller & Kaniskan, 2011; Smutny, 2003) that shows positive learning outcomes when differentiated instruction is utilized, the effects of course differentiation are unclear. Middle school and junior high level students vary in development, both physically and mentally. Both a healthy self-esteem and learning achievement are important for all students, especially at this awkward phase in life. Middle level students need to feel valued and supported socially as well as academically.

There are several issues in studying whether science course differentiation affects academic achievement in middle-level students, such as a comparison of science curricula, leadership concerns in the implementation of differentiated curricula, measurements of academic achievement and their validity, understanding middle-level student learners, and general information regarding differentiation, ability grouping, and tracking. This literature review focuses on the latter. This study, concerning details of differentiation and ability grouping, is important because high academic achievement is linked to future positive outcomes, such as high school and college success (Taylor, Goede, & Steyn, 2011). This literature review includes a historical review of instructional differentiation, the benefits and drawbacks of those practices, and the legal viewpoints concerning various forms of differentiation.

History of Differentiation in Curricula

There have been several types of teaching differentiation in educational systems throughout the history of organized schooling in the United States prior to the 20th century, but this study begins a review at the start of the last century. Long before *A Nation At Risk,* there were efforts to make education more efficient and effective. Instructional leaders determined to improve education implemented several plans, including various differentiation methods. Instructional differentiation in the 20th century consisted mainly of one-room school houses with teachers dividing the room and their instruction according to abilities and age (Tyack & Cuban, 1995). Some schoolhouses at that time were implementing the *Double Tillage Plan*, which consisted of dividing the school year into two distinct parts: the first half of the year covered the subjects in broad strokes, and the second part of the year was devoted to the details of the same material repeated for average or struggling students. However, the advanced students were allowed to skip the repetition and study content at the next grade level (Ryan & Grecelius, 1927). In this plan, teachers were given authority to group average students together, while advanced students were grouped with older students.

Another form of differentiation involving ability grouping was called *The Santa Barbara Plan*, which divided students into three groups of ability (Ryan & Grecelius, 1927). In 1902, some schools implemented *The Baltimore Plan*, which allowed gifted students to attend a separate building for enrichment classes (Ryan & Grecelius, 1927), thus separating out the advanced students from the rest of the population. The *San Francisco Plan*, implemented in 1904, resembled current differentiated instruction, in which groups within a class would work on material at different levels (Ryan & Grecelius, 1927). There are no studies that measured efficacy of any of these primitive plans, but variations of these plans continued. One variation eventually came about in the 1960s in Missouri to improve reading ability called *The Joplin Plan* (Robinson, Shore, & Enersen, 2007). This plan grouped children together regardless of age or grade level, using reading ability and achievement levels as determinants for inclusion in reading instructional groups. The placement of students of any age into any grade level from third grade to eighth grade, showed slight improvements in reading ability in elementary level students, but it sometimes caused embarrassment for older learners (Robinson et al., 2007). Gifted and advanced students were shown to improve, which led eventually to a gifted pull-out program model that is still used widely today. This type of self-contained gifted classroom, in which aptitude determines a set of students and their pathway to successful outcomes, led to another form of grouping called tracking. Tracking is the process of sorting students according to potential for success, measured in different ways, so that each track of students is aligned with different educational goals that focus on their potential. According to Altenbaugh (1999), the origin of this type of differentiation is unclear:

> Tracking is a term with no one point of origin. Instead, there are numerous starting points from which we can chart the rise of tracking within public education; including the postcolonial era, late-nineteenth-century industrialization, and the rise of the intelligent quotient (I.Q.) as a sorting mechanism....We can also trace the concept of tracking to late nineteenth-century industrialization. Tracking became a way of funneling urban youth from public schools where they were inculcated with the ideals of punctuality, obedience, and repetition, to the urban factories, where they lived out these ideals. (p. 366)

The practice of tracking went on until the 1960s, when it was challenged as a form of racism or sexism in an era of new civil rights in America (Altenbaugh, 1999, p. 366). Esposito (1973) stated that the 1960s was a time in which thousands of American schools utilized homogeneous grouping as the primary method of organizing schools, and that the National Education Association (NEA) at that time reported its positive effects, using standardized test scores as a way of separating those students.

Differentiation grew into a practice called curriculum differentiation, which was established in the early 20th century in America for two reasons: First, it was established to provide remedial education for many new immigrants to learn to read and write English in a time when shiploads of people began to arrive in this country. Secondly, it was established mainly at high schools as a means of supplying vocational training (Altenbaugh, 1999). High school-level curricula have never strayed from that course to this day, providing several different choices of classes that enable students to learn various topics along different levels. Terwel (2005) stated that differentiated curricula are commonly offered at high school level, and it is unlikely to change. At middle-level schools, special education classes, as well as gifted education classes, appeared more prevalent after World War II (Tyack & Cuban, 1995). Reading and mathematics were sometimes differentiated in middle-level schools as early as 1960, with reading differentiation practiced at elementary levels as well (Weinstein, 1976). Many of those practices continue today in those topics; however, there are new differentiations beginning to trend concerning middle-level science curricula.

The practice of differentiated instruction began in the 1970s at about the same time that homogeneous ability grouping was contested (Tyack & Cuban, 1995). This practice is often confused with differentiated curricula, in that both attempt to adjust the content of the curriculum for positive student learning outcomes. However, differentiated instruction involves varying the teaching method toward different groups within the same classroom population, and not homogeneous class groups of different ability levels. Differentiated instruction grew in popularity with the recognition of Gardner's (1993) Theory of Multiple Intelligences, which emphasized the idea that each student has many talents and can learn best when utilizing those strengths. Differentiated instruction is used more frequently each year at all levels of public education in the United States.

Benefits and Drawbacks of Differentiation Techniques

Reports of the effects of the many forms of differentiation in instruction vary in scope and content, depending on the type of differentiation. Although there are several types, the instructional differentiations reviewed in Table A1 (see Appendix A) consist of ability grouping, tracking, curriculum differentiation, and differentiated instruction techniques. Also included in the table for comparison is a mention of mixed-ability grouping. Table B1 (see Appendix B) explains the research method types mentioned in this literature review.

Ability Grouping

Attitudes toward ability grouping (homogeneous classes) vary as well. For example, parents whose children are in high level classes prefer them to mixed-level classes

(Loveless, 1994). Some teachers are in favor of ability grouping in homogeneous classrooms because they believe the method is benefitting students, and that it makes them feel superior when teaching the high-level groups in a form of professional hierarchy (Lindle, 1994). Braddock (1990) stated that some people believe utilizing ability groups helps to create a positive learning environment by meeting the needs of similar students. Those surveys show qualitative data concerning ability grouping, but quantitative data exists to support ability grouping as well. According to a meta-analysis involving five different studies comparing achievement test results of grouped and non-grouped students (Kulik & Kulik, 1987), gifted students experienced greater achievement in homogeneous classes containing high-achievers, and schools should attempt to maintain programs of enrichment for higher-level students. However, another researcher, using raw data, standardized test scores among grouped and non-grouped students in a comparative meta-analysis (Slavin, 1987, agrees only on a few points:

> Within-class ability grouping in mathematics was found to be effective. Ability grouping is most effective when done for only one or two subjects, with students remaining in mixed-ability classes most of the day. However, grouping is only advantageous when specific criteria are met, such as frequent reassessing, pace variation of instructional material, and in situations that group students for only one or two subjects while the remaining classes remain heterogeneous.

In addition to achievement, self-esteem issues can affect learning and should be investigated in regard to ability grouping. Surveys of student participants in schools that utilized ability grouping were compared in a qualitative meta-analysis. Kulik and Kulik (1987) found: “Ability grouping has minor effects and is generally positive. Students who were ability grouped for a specific subject had a better attitude toward that subject, and grouping did not change attitudes about school in general” (p. 24).

Other studies utilizing best-evidence synthesis support the idea that advanced students are benefitted by homogeneous ability grouping, although it is only a weak positive effect (Hoffer, 1992). While this best-evidence synthesis research method combines the quantification syntheses with the attention to narrative reviews, it can give as much information as a meta-analysis. In the same study, Hoffer (1992) stated that average-level middle school science and math students had no effect when compared to average students who were not grouped. He also stated that low-achieving students showed a strong negative effect of ability grouping (Hoffer, 1992). In a study of three medium-sized, suburban, public middle schools in the Midwest consisting of 321 participants, a survey was used to investigate the effect of grouping on motivation. The results show that motivation was negatively affected in a study of ability-grouped middle-level students (Eccles et al., 1993). However, these results pertained only to a limited population.

Ability grouping has been done in diverse populations as well. In a longitudinal study of ability grouping in an urban elementary school consisting of mostly minority students, it was found that higher-grouped students learned slightly more over the first few years of instruction compared to students who were not in ability groups (Lleras & Rangel, 2009). Similarly, a study that collected data from 2,720 Hong Kong junior high school students and a review of their teachers' quantitative reports (Cheung & Rudowicz, 2003) showed that the homogeneously-grouped students had higher self-esteem and significantly higher subsequent academic achievement. Slavin (1990) also stated that evidence shows that low achievers can benefit from some type of ability-grouped remediation program built within the school day, probably in the form of a pull-out program.

However, in an qualitative urban middle school study, reading ability-grouped students surveyed stated that they saw themselves as getting more help from peers in mixed-ability groups, and they saw themselves as making more progress in reading than those in the same-ability groups (Elbaum, Schumm, & Vaughn, 1997). Again, this sample set was small and therefore was limited in its scope.

Attitudes also vary with gender. In England, 5,000 13- and 14-year-old students representing three levels of grouping in 45 different schools responded to questionnaires about their grouping experiences. According to Hallam and Ireson (2007), most middle-level students who were grouped on ability preferred mixed-ability classes, especially if they were in the lowest level, were categorized as being from a low socio-economic class, or were males. Higher achieving females in this study (Hallam & Ireson, 2007) preferred homogeneous groupings. Due to the high number of participants in this study, it is valid, but it was concerning British and not American schools.

Contrary to that finding is a report that combined interview and questionnaire data with 13- and 14-year-olds in six schools that utilized ability grouping. In that study, Boaler (1997) stated that the surveyed students in the top ability group wanted to return to mixed-ability groups due to increasing stress of the faster-paced class, and they did not care for the competitiveness of the high group. Again, Boaler's study was conducted in England, where attitudes of students may vary from those of students in the United States.

Some form of ability grouping is prevalent in the United States in middle-level schools. In a study of more than 100 schools across the nation, some type of ability grouping is used in many middle-level schools. The prevalence of some form of instructional differentiation has changed over the last decade due to pressures to abandon the methods, or pressures in favor of adopting the methods based on the need for school reform that improves student achievement. Braddock (1990) showed recent statistics of the use of ability grouping methods at middle levels in the United States, based on a survey completed by middle-level principals (see Table C1 in Appendix C). His results show that most middle schools have some subjects grouped, although science is rarely differentiated until ninth grade. This was a self-reporting survey, which may contain errors in the definition of ability grouping.

Conflicting results among researchers remain concerning this practice, while some find positive findings, some find negative. On a positive note, a review of the literature in light of school reform states that some ability grouping may result in significant achievement gains for average and high ability students (Tieso, 2003). On a negative note, a different study found, “Ability grouping and the differential distribution of expectations that accompanies the practice are key elements in locking students out of meaningful opportunities for future success” (Smith-Maddock & Wheelock, 1995, p. 222). Researchers, as well as school administrators, teachers, and community members, continue to disagree on this controversial practice. However, ability grouping is still widely practiced in urban, suburban, and rural schools across the United States.

Tracking

Tracking is different than ability grouping in that it differentiates the entire route of instruction, in which students are divided into different academic groups across the curriculum that tend to pre-determine the likelihood of a “track,” or a set of classes, such as a college track or a vocational track. Like ability grouping, tracking shows both positive and negative research findings. A study of middle-level students who were tracked showed that students preferred their tracks (Hallam & Ireson, 2006). In a separate study of 754 middle-level students using observational and survey data, those that were on the advanced track (specifically in mathematics) were less likely to exhibit some form of delinquency (Jenkins, 1995). Both of these studies consisted of hundreds of students, making the results valid. However, more research is necessary to understand the long-term effects.

In a meta-analytical study of gifted programs using a total of 38 primary studies conducted between 1984 and 2008, talented students were surveyed on self-concept and other social factors. This study showed the effect of accelerated tracks on high-ability learners (Steenbergen-Hu & Moon, 2011): “Academic acceleration tracks influence high-ability learners in positive ways, especially on academic achievement. Accelerants equal or surpass non-accelerants in self-concept, self-esteem, self-confidence, social relationships, participation in extra-curricular activities, and life satisfaction” (p. 48). Gifted students, being in the high academic track, were likely to respond positively to surveys due to the nature of being in the admired “top track.” More studies need to be done on students who are not labeled as gifted.

The effect of middle-level tracking on future academic success was done by Abadzi (1985) using a regression-discontinuity analysis, which employed a pretest/posttest model among fourth through sixth graders at a large Texas school district. This study found that those on the advanced mathematics track performed above expectations, but the effect was temporary. This study should be broadened to include a larger sample set from different parts of the country.

Many researchers have concluded that tracking has an overall negative effect and may even be the cause of negative learning outcomes. Oakes (1985) stated: “Classroom differences that inhibit the learning of those in low and average groups are a result of placing these similar students together for instruction. These differences are institutionally created and perpetrated by tracking” (p. 194).

Diverse populations are over-represented in low-tracked populations (Abadzi, 1985). A comparative study between urban and suburban students would be beneficial. Tracking is seen by many as a negative attempt to meet learners’ needs and appears to discourage students. According to Smith-Maddock and Wheelock (1995), middle-level students’ future academic progress seems predetermined, with few low-tracked students interested in pursuing college preparatory classes at high school, when compared to non-tracked peers. Self-esteem has been reported in some studies to diminish from this practice (Braddock & Slavin, 1992; Wong & Watkins, 2001). In contrast, other studies report that self-esteem is not affected by tracking or ability grouping (Chiu et al., 2008; Newfield & McElyea, 1983).

The practice of tracking is so unpopular in some areas that there are attempts to undo this type of differentiated instruction, known as untracking (Smith-Maddock & Wheelock, 1995). Untracking involves replacing the grouped students with mixed-ability learners, while changes in curriculum, teaching methods, and assessments are utilized to enhance diverse student learners (Wheelock, 1992). Although tracking is considered rather unpopular currently, it has not been completely abandoned. A survey comparing schools that do not track, schools that do track, and schools that untrack would be important in a longitudinal study of achievement.

Curriculum Differentiation

Curriculum differentiation, sometimes known as "between classes ability grouping" or "within-school tracking," is similar to both standard vocational tracking and ability grouping in that it allows a homogeneous set of students to enter into ability-based classrooms for the purpose of improvement in learning. High schools have done this type of differentiation for decades, and middle-level schools have also participated in the areas of reading and mathematics (Tyack & Cuban, 1995). A longitudinal study of one large school district in the southwest United States used information on seventh and eighth graders who were participants in the advanced math group. They were given the opportunity to be in the advanced math group based on achievement scores in math the prior year. This study showed that providing advanced mathematics classes at the middle school level developed students who participated in those advanced classes as eighth-graders higher rates of college attendance than those who did not (Spielhagen, 2006). Although the study was small, other studies showed similar results. One was a mathematics investigation on average-achieving eighth grade students, who were placed in higher-level pre-algebra classes to investigate the effects on their learning. Researchers found that the average achievers who were placed in the higher-level classes outperformed average achievers who were not in the higher-level classes, and those students were also more likely to enroll in advanced classes in high school (Mason, Schroeter, Combs, & Washington, 1992). Clearly, offering advanced classes can be a benefit to some students.

In contrast, Slavin (1993) stated that achievement of middle-level students was not significant in those students who were in non-advanced classes. In addition, Slavin (1990) found there was no evidence to support the idea that gifted students were negatively affected by removing them from their advanced pull-out programs. Similarly, a literature review by Betts and Shkolnik (2000) found that there were no significant effects in learning among any of three different levels of eighth-grade math students. However, Betts and Shkolnik (2000) estimated only the overall effects of being in a school that utilizes ability grouping, and their study did not reflect the effects of ability grouping on individual achievement.

Although there are several proponents for offering advanced middle-level math classes, some researchers are concerned about the effect of the absence of advanced students from non-advanced classes. Mastropieri et al. (2006) studied quantitative outcomes of 13 different classrooms using this type of differentiation and suggested that mixed-ability classrooms raised up lower performers when the advanced students were present.

A four-year longitudinal study of an ethnically and linguistically diverse community of middle-level students was conducted to investigate the effect of advanced course offerings and future success. The results of this study showed that although many students participating in middle-level advanced math classes tended to be more successful in high school, the achievement gap between White and non-White students widened as well (Wang & Goldschmidt, 2003). In a longitudinal study using quantitative assessment measures, Hoffer (1992) found that both advanced math and advanced science classes offered at middle level was not a good arrangement because the small positive gains made by the advanced groups did not justify the larger negative achievement effects in regular classes or remedial classes. Both of these studies hold merit because of the ability of longitudinal studies to follow the subjects over time to monitor effects. Hoffer (1992) also spoke specifically of middle-level science curricular differentiation:

> In some localities, science first enters the curriculum in the seventh grade; in most others, elementary science is generally considered to be a haphazard affair at best. Middle school science may lack the sequential development of mathematics, and the definitions of what constitute “high ability” and “low ability” science would be correspondingly blurred. (Hoffer, 1992, p. 216)

Abstract topics such as science can be difficult to make linear by way of advanced course offerings the way mathematics can, and students chosen for advanced classes have little to do with being chosen based on science skills. Braddock (1990) stated that students tend to be grouped based on their achievement in math or reading, instead of general achievement. His study was based on a recent national survey, and the sample size was not made known in his article, although he did state it was a large national survey. Knowing the sample size would lend more credibility.

Enrolling for differing curricular choices, such as advanced or regular science, can involve various ways to be admitted into a certain class. For example, in mathematics, some schools employ a test score to determine which students should be in pre-algebra, and other schools allow parent and teacher input to be a factor. In fact, studies (Baker, 2009; Useem, 1992) show that parental influence is a significant factor in placement of students, either directly or indirectly. Direct parental influence consists of contact with the school to request certain classes; indirect influence includes the child’s home environment and parental income. Blossfeld and Shavit (1993) stated that parental background influenced educational progression, especially at younger ages in a phenomenon they call “life course hypothesis.” This phenomenon is thought to shape a child’s ideas about themselves and their expectations for the future, yet it is difficult to measure.

Despite the effects of differentiated course offerings at the middle level, the implementation of differentiated curricula challenges school officials in several ways, from aligning academic standards to scheduling. A qualitative study of teacher interviews and surveys by Harris (2012) suggested that teacher expectations with regard to academic standards in differentiated curricular areas were sometimes contradictory to those standards. Hallinan (1992) argued that various tracking methods were set in place principally as a response to organizational motives and outside influences rather than on data based on students' needs. Organizational motives can include personnel assignment issues, community expectations, the need to increase standardized test scores, and the need to increase participation in higher-level classes. Even with the conflicting research on achievement affects, advanced offerings in areas other than mathematics in middle-level schools are on the rise.

Differentiated Instruction

Differentiated Instruction (DI) is the practice of grouping students based on ability within a heterogeneous classroom and involves no formal curricular redesign or prerequisite. A form of cooperative learning, DI is beneficial in that all members are rewarded when all group members learn, and students in DI classrooms learn consistently more than do students in traditional settings (Slavin, 1983). A longitudinal study concerning one upper elementary school by Lewis and Batts (2005) showed improved student outcomes when attempting to meet the needs of all students through DI methods when a strategic teaching plan was in place. Research suggests that the use of DI improves motivation and classroom participation (Wheelock, 1992). The main drawback to DI is the extra time and effort required of teachers to meet the needs of students where they are, instead of planning the lesson from the curriculum guide (Bennett, Dworet, & Weber, 2008).

Legal Concerns with Differentiation Efforts

Educational differentiation methods meant for improved learning outcomes can sometimes unintentionally divide students along gender, race, and ethnic lines. School leaders must be cognizant of the perceptions made about school programs intended to increase achievement. Differentiation can produce a gap that separates students by socioeconomic status (SES), race, and gender. Chmielewski (2014) found that although within-school differentiation produced a smaller overall achievement gap than standard vocational tracking efforts, the effect was still present, and the SES divergence was greater. Schools need to be aware of the ways their curricular arrangements are perceived and how they affect the student population:

> If minority or protected class students make up a disproportionate number of students in a particular track, the school could be open to charges of improper segregation and discrimination.
>
> The lesson is that a school using ability grouping is probably doing so for legitimate pedagogical reasons. But the school must be aware of how the student population is grouped as factors other than just ability can have serious consequences. (Wheelock, 1992, p. 223)

However, studies show that many in the community can support what appears to be segregation if they believe the selections were made fairly using a standard, such as test scores or some other form of demonstrated achievement (Oakes, Gamoran, & Page, 1992). Although most Americans find racial and ethnic segregation offensive, it seems to be permissible when associated with some objective justification, such as a test score. Even though test scores are highly correlated to family wealth, race, and ethnicity, the scores are generally accepted as objective (Oakes et al., 1985). A study that compared urban student achievement in high-ability classes with suburban high-achievers would contribute beneficial information to this discussion.

The nation's first segregation case in 1931 arose from the separation of Hispanic students from their White classmates in Lemon Grove, California, disallowing them from attending the same school (Willie, Ridini, & Willard, 2008). Even then, the idea of integration was upheld in the same vein as the landmark *Brown v. Board of Education* decision of 1954. Unfortunately, ability grouping, tracking, and differentiated curricula can tend to form groups that increase learning gaps between White and non-White students, as stated by Lefkowitz (1972) concerning differentiation techniques:

> Grouping results in a de facto segregation by ability as well as by social class. Since achievement is related to socio-metric status, and since it is well known that children from upper- and middle-class backgrounds attain higher academic achievement levels than lower class counterparts, then ability grouping perpetuates social class differences manifested outside educational institutions. (pp. 296-297)

Schools that utilize ability groups and tracking as well as curriculum differentiation tend to show more minorities in lower tracks. According to Wheelock (1995), "While tracking may promote excellence for certain groups—namely those in the high track—it most certainly does not promote equity" (p. 222). Groups that separate on ability show disproportionately high numbers of Asian and White students in higher-level ability groupings and advanced curricular classes, while non-White students are disproportionately represented in lower-ability tracks (Oakes et al., 1992). Another way to research this issue would be a study comparing ethnically differing groups of low ability in a longitudinal study to discover the long-term effects of this type of grouping.

Lucas (1999) found that enrollment in advanced middle-level classes increased the achievement gaps between high-achievers and low-achievers as they continued to advanced classes in high school. In addition, Smith-Maddock and Wheelock (1995) stated,

> The pressure to eliminate tracking emanates from many studies that have shown that the practice has negative consequences for the future of educational opportunities and schooling outcomes of many children. These negative consequences disproportionately affect low-income, African-American, and Latino children. (p. 222)

Slavin (1993) contended that most forms of ability grouping can be hard to justify, and they appear anti-democratic. Questions remain as to the methods used to separate students participating in ability grouping, curriculum differentiation, and tracking programs. In a review of empirical evidence, one research report (Betts & Shkolnik, 2000) stated that the effects of ability grouping of any type are inconclusive due to uncontrolled variables. Because parental involvement has been shown to be a key factor in student success, a suggestion for future study would be to compare the long-term effects of ability grouping, using level of parental involvement as a survey factor.

Grouping gifted students together is a practice that begins in most schools at the elementary level and continues through middle level. Studies support the idea that gifted students benefit from ability grouping and enrollments in accelerated curriculums (Kulik & Kulik, 1987). On the other side of the spectrum are students with disabilities. The education of students affected by some conditions is protected under section 504 of the Rehabilitation Act of 1973, which calls for removal of barriers that may impede learning (Altenbaugh, 1999). English Language Learners (ELL) students are protected as well so they can achieve equity in education. Using a mixed-method analysis, one study showed that high-level content is not available to ELL students in schools with curriculum differentiation (Harris, 2012).

Similarly, the Americans with Disabilities Act of 1975 seeks to provide the least restrictive environment to students who are eligible for remediation in the form of an Individualized Education Plan (IEP). A form of ability grouping in the form of a pull-out assistance program is not only acceptable, but the legal right of those students on an IEP. However, school leaders need to be aware of how regular students may be differentiated. When tracking is implemented, special education students tend to show great difficulty in advancing out of low-achieving tracks (Oakes et al., 1992). As Wheelock (1995) pointed out, a student or group of students might argue that grouping violates the concept of least restrictive environment, which is protected under the law. For example, an ability group may have a population of special education students that are over-represented in that group, which could be perceived as restrictive. However, some special education ability groups are a benefit, allowing teachers flexibility to teach students in a manner that maximizes instructional resources (Tyner & Green, 2005). A school leader with knowledge of legal issues is imperative when it comes to instructional differentiation of any kind. In legal issues, a review of the literature concerning events can be helpful in understanding potential pitfalls of differentiation. In their literature review, Zirkel and Gluckman (1995) stated, “The legal boundaries are, on the whole, notably broad with regard to ability grouping. Principals should recognize that the answer to the issue of heterogeneous versus homogeneous groups is in many cases a matter for educators, not judges, to determine” (p. 105).

Theoretical Constructs Related to Differentiation

Vygotsky's Social Development Theory applies to all students, but especially to middle-level students. It states that social interaction has a great deal to do with cognitive connections. According to one part of this theory, students experience learning through social interactions before learning them on an individual level. When differentiated curriculums are in place, separating peers into groups can affect students' self-perception and socialization, which may have an effect on their learning. Vygotsky's theory states that higher cognitive functions originate as social connections and relationships among individuals (Moll, 1990). Another part of Vygotsky's Social Development Theory states that all learners have a Zone of Proximal Development (ZPD), which is a level of development obtained when social interaction among peers is taking place. Adolescents' social interactions precede their development into fully functioning thinkers (Moll, 1990). Vygotsky's theory also suggests that a part of this development is the More Knowledgeable Other (MKO), which can be anyone with a better understanding of a classroom concept, including peers. In self-segregated differentiated curriculum schools, these MKOs may be out of reach because they chose a different path when a choice was available. On the other hand, the MKOs who have chosen similar curricular paths may find an increase in social comfort. In addition, Vygotsky's theory also suggests that the quality of social interactions "may have a significant effect on the development of self-regulation" (Moll, 1990, p. 152). Not only learning but behavior, according to this theory, may be affected by the presence of differentiated classrooms.

Another theoretical construct that may affect learning with regard to grouping students is Weiner's Attribution Theory, which suggests that a student's motivation is connected to their self-esteem (Martinko, 2004). In other words, expectations can have a large effect on effort and success or failure. The Attribution Theory employs the foundation of Blossfeld and Shavit's (1993) "life course hypothesis," which places importance on the expectations instilled in the student by parents and their surroundings. In the classroom, those students who are in more challenging courses may expect to out-perform peers who chose not to be in the advanced class based on Weiner's explanation of motivation. Likewise, the opposite may occur in a differentiated curriculum situation, in which the students in less challenging classes have lower expectations for themselves, which may affect their effort, and thereby their success as well. According to Weiner's theory, students will internalize their successes, giving credit to themselves, and externalize their failings, putting the blame outside of themselves. Students who enrolled in a more challenging class may struggle, blaming it on the curriculum or the teacher. Student effort or lack of it may affect the outcome of comparison studies such as this one. In situations where curriculum differentiation is practiced, students may have a self-perception that causes them to change their effort output based on the class in which they are enrolled. Martinko (2004) suggested that students may attribute low performance to their ability.

In addition, Vroom (1995) proposed the Expectancy Theory, which states that people will be motivated to behave in certain ways if they believe those actions will bring them value or a reward. Applying those thoughts to differentiation, students can be said to be more motivated to perform in higher-level classes to earn the reward, which may be status, praise, or advancement to other higher-track classes, along with intrinsic confirmation of their upper-track placement. Therefore, the effects of differentiated curriculum options may have more to do with psychological variables and less to do with instructional variables.

Finally, the cultural variables that affect student performance is explained in Van Houtte's Differentiation-Polarization Theory (2006), in which pupils will align themselves into "pro-school" and "anti-school" cultures based on whether they are in higher-challenge classes or not. In addition, Van Houtte's theory suggests that teachers of high-challenge classes tend to expect more from their student than those of low-challenge classes. Although stakeholders would not intentionally put less effort into teaching and learning, it appears that some psychological effects of the knowledge of existing groups may shape unconscious actions. Adolescents' perceptions of their school environment can influence their motivation (Wang & Holcombe, 2010). Van Houtte's theory proposes that not only the students' environment, but their perception of it can affect their motivation and education experiences.

Conclusion

All children should be provided equal access to learning opportunities. Instructional improvement to advance student achievement and promote excellence is sought by all stakeholders in education. However, several methods can be utilized to help students have positive gains in learning. Middle school students are preparing for high school and obtaining foundations for further instruction; however, educators need to recognize social, psychological, and physical concerns in addition to improving achievement scores. Additional research needs to be gathered concerning differentiated curricula, not only for the effect on achievement scores, but for the effect on the whole student in regard to social or psychological issues that may occur in forming student groups. Longitudinal data should include comparisons in the studies of such factors as urban, suburban, rural, different ethnicities and gender, as well as levels of parental involvement.

Student achievement studies have always been important to education. The No Child Left Behind Act (NCLB) requires increased accountability for education professionals, especially for low-performing schools. States now have greater flexibility in how they use federal funding in exchange for improved achievement, thereby making efforts to improve achievement more important. In addition, tough penalties may be imposed on schools that fail to show improvement. School reforms that have been shown to improve achievement, specifically in middle-level learners, are necessary to meet these strict requirements and to improve learning.

In addition, school leaders and instructors need to be aware of legal considerations when any type of differentiated instruction is being considered. Considerations must be made regarding the effects of grouping on students who are in a lower socioeconomic group or minority students. Senge (2006) suggested that school leaders understand that basic interrelationships control behaviors, which in turn affects perceptions, goals, and how we interpret our environmental norms. In curricular decisions, such as implementation of curriculum differentiation, teachers with advanced students should hold the same expectations as those with non-advanced students. Leaders who frame curricula must understand how implementation affects the school environment for the good of the system as a whole, reflecting often on practices and effects. Reflection is an integral component of functional educational leadership (Senge, 2006); therefore school leaders need to keep in mind that the goal of any program is to improve education. Differentiation done to reach all learners can be a practice that is commendable, but careful consideration needs to be given before implementing any differentiation method. Although several researchers suggest that differentiated instruction within heterogeneous classes creates positive outcomes, more research is needed to connect achievement to homogeneous advanced class offerings at the middle level, specifically for science. More research is needed to understand fully the effects of group formation at the middle level and how to measure middle level achievement before and after the utilization of differentiated curriculum groups. In addition, the effects of cognition theories, such as those of Vygotsky, Van Houtte, Vroom, and Weiner, should be considered in understanding the outcomes of curriculum differentiation.

CHAPTER 3

METHODOLOGY

Introduction

The purpose of this study was to analyze science test scores of eighth grade students using data from standardized achievement test results to determine whether offering more curricular choices in science would improve achievement scores for middle-level learners. In addition, this study attempted to evaluate the relationship between relative growth in middle school science students and other factors such as race, gender, free/reduced lunch status, and the type of science class chosen in schools that offered a choice between regular and advanced science.

Research Questions and Hypotheses

The research questions were designed to explore the relationship between curricular choice in middle level science classes and achievement outcomes over three years as measured by the Missouri Assessment Program (MAP) state standardized tests. The research questions addressed in this study were:

RQ1: What is the relationship between schools that offer science curricular choice and those that do not as it effects relative growth in science?

H1null: There is no relationship between schools that offer science curricular choice and those that do not as it effects relative growth in science.

H2alternative: There is a relationship between schools that offer science curricular choice and those that do not as it effects relative growth in science.

RQ2: What is the relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it effects relative growth in science?

H2null: There is no relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it effects relative growth in science

H2alternative: H2null: There is a relationship between students enrolled in advanced science and those enrolled in regular science in schools that offer a choice as it effects relative growth in science

RQ3: What is the relationship between gender and relative growth in middle school science?

H3null: There is no relationship between gender and relative growth in middle school science.

H3alternative: There is a relationship between gender and relative growth in middle school science.

RQ4: What is the relationship between race and relative growth in middle school science?

H5null: There is no relationship between race and relative growth in middle school science.

H5alternative: There is a relationship between race and relative growth in middle school science.

RQ5: What is the relationship between free/reduced lunch status and relative growth in middle school science?

H5null: There is no relationship between free/reduced lunch status and relative growth in middle school science.

H5alternative: There is a relationship between free/reduced lunch status and relative growth in middle school science.

RQ6: Is there a tendency of the science achievement category assigned to students on state standardized tests will change over time in middle school?

H6null: There is no tendency for science achievement categories assigned to students on state standardized test will change over time.

H6alternative: It is likely that science achievement categories assigned to students on state standardized test will change over time.

Theoretical Model

Through the use of archival data, an examination of the achievement outcomes as measured by MAP science scores for each participant was conducted. Relative growth from science test results from the fifth-grade 2009-2010 cohort to their science MAP results three years later in the 2012-2013 eighth-grade cohort were measured. Independent variables included race, gender, free/reduced lunch status, type of school each student was enrolled in (science curricular choice available versus no science choice available), and the type of science course each student was enrolled in (regular or advanced). The dependent variables were the MAP score and MAP category. The moderating variable was student cohort year.

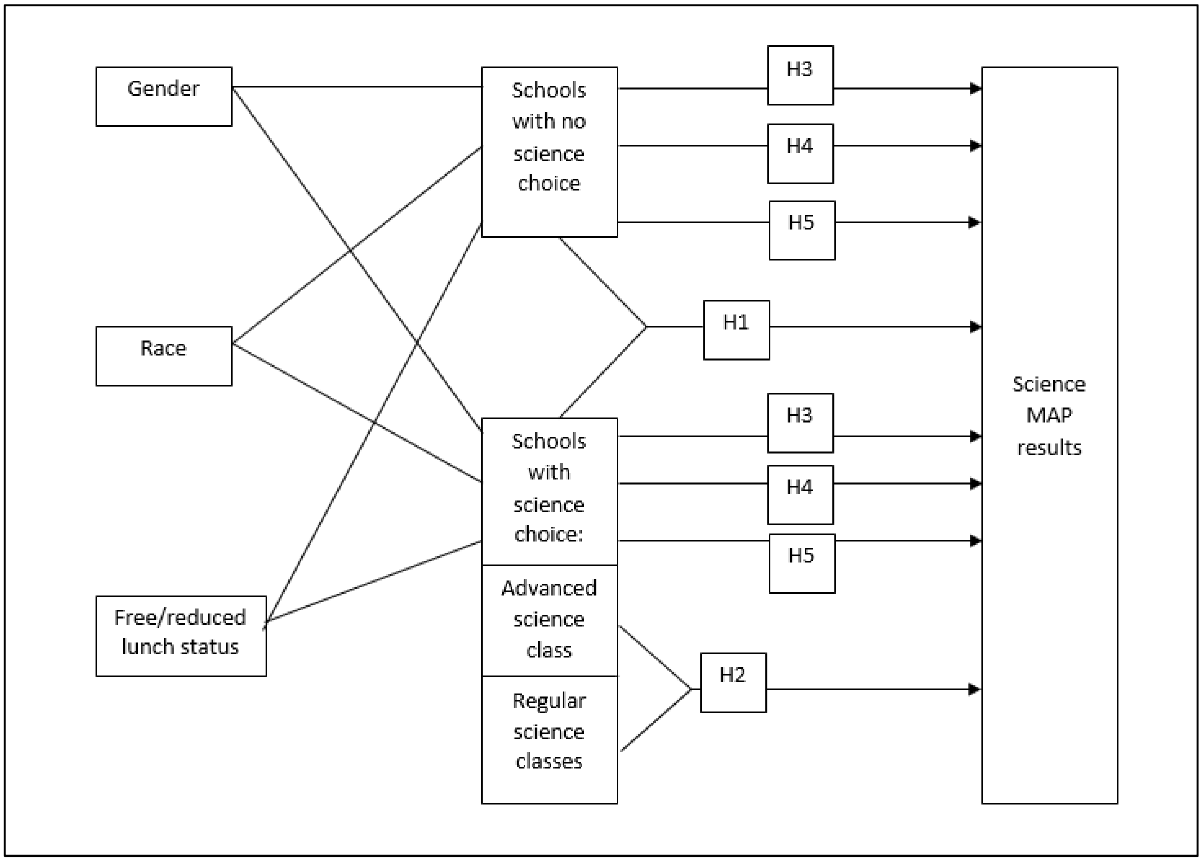

Figure 3.1. Model of Hypothesized Relationships between Independent and Dependent Variables.

Research Design

This was a quantitative, causal-comparative ex post facto study to investigate the impact of curriculum differentiation on student achievement in middle-level science. This research will add to the body of knowledge concerning middle-level science learners and the impact of curriculum and other factors such as gender, race, and free/reduced lunch status on student science achievement. The researcher employed a one-way repeated measures ANOVA for most of the data because this statistical treatment allowed for multiple observations over time and under different experimental conditions. The conditions investigated in this study included a comparison between the curricular designs of science in some districts, and between participants in different curricular paths within the same district. An advantage to using a repeated measures ANOVA is that the differences found in the dependent variable are not connected to individual characteristics of the participants because each score is its own control (Girden, 1992). The researcher also employed a Chi Square test for Independence when dealing with the categorical MAP groups for each participant between the two test times. According to Shafer and Zhang (2014), the Chi Square test shows whether two groups are independent, allowing the investigation of the relationship among the MAP categories.

Population, Sample, and Sample Demographics

Population

The population consisted of a convenience sample of middle school students from five public school districts in the state of Missouri. In 2009, the year of the first cohort in this study, only seven public school districts in the state offered a choice in science curriculum at middle level, so the pool of participants for that factor was limited. Of those seven districts, three gave permission to be included in this study. Two other districts without school curriculum choice were chosen for their similarity to each other to use as a contrast to the other participants.

Sample

This study consisted of two test scores from each of the 3,134 eighth grade students from five different public school districts in the state of Missouri. The researcher used test results from the science portion of the Missouri Assessment Program state standardized test for each student during their fifth grade year, and then again in their eighth grade year to measure relative growth per student. This convenience sample included students of both genders, different races, and various socioeconomic backgrounds. The five school districts in this study comprised three large suburban districts with similar demographics and two small rural districts with similar demographics. Two of the three large suburban school districts and one of the two small rural school districts offered students a choice in science classes during the years between the two standardized test scores. In those three school districts that offered a choice in science class, all offered only two choices: Challenge science and Regular science class. Additionally, in the three school districts that offered a choice in science class, all students were allowed to choose either class with no prerequisites or limitations. To help students decide which type of science class to take in the districts that offered a choice, parents and students were given information prior to enrollment that explained details of the advanced science choice, stating clearly that it would be faster-paced to allow for more writing, research, and project-based assignments, and it would include more homework than the regular science classes. The information also stated that unlike pre-algebra, the advanced science classes would not be a prerequisite for any science class in ninth grade, nor would it excuse them from taking the science portion of the MAP test. Currently in the state of Missouri, eighth grade pre-algebra students are excused from participating in the mathematics portion of the MAP test and must instead take an end-of-course (EOC) test for pre-algebra. Conversely, all students are expected to participate in the science portion of MAP testing. Advanced science is a weighted class in two districts in this study, so additional grade points may be a factor in some students' choice of class. Likewise, some students who preferred to enroll in advanced science classes were in a few cases unable to due to individual scheduling conflicts.

The researcher obtained approval from the Institutional Review Board before obtaining data. Parental consent was not necessary in this ex post facto research study because the standardized test scores did not include any identifying information and the collection of the data was part of the standard protocol for each district.

For the districts that offered two different types of science, the researcher analyzed the results of the science portion of the state standardized tests of the student sample when the students were in fifth grade prior to the introduction of advanced science courses, and again after advanced science courses had been utilized for two years, at the end of eighth grade to measure relative growth among the "advanced" group compared to the "regular" group. For the districts that had only one type of science class, the researcher analyzed the results of the science portion of the state standardized tests of the student sample when the students were in fifth grade and again at the end of eighth grade to measure relative growth. Permission to access the MAP results for this student sample for the purpose of statistical analysis was requested from the school districts for the 2010 MAP science test and 2013 MAP science tests. The researcher contacted administrative personnel in each participating school district to request permission to use the aforementioned data. The study itself was not mentioned to students or parents.

MAP data is compiled at the state level each year and is sent to each school district in both hard-copy and electronic formats. Figure 3.2 shows the overall data collected from the state for the years of the study. The researcher asked to obtain electronic formats for data analysis of the student science test scores in the study. Although the MAP test assesses other content areas such as mathematics and language arts, only science scores were examined in this study. The researcher compiled the data from each school and analyzed whether the addition of advanced science had an effect on standardized test scores, but also looked at other factors, such as race, gender, and free/reduced lunch status. One independent variable was the differentiated curriculum (offering a choice in science classes) compared to only one science class offering. Other variables included gender, race, free/reduced lunch status, and type of science class. The dependent variables were the achievement scores and categories consisting of one of four MAP achievement categories in which each raw score was placed: Below Basic, Basic, Proficient, and Advanced. The lowest scores were in the Below Basic category, and the highest scores were in the advanced category. Basic scores were considered above Below Basic but not as high as Proficient.

Study Participants	Below Basic		Basic		Proficient		Advanced	
	5th	8th	5th	8th	5th	8th	5th	8th
School A	3.5%	8.0%	31.9%	28.2%	33.4%	47.6%	31.2%	16.3%
School B	7.3%	9.0%	35.0%	20.4%	35.2%	45.1%	22.5%	25.6%
School C	1.7%	6.8%	18.4%	25.8%	31.0%	44.9%	49.0%	22.5%
School D	2.1%	3.9%	17.7%	15.6%	34.1%	53.1%	46.1%	27.4%
School E	4.0%	6.7%	33.7%	32.8%	36.8%	45.4%	25.5%	15.2%

Figure 3.2. Study Participants Middle School District MAP Results 2010-2013. (Missouri Department of Elementary and Secondary Education, 2017c).

Instrumentation

To explore whether offering a choice between advanced science and regular science increased achievement scores, a sample of student science standardized test scores was used in this study. The data from the Missouri Assessment Program, a state standardized test that was administered to all fifth-grade students in both school districts involved in this study in 2010, were collected and analyzed focusing on the categories Proficient, Advanced, Basic, and Below Basic. Then the data from the science portion of the MAP test, administered to those same students when they were eighth graders in both school districts in 2013, were collected and analyzed focusing on the same four categories. Relative growth was analyzed to examine the impact of the variables on those students who were enrolled as advanced science students compared to those who were in regular science.

The MAP test began as a measurement tool for Missouri's education standards, called the "Show-Me Standards" (CTB/McGraw-Hill, 2010). The test now has evolved to include not only those state standards, but also content and process standards, as well as grade-level expectations (GLEs). The current version of the test, including Communication Arts and Mathematics, was started in 2006 to comply with the requirements of the No Child Left Behind (NCLB) law. NCLB legislation at first required states to develop an assessment tool to measure academic progress for communication arts and mathematics. A science portion was added in 2008, and it currently tests grades five to eight. Typically, the science portion of the MAP test involves mostly constructed response-type answers, with a brief multiple choice section. The science portion of this test usually covers knowledge of all middle-level science topics, not just those taught in one grade. It is intended as a measure of science knowledge retained by students over years. Students are expected to remember science facts from all years of middle-level learning to achieve a higher score on the science portion of the MAP test.

The MAP test divides students' total scores into four categories called achievement levels: Proficient, Advanced, Basic, and Below Basic for each separate test subject area. For example, a student may be proficient in communication arts, but below basic in mathematics. Test scores are meant to be used to identify strengths and weaknesses in both students' learning and school or district programs. A copy of the Individual Student Report (ISR) is provided to school districts to pass along to parents for each test-taker. The ISR contains not only a scale score, but a state mean for comparison and the achievement level category that is assigned to the scale score (CTB/McGraw-Hill, 2010).

Scores on the MAP tests are obtained from a group of trained test graders, who go through extensive training to grade tests accurately and consistently. Approximately 5% of the tests are scored by an additional grader to establish reliability in grading the constructed response items (CTB/McGraw-Hill, 2010).

Reliability and validity of MAP scores are important to this research. The reliability of the MAP test is considered to be internally consistent using Cronbach's alpha (1951), which is a ratio of the variance of a true test score to those of the observed scores with values ranging from 0 to 1. The closer the value is to 1, the more consistent the scores (McGraw-Hill, 2010). For the science test, the value is 0.93, which is considered high reliability. Also, test validity was controlled with convergent and divergent validity. Convergent validity was analyzed to ensure that the items on the test were actually measuring what they were meant to measure. Divergent validity was analyzed to determine whether constructs that should not be related to each other are shown not to. Both of these validity measures were shown to be high using Cronbach's alpha.

In addition, the four academic level categories needed a cut-off score in order to determine into which categories a score would fall. Therefore, a standard error of measurement (SEM) was imposed to determine the range within which a student's true score would be likely to fall (CTB/McGraw-Hill, 2010). The SEM shows reliability of score reporting and is used to measure random variability in test scores. Also used to support reliability was the conditional standard error of measurement (CSEMs), which shows the degree of measurement error in scale score units and varies in magnitude across students' scale scores. In summary, the SEM and CSEM indexes show that the cut-off scores are between the middle of the scale range, and measurement error is low. Controlling for outliers by disregarding those results in the SEM and CSEM, the test designers state that the scale score divisions are evenly distributed between the four categories of achievement levels.

Validity

Internal validity. Internal validity allows researchers to state that their conclusions accurately reflect the investigation of a study. It assumes the data collection and statistical techniques were appropriate for the analysis, and how confident the researchers are that the observed effects were caused by a particular treatment (Agarwal, 2013).

The publishers and authors of the assessment instrument in this study, CTB/McGraw-Hill LLC, have completed validity and reliability analyses to ensure the measurements of students' progress are dependable. In the 2010 Technical Report, CTB McGraw-Hill found that the raw scores on assessments for all content areas, including science, were reliable with a Cronbach's alpha coefficient above 0.90. In addition, the report found that the scoring performance level classifications (Below Basic, Basic, Proficient, and Advanced) were statistically accurate at or above 0.85, which suggests that consistent and accurate performance level labels are being made for students based on MAP scores.

External validity. External validity is the degree to which the results of a study will be applicable to the wider population outside the study. This characteristic is important because it shows that the conclusions of a study are meaningful and that the sample was an appropriate representation of the population at large (Agarwal, 2012). Although this study did not have many school districts from which to draw data that offered curricular choices in science at middle school level, the population of individuals in this study exceeded 3,000 students.

Data Collection

Several public school districts of similar size and demographics were chosen for this study. Of the responders who chose to participate, the data coordinator of each school district was responsible for sharing individual school district data; some electronically, and some by using hard copies sent through the mail. Each district's data coordinator removed all identifying information about each student prior to sharing their data. The researcher used Microsoft Excel spreadsheets to organize the data by district and then used the Statistics Package for the Social Sciences (SPSS) software program to analyze the data.

Operationalization of Variables

In the theoretical model, eight variables were described, including two dependent variables, five independent variables, and one moderator variable. The dependent variables were MAP science scale sub-scores and corresponding MAP performance level classification labels. The independent variables were race, gender, free/reduced lunch status, type of district science curricular arrangement, and type of science class attended. The moderating variable was the student cohort (fifth grader in the 2009-2010 school year).

Missouri Assessment Program (MAP) Science Scale Score

MAP scores consist of different topics depending on the grade level. In fifth and eighth grade, students in Missouri take the Communication Arts, Math, and Science standardized MAP tests. The scale score reported for each test-taker represents the student's achievement level in those topics, and the scale scores vary among topics. In science, the scale scores range from 470 to 895. The state of Missouri allows a four-week window in

April in which the test must be given. The Missouri Department of Elementary and Secondary Education (MODESE) uses the scale scores from the MAP tests, converting them into index scores to be used as performance indicators for the state Annual Performance Report (AYP). The science assessments include constructed response, multiple choice, and a performance event that requires a ruler (provided by the test developers). Science MAP tests in fifth grade during this study consisted of three test sessions, and the eighth grade students had four test sessions, one of which was timed. All tests across the cohort time period were hard-copy paper booklets into which the students would record their answers. The science multiple choice tests were graded by a machine, and the constructed response items, as well as the performance events, were scored by trained personnel using established scoring criteria.

Missouri Assessment Program Achievement Levels

The scale scores that are earned by each test-taker place students in one of four possible achievement levels. These levels represent standards of performance for the tested content areas and are based on Missouri Learning Standards. Achievement levels allow a quick summation of what the students' abilities are at that time. The lowest level is known as Below Basic, and is sometimes referred to as Level 1, which for fifth grade includes scale scores of 470 to 625, and for eighth grade includes scale scores of 540 to 670. Below Basic students exhibit a minimal understanding of science concepts. Specifically, the description of fifth grade below basic states:

> Students identify the relationship between mass and force; classify bodies of water; identify weather instruments and their uses; identify characteristics of the solar system; compare amounts/measurements given in a simple format; identify appropriate tools for simple scientific measurements; identify how technological

> advances may be helpful to humans (Missouri Department of Elementary and Secondary Education, 2017b)

Below Basic students in eighth grade, having had additional curriculum by that time, have a slightly different descriptor:

> Students identify simple terms related to matter and energy; demonstrate beginning understanding of properties of light and how it travels; identify structures of plants and animals needed for survival; identify levels of organization in multicellular organisms; read simple graphs and make simple data comparisons. (Missouri Department of Elementary and Secondary Education, 2017b)

The next level is the Basic level, otherwise known as Level 2, which includes scale scores in fifth grade of 626 to 668, and in eighth grade of 671 to 702. In the Basic level, students may be able to explain some science relationships with more accuracy, but are not achieving depth in the topic. Specifically, a fifth grade Basic level student's knowledge is described as follows:

> Students explain the relationship between mass and force; describe how specialized body structures help animals survive; match environments to the plants and animals they support; identify environmental problems and find solutions; construct part of a graph; determine the appropriate scientific tool and its function in an investigation; determine how technological advances address problems and enhance life. (Missouri Department of Elementary and Secondary Education, 2017b)

Science knowledge represented in the Basic achievement level is limited as well and is expressed as follows:

> Students identify an example of a force; demonstrate simple understanding of how traits are passed from one generation to the next; have a basic understanding of climate; identify a simple hypothesis; recognize a trend in a data table; demonstrate some awareness of how various factors influence and are influenced by science and technology. (Missouri Department of Elementary and Secondary Education, 2012)

The third achievement level in MAP reporting is called Proficient, or Level 3, and consists of fifth grade scale scores of 669 to 691 and eighth grade scale scores of 703 to

734. Proficient students have a quality understanding of several science concepts. Specifically, the fifth grade Proficient student in science is described as follows:

> Students describe changes in properties of matter; identify uses of simple machines; explain how work is done; identify forces of magnetism; describe the motion of objects; identify plant parts and their functions; classify vertebrates and invertebrates; classify producers, consumers, or decomposers; predict changes in food chains; identify the effects of human activities on other organisms; describe the Sun as a source of light and heat, or the moon as a reflector of light; explain the day/night cycle; identify characteristics and variables of a fair test; interpret data and make predictions; draw conclusions based on evidence; distinguish between man-made and natural objects; apply problem solving skills to a situation. (Missouri Department of Elementary and Secondary Education, 2017b)

Eighth grade science proficiency as described by the developers of the MAP test is characterized by calculations, explanations, and the ability to make educated inferences, specifically:

> Students classify types of motion; calculate the speed of an object; demonstrate simple understanding of life processes; classify and/or show relationships between organisms; explain how adaptations help organisms survive; explain how species are affected by environmental change; understand and describe a food web; explain rock and fossil evidence of changes in the Earth; explain how Earth's systems interact; draw conclusions from tables or graphs; demonstrate basic understanding of the solar system; recognize the need for, and calculate, averages; understand the importance of constants in investigations; use appropriate tools and methods to collect data; describe tools and discoveries that advance scientific knowledge. (Missouri Department of Elementary and Secondary Education, 2017b)

The highest category of achievement level as determined by the MAP developers is called Advanced or Level 4, and is represented by fifth grade scale scores of 692 to 855 and eighth grade scale scores of 735 to 895. The advanced science student is described as having an outstanding grasp of science topics and excellent reasoning skills. Specifically, fifth grade proficiency in science is outlined as follows:

> Students identify energy transformations; predict the effect of heat energy on water; diagram a complete electrical circuit; predict how simple machines affect the force needed to do work; describe the effects of weathering and erosion on Earth's surface;

> describe relationships in weather data; explain how the Sun's position and the length and position of shadows relate to the time of day; interpret and apply knowledge from a data table; identify appropriate steps, tools and metric units in an investigation; construct a graph and plot data; formulate a question for an investigation. (Missouri Department of Elementary and Secondary Education, 2017b)

Likewise, Advanced eighth grade science students demonstrate superior understanding of a variety of science themes, the specifics of which are explained as follows:

> Students explain the physical and chemical properties of matter; apply knowledge of energy and energy transfer; demonstrate understanding of physical and chemical processes of organisms; evaluate the effects of balanced and unbalanced forces; predict the impact of environmental change in ecosystems; justify how adaptations help organisms survive; demonstrate understanding of the water cycle; compare and contrast weather and climate; explain the cause of seasons on Earth; demonstrate understanding of the solar system; apply the concept of light years; construct a complete graph; evaluate experimental design; create testable questions and hypotheses; apply awareness of the influence of science and technology in society. (Missouri Department of Elementary and Secondary Education, 2017b)

Gender

On the MAP test, students choose either male or female. Gender refers to being either male or female, and students self-identify with one gender.

Race/ethnicity

Race/ethnicity is a social construct that categorizes people into groups based on physical and/or cultural characteristics. The MAP test requires students to choose a race/ethnicity from the following categories: American Indian/Alaska Native, Asian/Pacific Islander, Black, Hispanic, White, and Other.

Free/reduced Lunch Status

The National School Lunch Act of 1946 established a nationwide, federally-assisted food program that is nutritionally balanced for school children called the National School

Lunch Program (NSLP). This program provides low-cost or free lunch meals to students who have economic qualifications. Students who receive free or reduced lunches are recorded on MAP forms for statewide data collection. To qualify for free or reduced lunches, households must meet criteria based on size and income so that financially stressed families can receive nutrition. Households receiving assistance from various government food programs, such as Food Stamps, are eligible. Homeless, runaway, foster children, and migrant children are also eligible for free meals. On the MAP test, Free/Reduced lunch status is required on the test forms via the district, and is used for analysis of data as it relates to economically disadvantaged students (Missouri Department of Elementary and Secondary Education, 2017a).

Type of School

In the state of Missouri, school districts are arranged in various configurations based on local resources, tradition, or pedagogical philosophy. While most public school districts in Missouri do not offer curricular choice in science in middle-level years, a few do. For this study, data from two types of schools were compared: schools that offered a choice in science classes, and those that did not.

Type of Science Class

The type of science class in which students chose to enroll is considered the type of science class. In the schools that offered a choice in science curriculum, students had the opportunity to choose between regular and advanced classes. In all cases in this study, there was no prerequisite for any advanced science class, so students and their parents/guardians had full control over which type of science class to take.

Cohort

A cohort is a group of people who share characteristics. In this study, the cohort of students were in fifth grade during the 2009-2010 school year; therefore, those same students were in eighth grade during the 2012-2013 school year. The moderating variable in this study was this cohort of students.

Ethical Considerations

Five school districts chose to participate in this study, none of which wished to be identified. To address this risk, the researcher numerically coded each school district to prevent identification. Student data were coded by administrative personnel with random numbers prior to being presented to the researcher to eliminate individual identification of students. Because this study was an ex post facto examination, the researcher did not have contact with any of the student participants, nor did the students or parents have knowledge of this study.

Limitations

The primary limitation in this study was the small number of school districts that offered a science curricular choice from which to draw data at the time of the cohort. In the 2010-2011 school year when the study cohort was beginning fifth grade, only seven public school districts were known to offer curricular choice in science classes for middle level learners in Missouri. The researcher contacted hundreds of school districts across the state to find such a configuration and was granted permission to investigate data from only three of those districts. Because this study was longitudinal in nature, other schools that began to offer science curricular choice in subsequent years were excluded from this study. Another limitation concerned one large suburban district in this study that chose not to provide information on gender, race/ethnicity, and free/reduced lunch status, preventing that data from being included in this study. Also, a different large suburban district in this study failed to share full data on about 60 students due to their clerical error that they chose not to correct, negating those scores from inclusion.

Unknown variables may have influenced results from the school districts. For example, a four-week mandatory testing window is required for presenting the MAP test to students, so districts have a little flexibility concerning how the test is given in each district across the state. The daily schedule for tests in individual school districts can vary and may affect test performance. For example, one district may give the test only in the mornings for a month, while another district gives the tests all day for two weeks.

Another limitation is the unknown preparation time the participating school districts may have implemented prior to administering the MAP test. While some districts take a few days to review in preparation for standardized tests, others may take longer or offer incentives for good performance.

This study did not examine within-district variation as it related to teacher quality. According to Rivkin, Hanushek, and Kain (2005), students will achieve at significantly higher levels with experienced teachers than students of teachers with less experience. Another variation that could affect test scores was the number of students in each science class involved in this study. In a study of elementary school students, small class size had a positive effect on achievement up to fifth grade (Rivkin et al., 2005). Yet, there are mixed findings on whether class size affects achievement. According to Rockoff (2009), there is little evidence that class size affects student achievement. While not all studies agree with the effect class size has on student outcomes, it was not a controlled variable for this ex post facto study. Another limitation was the amount of pupil support received in the home. While some students have stable homes, others may not, and studies show that students with stable support at home have better rates of academic achievement (Stewart & Suldo, 2011; Wang & Sheikh-Khalil, 2014).

Delimitations

This study included only science scores of middle-school students in five Missouri public school districts. Only public school districts were investigated to control that variable. Although nearly 5,000 data points were collected, several were disregarded to ensure consistency. Some student scores were disqualified and removed from this study to maintain homogeneity in treatment conditions. Because the study was longitudinal in nature, the scores of students who moved in or out of the district and did not take both science MAP tests in the same district from fifth to eighth grade were disregarded. Students whose scores were included in this study were required to be enrolled in the same district continuously from fifth to eighth grade. Scores from special education students who took the alternative form of the test called the MAP-A, or who had benefit of any special accommodations, were disregarded. Scores from students who were labelled as English Language Learners, or who were given accommodation materials in that regard, were excluded. In the school districts that offered curricular choice in science, the students who changed their scheduled science classes from regular to advanced, or the reverse, were disregarded so that students in science classes labelled regular received that version of instruction for all years in their cohort for science, maintaining treatment conditions. Another small set of scores was disregarded from one of the large suburban districts because part of the data was missing, a reporting error that the submitting district chose not to correct. Also, students who missed school for more than ten days due to health, disciplinary actions, or other unknown reasons were excluded from this study. Only suburban and rural schools were represented in this study. No urban schools were included in this study because of the difficulty in finding treatment conditions that mirrored those of the other participating districts.

Statistical Analysis

This ex post facto, quasi-experimental quantitative study used a one-way repeated measures ANOVA because a within-subjects examination over two test events was a pre- and post-treatment design that was appropriate for this study. The students were studied longitudinally, taking the MAP test on two points in time, once in fifth grade and again in eighth grade, while experiencing the treatment of either regular science instruction or advanced science instruction. The repeated measures ANOVA fit this design more than a paired-samples t-test because the ANOVA measures across multiple conditions. Other than the two conditions of type of science class each student chose, another condition was the general setting or type of school. For example, the pedagogical organization of schools that offered choice versus those that offered no choice in middle level science classes was an added condition being investigated. Other variables examined included race/ethnicity, gender, and free/reduced lunch status. A univariate assumption when using a repeated-measures ANOVA is that the paired differences should be normally distributed. The Levene's Test of Equality of Variance is used for testing normality. A significant Levene's statistic qualifies as rejection of the hypothesis of normal distribution. In samples of more than 30, the assumption of normality can be ignored. In this study, there were 3,134 participants, far more than 30, so normality was met. Another assumption in this design was that the population variance of difference in scores between the two levels were equal, making the p value more credible, which is called sphericity. Mauchly's Sphericity Test, calculated by the SPSS software program, would be significant if the p-value was less than 0.05, whereby sphericity has been violated. In this study, Mauchly's Test of Sphericity was equal to 1.0 and did not violate sphericity. Another assumption in the repeated-measures ANOVA is that of independence, meaning that there is no dependency in the scores between participants. In this study, this assumption was met due to each set of scores representing a different person, and methods were standardized by each school district when implemented. Lastly, the assumption that the data are normally distributed with no outliers is key in ensuring validity. Outliers are data points that stand well outside the usual scores and may present a threat to validity. Therefore, the researcher ran quantile-quantile (Q-Q) plots through the SPSS program on the data sets of fifth grade tests and eighth grade tests. In statistics, Q-Q plots that show data points distributed along a straight line are normally distributed. Figure 3.3 displays the results, which confirm no outliers in the fifth grade data set; however, there was one outlier in the eighth grade data set, which was removed before analysis of the data.

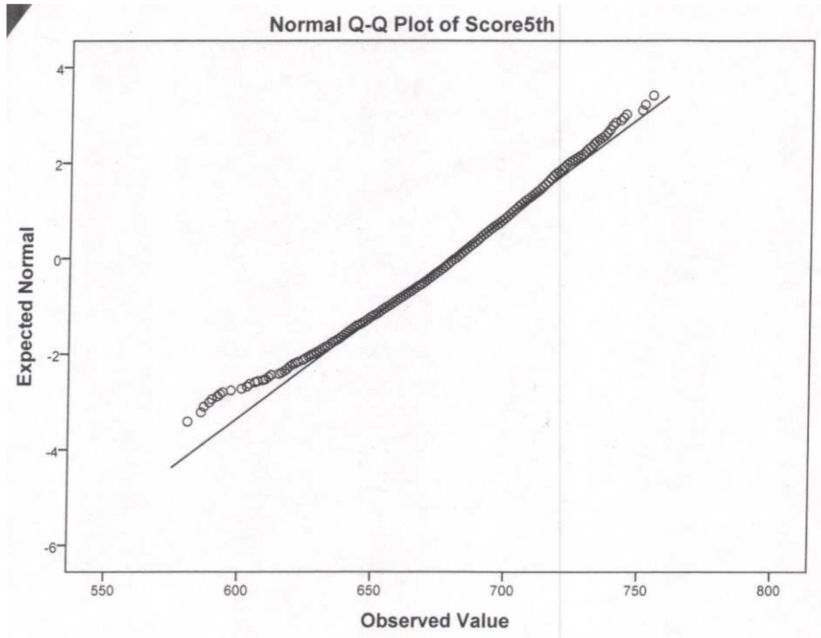

Figure 3.3. Normal Q-Q Distribution Plot for 5th grade Science Achievement Scores

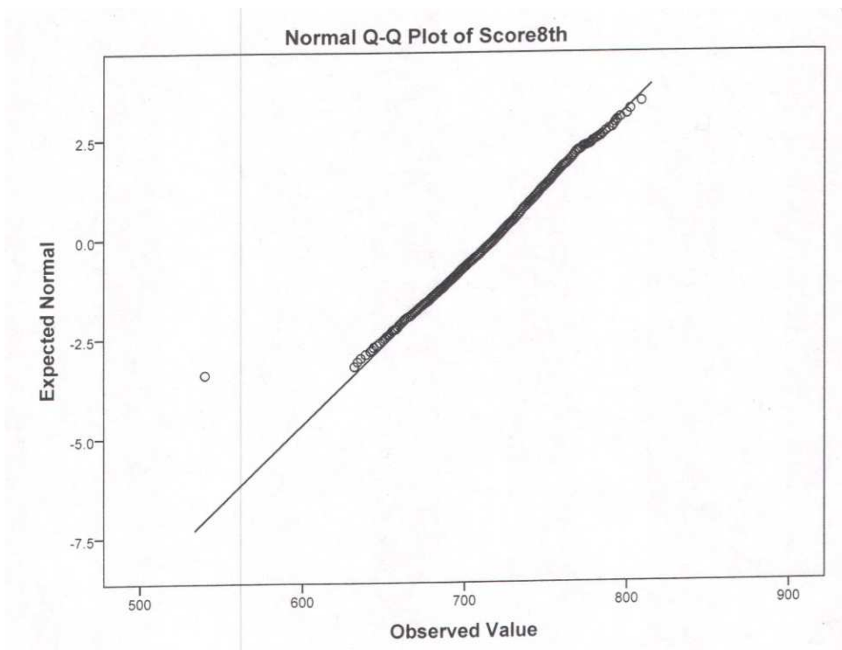

Figure 3.4. Normal Q-Q Distribution Plot for 8th grade Science Achievement Scores.

A Chi-square test of independence was another treatment used in this study to examine the relationship between achievement levels assigned in two different grade levels.. This test helps to discover how likely it is that a distributed characteristic in categorical variables is due to chance. The MAP achievement levels assigned by the test developer from scores consist of four achievement level categories: Below Basic, Basic, Proficient, and Advanced. This study attempted to discover whether science achievement level during fifth grade was related to the student's assigned achievement level in eighth grade. One assumption necessary when using a Chi-square test is that the levels are mutually exclusive, which is met using standardization of test scores. Another assumption with the Chi-square is that of sample size, having a minimum of 20 data points, which is met in this study. Test results show significance with a p value less than or equal to 0.05, meaning there is some association between the variables. Results are presented in chapter 4, including a detailed analysis and summary of the statistical findings.

Sample Demographics

Of the three large suburban districts in this study, one was labeled district A, which included sample scores drawn from a student population (n = 944) consisting of 21.1% students on free and reduced lunch status, much lower than the state average of 49.5%. District A consisted of 2.5% Asian students, slightly more than the state average of 1.9% Asian students. This school district consisted of 13.6% Black students, slightly less than the state average of 16.5% Black students. District A consisted of 5.1% Hispanic students, identical to the state average. District A had 0.5% Indian students and 0.20% Pacific Islander students, both numbers nearly identical to the state average. Students who were listed as Multi-race individuals totaled 0% for district A, while the state average was 2.10%.

White students made up 78% of district A, slightly above the state average of 73.7%. This school district had a four-year high school graduation rate of 94.1%, much higher than the state average of 86.0%. School district A was made up of 18 elementary schools, three middle schools, three high schools, and a secondary alternative school. Each middle school in this district housed grades seven and eight, with the elementary schools housing K through six. The district employed 1,482 certified staff and had a total of 18,261 students, with 2,850 of those students in middle schools. In this district, the student-teacher ratio averaged 20 to 1. Average teacher classroom experience was 14.7 years, slightly higher than the state average of 12.4 years. In this “science choice” district, 83.4% of teachers had achieved a Master’s degree or higher, which was a slightly higher rate than the “no science choice” district. Attendance in this district was rated at 95.7%, very similar to the comparison district as well as the state average of 94.7%. District A offered students both regular and challenge science at the middle level.

A second large suburban school district in this study, known in this study as district B (n = 746), also offered curricular science choice to its middle-level population, in a school district of which 20.3% were in the free/reduced lunch program. District B consisted of 11.4% Asian students, far above the state average, and 14.9% Black students, slightly less than the state average. This school district listed 0% for students who identified themselves as Hispanic, Indian, Pacific Islander, or Multi-racial. The percentage of White students in this district was 64.8%, lower than the state average. School district B was made up of 18 elementary schools, five middle schools, three high schools, and a secondary alternative school. Each middle school in this district housed grades six, seven, and eight, with the elementary schools housing K through fifth grade. The district employed 1,857 certified staff and had a total of 17,274 students, with 4,027 of those students in middle schools. In this district, the student-teacher ratio averaged 15 to 1. Average teacher classroom experience was 13.1 years, slightly higher than the state average of 12.4 years. In school district B, 79.4% of teachers had achieved a Master's degree or higher. Attendance in this district was rated at 95.3%, and the four-year graduation rate was 94.0%.

In the final large suburban school district, known in this study as district C (n =830), there was no curricular choice in science classes. This district was made up of 14 elementary schools, four middle schools, a freshman center, two high schools, and a secondary alternative school. Each middle school in this district housed grades six, seven, and eight, and the elementary schools housed grades K through five. The district employed 1,075 certified staff and had a total of 14,133 students, with 3,336 of those in sixth through eighth grade. In this district, the student-teacher ratio averaged 20 to 1. Average teacher classroom experience was 12.9 years, almost equivalent to the state average of 12.4 years. Teachers in the sample district tended to be well-educated, with 81.9% of all the teachers in the district having achieved a Master's degree or higher, which was much greater than the state average of 58.9%. Attendance in the sample district at 94.8% nearly mirrored the state average of 94.7%. The four-year graduation rate was 92.3%. The student population in district C consisted of 29.5% free/reduced lunch status, slightly higher in comparison to the other two suburban districts, yet still far below the state average. Asian students made up 2.4% of the district student population, and Black students made up 11.6% of the students. Those students who identified as Hispanic totaled 5.8%, Indian students totaled 0.5% of the students, and 0.20% identified as Pacific Islander. In district C, students who identified as Multi-racial totaled 2.6%, and White students totaled 76.9%. Table 3.1 compares the three large suburban districts to show their similarities compared to the overall average Missouri demographic information.

Table 3.1

Large Suburban District Comparisons

District Traits	District A	District B	District C	Missouri Ave.
Number in study	944	746	830	---
Middle School Science Curriculum	Choice	Choice	No Choice	---
Free/Reduced Lunch Status	21.1%	20.3%	29.5%	49.9%
Asian	2.5%	11.4%	2.4%	1.9%
Black	13.6%	14.9%	11.6%	16.5%
Hispanic	5.1%	0.0%	5.8%	5.1%
Indian	0.5%	0.0%	0.5%	0.4%
Multi-race	0.0%	0.0%	2.6%	2.1%
Pacific Islander	0.2%	0.0%	0.2%	0.2%
White	78.0%	64.8%	76.9%	73.7%
4-yr graduation rate	94.1%	94.0%	92.3%	86.0%
Total number of certified staff	1,482	1,857	1,075	---
Total number of pupils in district	18,261	17,274	14,133	---
Total number of pupils in Middle School	2,850	4,027	3,336	---
Teacher – Student ratio	20-1	15-1	20-1	18-1
Middle-school arrangement	Grades 7 & 8	Grades 6, 7, & 8	Grades 6,7, & 8	---
Average years teaching experience	14.7	13.1	12.9	12.4
% teachers with advanced degrees	83.4%	79.4%	81.9%	59.1%
District Attendance Average	95.7%	95.3%	94.8%	94.7%

The final two school districts cooperating in this study were small and rural. The first rural district was known as school district D (n = 344), and allowed students to choose between regular and challenge science classes between fifth and eighth grade. District D had 18.7% of its population in the free/reduced lunch program. The percentage of Black student in this district was 5.5%, much lower than the state average, and Hispanic student made up approximately 6.0% of the student population. White students in this district comprised 86.4%, higher than the average Missouri school district. School district D was made up of five elementary schools, two middle schools, and one high school. Each middle school in this district housed grades six, seven, and eight, with the elementary schools housing K through fifth grade. The district employed 553 certified staff and had a total of 6,687 students, with 1,555 of those students in middle schools. In this district, the student-teacher ratio averaged 19 to 1. Average teacher classroom experience was 13.4 years, slightly higher than the state average of 12.4 years. In school district D, 79.7% of teachers had achieved a Master's degree or higher. Attendance in this district was rated at 95.8%, and the four-year graduation rate was 92.7%.

The last district in this study was a small, rural district that was labelled district E (n = 292) that was very similar to the other rural district being examined except that there were no choices in science curriculum in the middle level years. Everyone took the same science class in middle school in this district. This district was made up of five K-5 elementary schools, one middle school that housed sixth and seventh grade students, a junior high school that housed eighth and ninth graders, and two high schools. The district employed 469 certified staff, and had a total of 5,673 students, with 605 of those in sixth through eighth grade. In district E, the student-teacher ratio averaged 18 to 1, and average teacher classroom experience was 13.0 years. Teachers with a Master's degree or higher totaled only 44.2%, lower than the state average. Attendance in this district was higher than average, at 95.3%. The four-year graduation rate in district E was 96.7%, far higher than the state average, and the highest in this study. The student population in this district consisted of 38.2.% free/reduced lunch status, the highest of the districts in this study yet still below the state average. Asian, Indian, Pacific Islander, and Multi-race students were not represented in this small district lacking diversity. Black students made up 3.2% of the students, while those who identified as Hispanic totaled 4.5%. Table 3.2 compares the two small rural districts.

Treatment

Science classes in Missouri public school districts follow a list of objectives set by the state, although the order in which those units are presented to science students may be different from district to district. In the state of Missouri, the general units in science required in middle-level classrooms include weather, astronomy, life science, earth science, and physical science. According to the district curriculum guides of those districts in this study that offer a science choice, the advanced seventh and eighth grade classes cover the same units as the regular science classes, but have more in-depth lab experiences as well as more project-based assignments and writing. Science teachers in all the participating districts generally utilize lecture and guided practice in their middle-level classrooms, supplementing with lab experiences and hands-on activities, regardless of whether they were teaching the challenge science or the regular science classes. Science teachers within each district are given access to the same textbook and its materials, as well as supplemental materials that they may share, along with individual teacher-made materials. Although the science textbooks in the participating districts are not identical in all cases, the standard practice in all five of these districts is to use the textbooks as a supplemental reference to information imparted in class and thus should have little effect on the outcome of this study.

Table 3.2

Small Rural Districts Comparisons

District traits	District D	District E	Missouri Average
Number in study (n)	324	292	---
Middle School Science Curriculum	Choice	No Choice	---
Free/Reduced Lunch Status	18.7%	38.2%	49.9%
Asian	0.0%	0.0%	1.9%
Black	5.5%	3.2%	16.5%
Hispanic	6.0%	4.5%	5.1%
Indian	0.0%	0.0.%	0.4%
Multi-race	0.0%	0.0%	2.1%
Pacific Islander	0.0%	0.0%	0.2%
White	86.4%	90.4%	73.7%
4-yr graduation rate	92.7%	96.7%	86.0%
Total number of certified staff	553	469	---
Total number of pupils in district	6687	5673	---
Total number of pupils in Middle School	1555	605	---
Teacher – Student ratio	19-1	18-1	18-1
Middle-school arrangement	Grades 6, 7, & 8	Grades 6 & 7	---
Average years teaching experience	13.4	13.0	12.4
% teachers with advanced degrees	79.7%	44.2%	59.1%
District Attendance Average	95.8%	95.3%	94.7%

The science teachers in the participating districts did not teach the exact same way nor did they have the same amount of education or experience, nor did they use the same materials, some of which were teacher-made. The researcher had no control over those factors due to the ex post facto nature of this study.

The researcher chose to equalize the standardized scores prior to SPSS analysis because the standardized scores reported by the state are relative to each of the two tests given in fifth grade and eighth grade. Prior to equalization, both tests in this study (fifth grade 2010 and eighth grade 2013) have different means due to a different number and difficulty of test questions, and a different amount of total point value for each test. Therefore, equalizing the scale scores allowed the researcher to standardize both tests to a mean of zero in an attempt to negate those differences in reported scale scores.

Another point that is important to understand in this study is that the “science choice” districts offer advanced science classes for both seventh and eighth grade years. This study compared those students who were enrolled in advanced classes at middle level instead of just one year or two. Students who chose advanced science in this study did so voluntarily because there were no requirements for enrolling in advanced classes in any of the school districts in this study. Data were collected on each student to show which classes they were enrolled in for each year of middle school, and only those students who remained consistently in either advanced or regular science in the years between fifth and eighth grade were included in this study.

Besides fifth and eighth grade science MAP scores for each student, each district was asked to provide additional information about each student, including race, gender, free/reduced lunch status, type of science classes enrolled in for each year between the tests, whether or not the student was continuously enrolled in the same school district, special education status, and MAP categories for each of the two tests.

Summary

This quantitative study was designed to explore the effect of curricular choices in science on middle-level learners' achievement scores. It also explored whether differences in middle school science design had an impact or if race/ethnicity, gender, and free/reduced lunch status possibly affected science achievement scores. The research methodology described in this chapter was used to investigate these ideas. This chapter also described the sample, data collection procedures, and analysis, as well as the ethical considerations that were addressed. The next chapter consists of data descriptions, procedures for data analysis, and the study results as they relate to the hypotheses and research questions.

CHAPTER 4

ANALYSIS OF DATA AND RESULTS

Introduction

The purpose of this study was to investigate the effects of middle level science curriculum on relative growth in science achievement as measured by the Missouri Assessment Program (MAP) test. The students in the treatment group were those who chose to enroll in advanced middle school science classes instead of regular science classes in school districts that offered a choice. Therefore, the Independent Variable is advanced science course instruction. One part of the control group was the student population that chose to enroll in regular science classes in schools that offered a choice, while another part of the control group consisted of those students who were enrolled in regular science in school districts that did not offer a curriculum choice in science. As the longitudinal nature of this study suggests, all participants were measured at two points in time: fifth grade before the possible treatment of advanced science instruction, and again in eighth grade after three years of middle school science instruction. The data were furnished by three large suburban school districts and two small rural school districts in Missouri; three of the five offered science curriculum choice for the years 2010 to 2013. Prior to the researcher obtaining the data, all five cooperating school districts removed any data that were specifically requested by parents not to be used in any study. Because this study focused on non-special education students, those students who were on an IEP or who had a non-standard version of the MAP test given to them were excluded from this study. Three of the school districts in this study removed IEP student data prior to sending it to the researcher, and two of the school districts left that information to be filtered out by the researcher.

Another excluded group included students who were not consistently enrolled in the same district with the same level of science instruction, and any student who was gone for ten or more school days from school for any reason. Although data were collected (n = 4,104) for students in attendance for the five school districts in this study, only 3,135 students qualified for analysis due to consistency in the aforementioned longitudinal requirements. From that total number of participants, 864 students were in the treatment group because they chose to enroll in advanced science during their tenure at middle school. Therefore, 2,271 students in this study were enrolled in regular science classes, of which 1,121 were in regular science class because there was no option, while 1,150 chose regular science classes when presented with the option of regular versus advanced classes in school districts that offered a choice of science classes. Of the 3,135 students whose data was useable according to the researcher's parameters, an outlier test was done in SPSS that showed one student (who was enrolled in regular science from a school district that offered a choice in science classes) from one large suburban district as an extreme outlier, so that data point was excused from the complete useable data set (n = 3,134).

Two numerical data points were collected from each student to examine individual relative longitudinal growth in science: one was the MAP test score before they began middle school, taken in the spring of their fifth-grade year prior to any treatment; the other was the test score at the completion of their eighth-grade year. Because the fifth grade and eighth grade standardized tests were not the same test nor worth the same amount of points, the researcher equalized the data when working with the numbers in the SPSS program. Both scale scores and categories were compared for each student to study relative growth. By equalizing the numerical scores for each test, the researcher standardized the mean of both tests to zero, so that the scores were standardized relative to each test. Equalization allowed the researcher to create standardized means for time 1 (fifth grade) and time 2 (eighth grade) for a more reliable measurement of relative growth.

In addition to the investigation of curricular treatment, other factors were examined, including gender, race, and free/reduced lunch status. Although all five cooperating school districts presented the longitudinal MAP test data for each student, some school districts omitted data on some of those other factors. One large suburban district omitted gender, race/ethnicity, and free/reduced lunch status ($n = 949$), leaving only the MAP data. One of the small rural districts did not share the free/reduced lunch information on students ($n = 342$) on its data submission, but did include the other requested data. The remaining three school districts included all requested information. Therefore, the total numbers of subjects for different comparisons varied depending on the data available sent from the five cooperating school districts. These totals are noted in each test.

The researcher used MAP test results from 2010 and 2013 in a one-way repeated measures ANOVA to compare the effect of type of school district (science curriculum choice versus no choice in science) on relative growth in science achievement before and after three years of middle school science, by examining the test scores of both the fifth grade test results and eighth grade test results longitudinally.

Research Question 1

The first research question in this study asked if there is a difference in relative growth in science achievement between school districts that offer curricular choices in middle grades and those that do not. This question was meant to compare school district design in examining whether offering curricular choice in middle level science is advantageous for districts' standardized test scores and to examine the overall performance of science students under different curricular models. Eighth grade standardized test scores from one large suburban school district and one small rural school district, both with no choice in middle-school science curriculum (n = 1,121) were compared with those scores from two large suburban school districts and one small rural district that had two choices of science in their middle schools (n = 2,014). When sample sizes are large, as in this study, homogeneity is assumed with similarities in the standard deviations. If the lowest standard deviation in one group is not more than twice as large as the standard deviation in the other group, homogeneity is met. As shown in Table 4.1, the lowest standard deviation, the eighth-grade group scores (SD = .9556918) was not greater than twice the standard deviation of the fifth-grade group scores (SD = .99212549), indicating the homogeneity assumption had adequately been met.

Table 4.1

Comparing Relative Growth between 5th and 8th Grade

	Program Choice	Mean	Std. Deviation	N
Z score 5th grade	No	.0041016	.99212549	1121
	Yes	-.0022850	1.00459841	2013
	Total	.0000000	1.00000000	3134
Z score 8th grade	No	-.1517892	1.05863060	1121
	Yes	.0840529	.95569168	2013
	Total	-.0003268	.99999189	3134

Hypothesis 1_{null} stated that: There is no relationship between relative growth in science achievement and whether or not the school district offers a choice in science curricula in middle levels. Results show that there was a statistically significant effect for score, $F (1, 3133) = 7.63$, $p = .006$, partial eta-squared = .002, indicating that there was a significant difference between scores at time 1 (fifth grade) and time 2 (eighth grade). There was also a significant effect for the interaction between score and program choice, Wilk's Lambda = 0.984, $F (1, 3133) = 51.936$, $p < .001$, partial eta-squared = .016, indicating that the changes in scores from time 1 to time 2 were dependent on the program choice, although the significance was very small (see Figure 4.1).

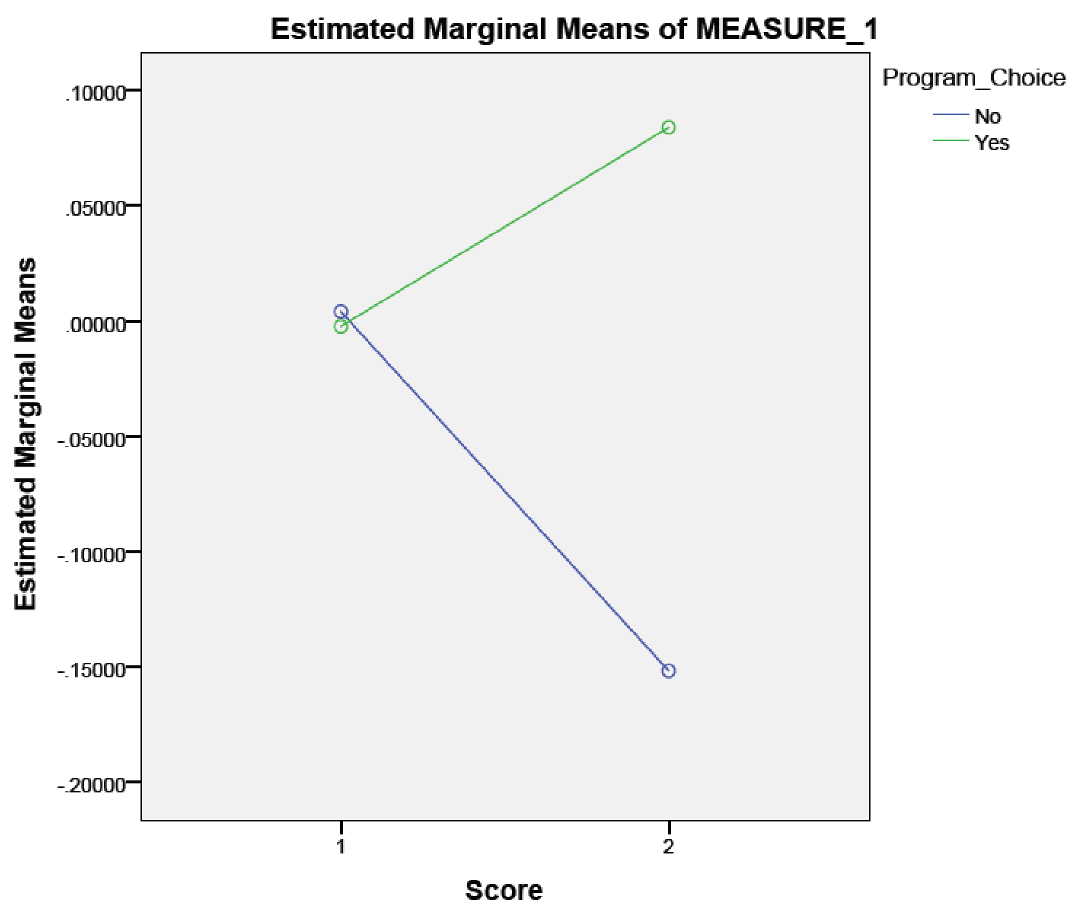

Figure 4.1. Comparison of Schools with and without Science Program Choice

Although the null hypothesis H1 was rejected, the effect size was very small in this instance. The lines indicating program type (see Figure 4.1) appear to be quite divergent, but in reality, the increments were very small between choice and non-choice schools at the completion of middle school.

The test of between-subjects effects (see Table 4.2) was used to further analyze the data to find whether the ANOVA result was statistically significant. According to Snedecor and Cochran (1989), the between-subjects effects provide the one-way ANOVA results for each dependent variable. Because the effect was so very small, the data showed that difference in performance may not be great enough to suggest that a choice option is really better than a non-choice curricular design. In addition, when comparing only students in regular classes across the board regardless of the type of curriculum offered, those in schools with a choice slightly outperformed those in the schools offering no choice, but only slightly as shown in Table 4.3. The confidence intervals in Table 4.3 show that in school districts that offer no science curriculum choice, the students in regular science classes tended to stay relatively low in science achievement over time M = -.074, 95% CI [-.123 -.024], and students who chose regular science classes in school districts with a choice tend to increase in science achievement a little more, although very slightly M = .114, 95% CI [.077 - .152].

Table 4.2

Test of Between-Subjects Effects for Schools with and without Science Program Choice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1.566	1	1.566	.890	.346	.000
Program Choice	18.969	1	18.969	10.782	.001	.003
Error	5513.530	3132	1.759			

Table 4.3

Confidence Intervals for Schools with and without Science Program Choice

Program Choice	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
No	-.074	.025	-.123	-.024
Yes	.114	.019	.077	.152

Research Question 2

The second research question investigated whether differences existed in relative growth in science achievement between those who enrolled in advanced science classes and those who did not in school districts that offered a choice. This question attempted to investigate if there is a social effect influencing student science achievement in school districts that allowed a setting of self-separation between advanced and regular science students. This research question focused only on school districts that allowed students a choice of science classes in middle-level years. In the participating school districts that offered a choice in science curriculum, all students were allowed freedom to choose which science class to enroll into with no prerequisite. Students from two large suburban districts and one small rural district (n = 2,013) were examined in this part of the study because those schools offered two science curricular choices: advanced science or regular science. As shown in Table 4.4, the lowest standard deviation, the eighth-grade group scores (SD =

.74912543) was not greater than twice the standard deviation of the fifth-grade group scores (SD = .77254436), indicating the homogeneity assumption had adequately been met.

Table 4.4

Comparison of Challenge vs. Regular Science in School Districts with a Choice

	Challenge Level	Mean	Std. Deviation	N
Z score 5th grade	Regular Science	-.4273298	.94781033	1150
	Challenge Science	.5634574	.77254436	863
	Total	-.0022850	1.00459841	2013
Z score 8th grade	Regular Science	-.3790037	.82364292	1150
	Challenge Science	.7003897	.74912543	863
	Total	.0840529	.95569168	2013

Hypothesis 2_{null} stated that: In school districts that offer a choice in science curriculum between advanced and regular science classes, there is no difference in relative growth in science achievement between students enrolled in advanced science and those enrolled in regular science. Results showed that there was a significant effect of two curricular choices being offered in the same school on relative growth in science achievement: Wilk's Lambda = .982, F (1, 2013) = 37.311, p = .000. The partial eta squared value was .018, indicating the effect to be very small; therefore the null hypothesis H1 was rejected. The data showed that there was a significant interaction between score and type of science class in schools that offered a choice in science curriculum, indicating that the changes in scores from time 1 to time 2 were dependent on the program choice (see Figure 4.2). The data showed that students who chose advanced science classes improved over time more than those in the regular science classes.

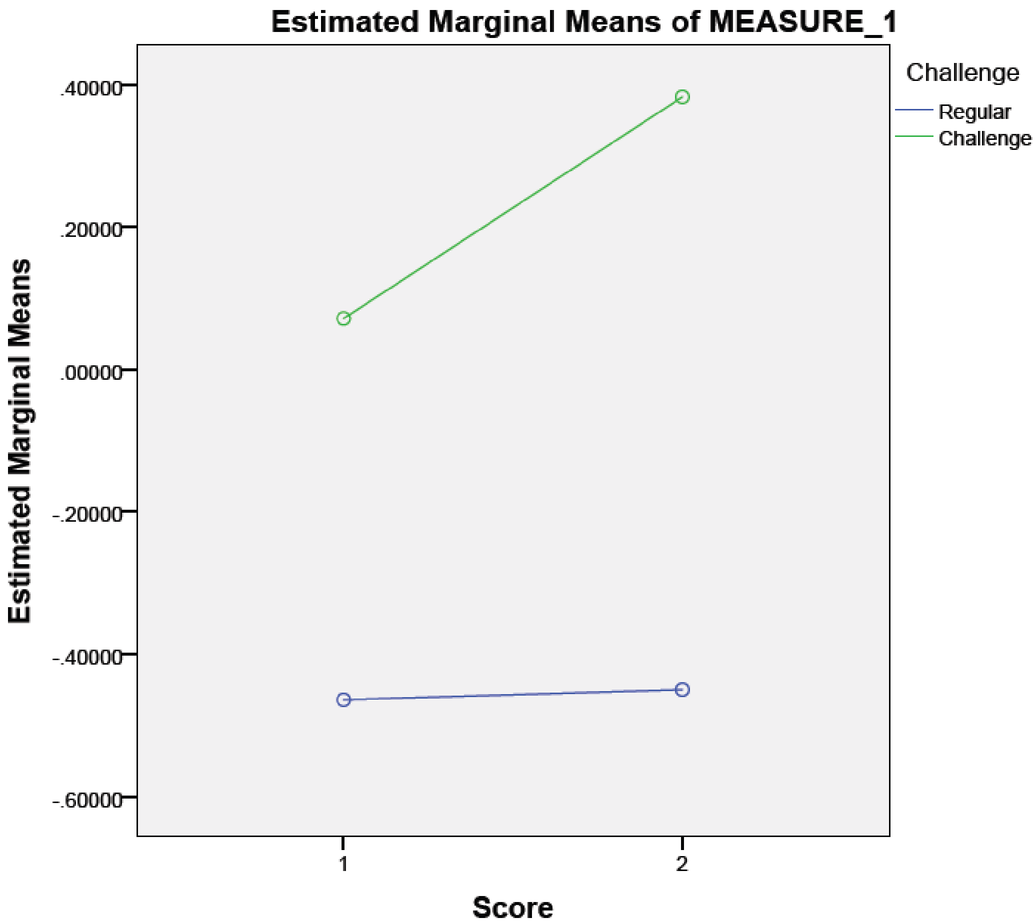

Figure 4.2. Regular vs. Advanced Science Students' Relative Growth over Time

The test of between subjects effects to find whether the ANOVA result (see Table 4.5) was statistically significant showed there is a statistical difference between performance on science achievement tests and type of science class students enroll into when there is a choice between advanced and regular ($p = .000$, $p < .05$).

Table 4.5

Test of Between-Subjects Effects Comparing Advanced and Regular Scores on Tests

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	51.633	1	51.633	44.122	.000	.021
Advanced	157.155	1	1057.155	903.372	.000	.310
Error	2354.507	2012	1.170			

This implies that in school districts offering a choice in science curriculum, those students choosing to enroll in advanced classes tended to have higher achievement scores than those who did not. There was a clear relationship between higher scores and enrollment in advanced science classes, but because classes were self-chosen, it is possible these differences may be attributed to factors other than instruction or curriculum differences.

Research Question 3

The third research question asked if gender had an effect on science achievement between those who enrolled in advanced science classes and those that did not. This question was meant to examine a relationship between gender and relative growth in science during middle school years. Hypothesis 3 stated: There is no difference in relative growth in science between the genders regardless of which type of science class the student chose. The researcher parsed this research question into three parts: comparing genders and science achievement overall without regard to other factors; gender comparison within only the no-choice school districts; and gender comparisons within the school districts that offered a choice differentiating between regular and advanced students.

First, the researcher investigated gender differences in science achievement and the relationship to curricular design. Of the five school districts participating in this study, four school districts offered gender data for students (n = 2,192). When sample sizes are large as in this study, homogeneity is assumed with similarities in the standard deviations. As shown in Table 4.6, the standard deviation for the lowest female group scores (SD = 24.277) was not greater than twice the standard deviation of the lowest male group scores (SD = 23.840), indicating the homogeneity assumption had adequately been met.

Table 4.6

Overall Relative Growth between Genders without Regard to any Other Factors

	Gender	Mean	Std. Deviation	N
Z score 5th grade	Female	678.22	24.277	1143
	Male	681.59	23.840	1049
	Total	679.83	24.122	2192
Z score 8th grade	Female	717.61	24.422	1143
	Male	719.48	26.050	1049
	Total	718.51	25.226	2192

Hypothesis 3_{null} stated that: There is no relationship between relative growth in science achievement and gender in middle levels. Results showed (see Figure 4.3) that there was no overall statistically significant effect for gender, Wilk's Lambda = .999, $F(1, 2182) = 2.400$, $p = .121$, indicating that there was no significant difference between scores at time 1 (fifth grade) and time 2 (eighth grade) between the genders overall without regard to the type of science class or type of district offerings for science. The null hypothesis was accepted.

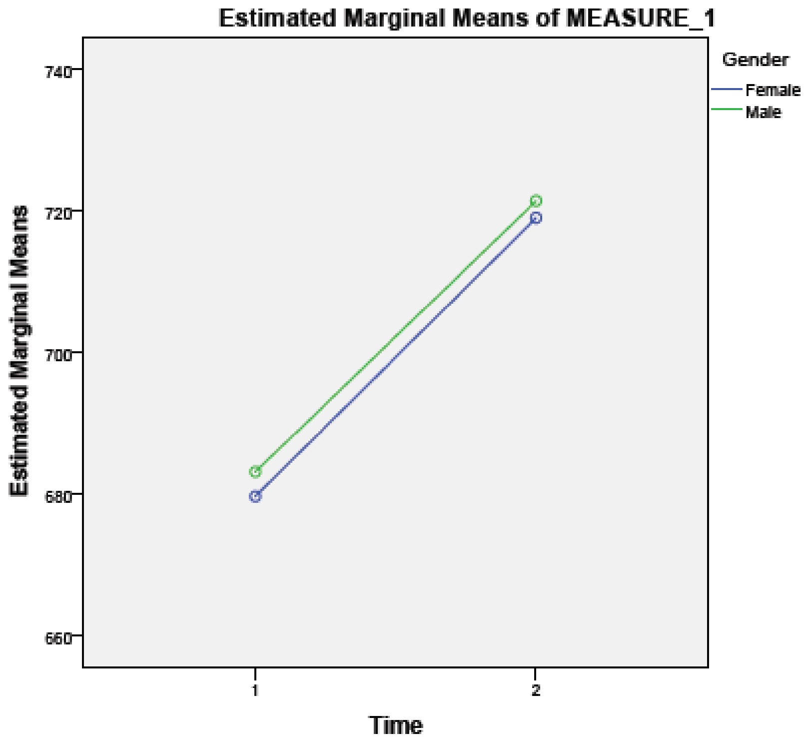

Figure 4.3. Relative Growth between Genders over Time.

However, to further analyze whether gender had an effect on science achievement scores in middle schools, the researcher compared males to females over time only with students (n = 1121) in school districts that did not offer science curricular choices. Homogeneity was assumed with similarities in the standard deviations. As shown in Table 4.7, the lowest standard deviation, the 5th grade female group (SD = .94144281) was not greater than twice the standard deviation of the 8th grade female group (SD = 1.00243790), assuming homogeneity.

Table 4.7

Descriptive Statistics Comparing Genders in No-Choice of Science School Districts

	Gender	Mean	Std. Deviation	N
Z score 5th grade	Female	-.0376829	.94144281	570
	Male	.0474027	1.04114055	551
	Total	.0041016	.99212549	1121
Z score 8th grade	Female	-.1904546	1.00243790	570
	Male	-.1117203	1.11337521	551
	Total	.1733227	.92232174	1121

Results showed (see Figure 4.4) that there was no statistically significant effect for gender, Wilk's Lambda = 1.000, F (1, 1120) = .025, p = .875, indicating that there was no difference in performance and relative growth between genders from scores at time 1 (fifth grade) and time 2 (eighth grade). Although there was no difference in how the different genders perform in the regular science in no-choice schools, it should be noted that both groups declined slightly over time.

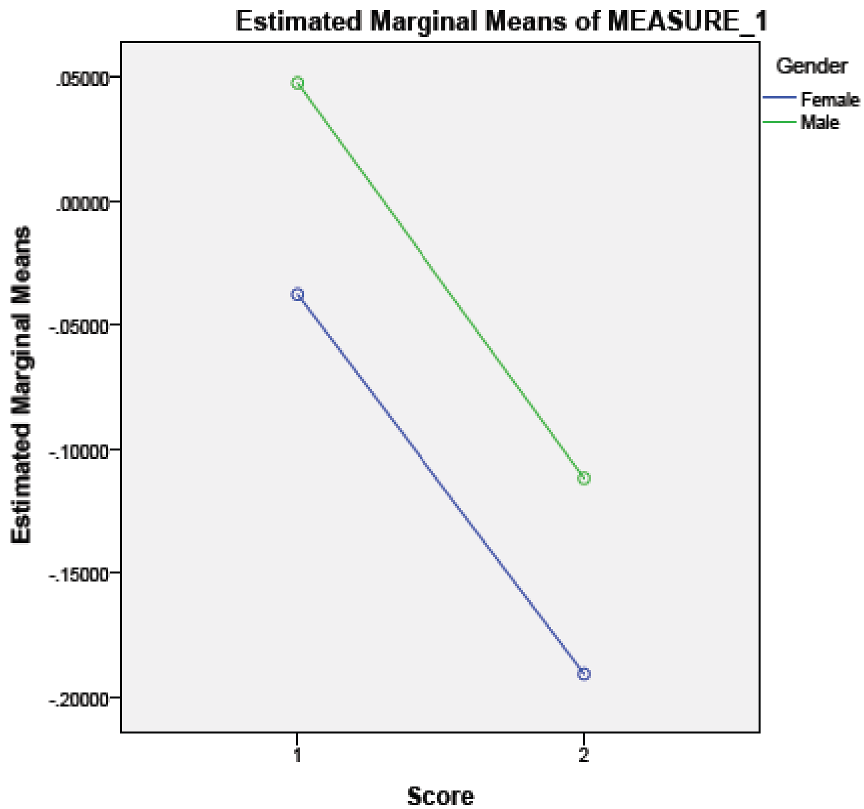

Figure 4.4. Genders in Regular Science Class in Schools with No Curricular Choice.

Finally, comparing science achievement between males and females (n = 1070) in school districts that offer a choice in middle school science curriculum between advanced and regular classes, homogeneity was assumed with similarities in the standard deviations. As shown in the data Table 4.8, the lowest standard deviation, the 8th grade female group (SD = .92038910) was not greater than twice the standard deviation of the 5th grade male group (SD = .96045684), assuming homogeneity.

Table 4.8

Comparing Genders Achievement in Schools with Science Curricular Choice

	Gender	Mean	Std. Deviation	N
Z score 5th grade	Female	-.0416078	1.09968371	572
	Male	.1631868	.96045684	498
	Total	.0537078	1.04176107	1070
Z score 8th grade	Female	.1324119	.92038910	572
	Male	.2203125	.92322360	498
	Total	.1733227	.92232174	1070

Results showed that there was a statistically significant effect for gender in curriculum-choice school settings, Wilk's Lambda = .993, F (1, 1068) = 7.369, p = .007, partial eta-squared = .007, indicating that there was a slight significant difference in scores between genders at time 1 (fifth grade) and time 2 (eighth grade). As shown in Figure 4.5 , males perform better overall, while females increase more sharply than males yet still fail to catch up with males by time 2. While it showed significance, the effect was quite small.

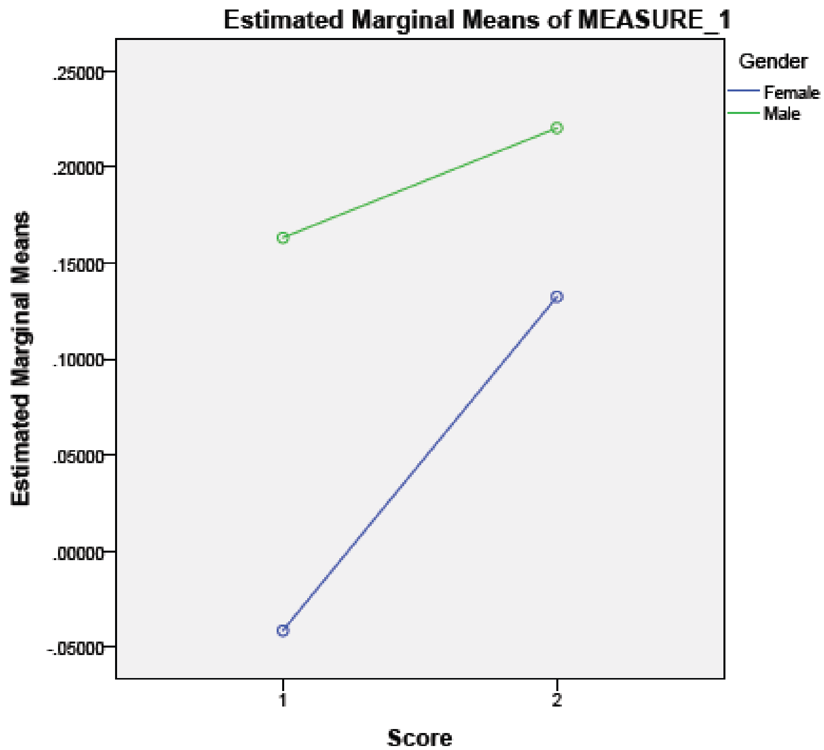

Figure 4.5 Genders and Overall Science Achievement in Schools with Curricular Choice.

Because the effect was so small, the data showed that difference in performance may not be great enough to suggest that a choice option was really better than non-choice curricular design (see Table 4.9).

Table 4.9

Test of Between-Subjects Effects regarding Gender and Science Choice Schools over Time

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	29.945	1	29.945	17.840	.000	.016
Gender	11.404	1	11.404	6.794	.009	.006
Error	1792.679	1068	1.679			

Although the gender differences are statistically significant, the size may deem them impractical.

Research Question 4

The fourth research question in this study investigated the relationship between race/ethnicity and relative growth in middle school science knowledge. Hypothesis 4 stated: There is no relationship between race/ethnicity and relative growth in science. On the 2010 MAP test, student race/ethnicity was selected among the following choices: American Indian, Asian, Black, Hispanic, White, and Other. Because no students chose the “Other” category in any of the data in this study, that category was not included in the data. This research question was parsed into six parts. The researcher examined a relationship between race/ethnicity overall and relative growth in science overall, without regard to curricular design or science class enrolled in; the relationship between race/ethnicity and science achievement in schools that did not offer science curricular choices; whether race/ethnicity and science achievement were related only in schools that offered choices in the science curriculum. The relationship between race/ethnicity and science achievement scores were compared between two curricular models. The researcher compared students enrolled in regular science with those who chose the advanced classes to examine whether race/ethnicity was a factor in science middle school achievement. Finally, the researcher examined enrollment patterns in the two types of science classes in schools that offered a choice.

Four of the five school districts included the data for students ($n = 2192$). When sample sizes are large, homogeneity is assumed when the lowest standard deviation in one group is not more than twice as large as the standard deviation in the other group. As shown in Table 4.10, the lowest standard deviation number, White 5th-grade group scores (SD = 22.604), was not greater than twice the standard deviation of the White 8th-grade group scores (SD = 23.880), indicating the homogeneity assumption had adequately been met.

Table 4.10

Ethnicity over Time with Science Achievement Scores with No Other Factors

	Race/Ethnicity	Mean	Std. Deviation	N
Z score 5th grade	American Indian	670.09	26.372	11
	Asian	681.87	23.931	140
	Black	657.88	24.599	206
	Hispanic	668.75	23.317	75
	White	682.77	22.604	1760
	Total	679.83	24.122	2192
Z score 8th grade	American Indian	708.18	30.377	11
	Asian	730.70	24.508	140
	Black	698.24	24.872	206
	Hispanic	708.52	26.307	75
	White	720.40	23.880	1760
	Total	718.51	25.226	2192

Results showed that there was a significant effect of race/ethnicity on relative science growth at the middle level, Wilk's Lambda = .991 (4, 2182) = 4.699, p = .001. Because $p < 0.05$, there existed a statistically significant relationship between relative growth in science achievement and races/ethnicity, although it was small (see Figure 4.6). Therefore, the null hypothesis H4 was rejected. Although all student improved over time, some race/ethnicities improved more and at a different rate than others overall.

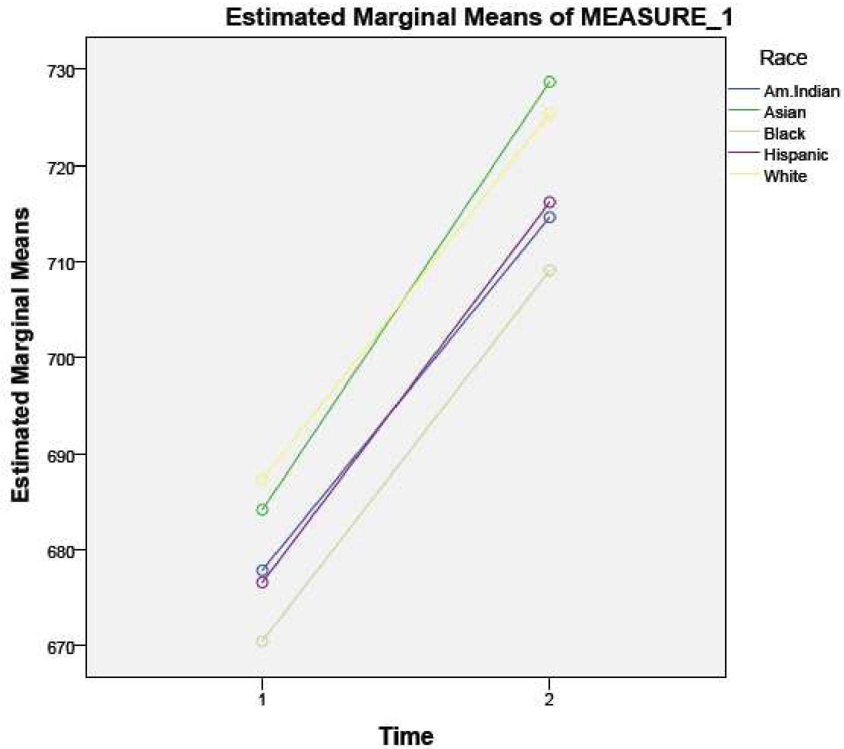

Figure 4.6. Science Scores by Race/Ethnicity over Time without Other Factors.

The test of between-subjects effects (see Table 4.11) was used to further analyze the data to find whether the ANOVA result was statistically significant. The data showed that there was a moderately significant relationship between race/ethnicity and relative science growth in middle school, without regard to other factors such as curriculum design or type of science class.

Table 4.11

Science Achievement Scores by Ethnicity in Schools without Curricular Choice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	186107205.5	1	186107205.5	228298.186	.000	.991
Race/Ethnicity	144600.015	4	36150.004	44.345	.000	.075
Error	1778752.296	2182	815.194			

The second part of R4 asked if there was a relationship between race/ethnicity and science achievement on students (n = 1121) in specific schools that did not offer science curricular choices. As shown in Table 4.12, the lowest standard deviation number, Hispanic 5th-grade group scores, (SD = .93957258) was not greater than twice the standard deviation of the White 8th-grade group scores (SD = 1.02744111), indicating the homogeneity assumption had adequately been met.

Hypothesis 4_{null} stated: There is no relationship between relative growth in science achievement and race/ethnicity. Although there was a moderate effect overall, results from only schools that lacked a curriculum choice also showed that there was a statistically significant interaction between race/ethnicity and science score, Wilk's Lambda = .997, F (4, 1117) = .957, p = .430, partial eta-squared = .003, indicating that the effect was small when the science classes were not self-divided (see Figure 4.7).

Table 4.12

Test of Between-Subjects Effects by Ethnicity in Schools without Curricular Choice

	Race/Ethnicity	Mean	Std. Deviation	N
Z score 5th grade	American Indian	-.1873197	1.17381889	7
	Asian	.1575570	1.04741149	29
	Black	-.5920866	.97383459	99
	Hispanic	-.3788660	.93957258	53
	White	.0856965	.96867671	933
	Total	.0041016	.99212549	1121
Z score 8th grade	American Indian	-.4754792	1.38165261	7
	Asian	.2193612	1.06892779	29
	Black	-.7983642	1.04147421	99
	Hispanic	-.5197206	1.09488083	53
	White	-.0714746	1.02744111	933
	Total	-.1517892	1.05863060	1121

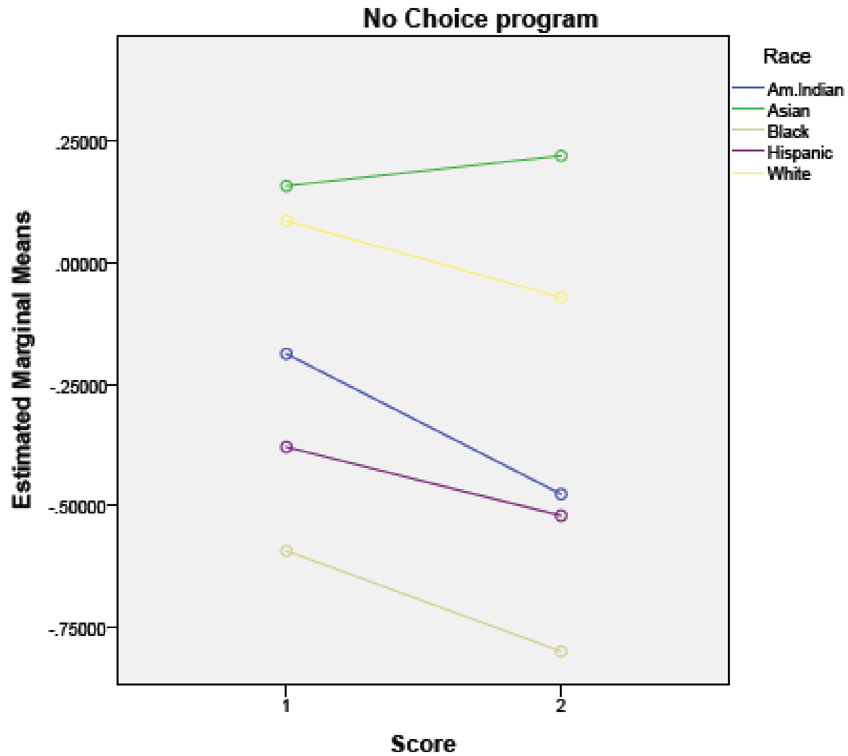

Figure 4.7. Science Scores by Race/Ethnicity over Time in Schools with No Curricular Choice

As seen in Figure 4.7, Asian students improved over time while the other race/ethnicities declined over time when science classes were heterogeneous. This finding was consistent with the first investigation in that the null hypothesis was rejected. The test of between-subjects effects (see Table 4.13) was used to further analyze the data to find whether the ANOVA result was statistically significant. Because the effect was so very small, the data showed that difference in performance may not be great enough to suggest that a choice option was really better than non-choice curricular design.

Table 4.13

Comparing Relative Science Growth by Ethnicity in Schools with Curricular Choice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	15.810	1	15.810	8.859	.003	.006
Race/Ethnicity	108.554	4	27.139	15.208	.000	.052
Error	1993.314	1117	1.785			

The third part of research question 4 investigated whether race/ethnicity and offering choices in science curriculum were related to science achievement. This question was meant to examine the effect of middle-level science curriculum design and self-segregation on racial/ethnic groups on overall performance of science students (n = 746).

Homogeneity was assumed with similarities in the standard deviations, as shown in Table 4.14, the lowest standard deviation, the White 8th-grade group scores (SD = .82949241) was not greater than twice the standard deviation of the White 5th-grade group scores (SD = .92923282), indicating the homogeneity assumption had adequately been met.

Table 4.14

Test of Between-Subjects Effects for Science Achievement by Ethnicity

	Race/Ethnicity	Mean	Std. Deviation	N
Z score 5th grade	American Indian	-.7232177	1.05793861	4
	Asian	.1030601	1.00286438	111
	Black	-1.1789815	1.01743316	107
	Hispanic	-.5833587	1.08932990	22
	White	.2274884	.92923282	826
	Total	.0537078	1.04176107	1070
Z score 8th grade	American Indian	-.2829325	1.02771196	4
	Asian	.5655196	.94582942	111
	Black	-.8064810	.95138747	107
	Hispanic	-.0841620	.88349115	22
	White	.2566094	.82949241	826
	Total	.1733227	.922322174	1070

Hypothesis 4_{null} stated: There is no relationship between relative growth in science achievement and race/ethnicity which was previously rejected overall, and was also rejected within the schools with no science choice. In schools that offered two choices of science in middle school, results showed that there remains a statistically significant effect for score, Wilk's Lambda = .943, F (4, 1065) = 16.080, p = .000, partial eta-squared = .057, indicating that there was a significant difference in science growth at time 1 (fifth grade) and time 2 (eighth grade) between the races/ethnicities in schools that offered self-segregation into different science classes at middle level, as seen in Figure 4.8.

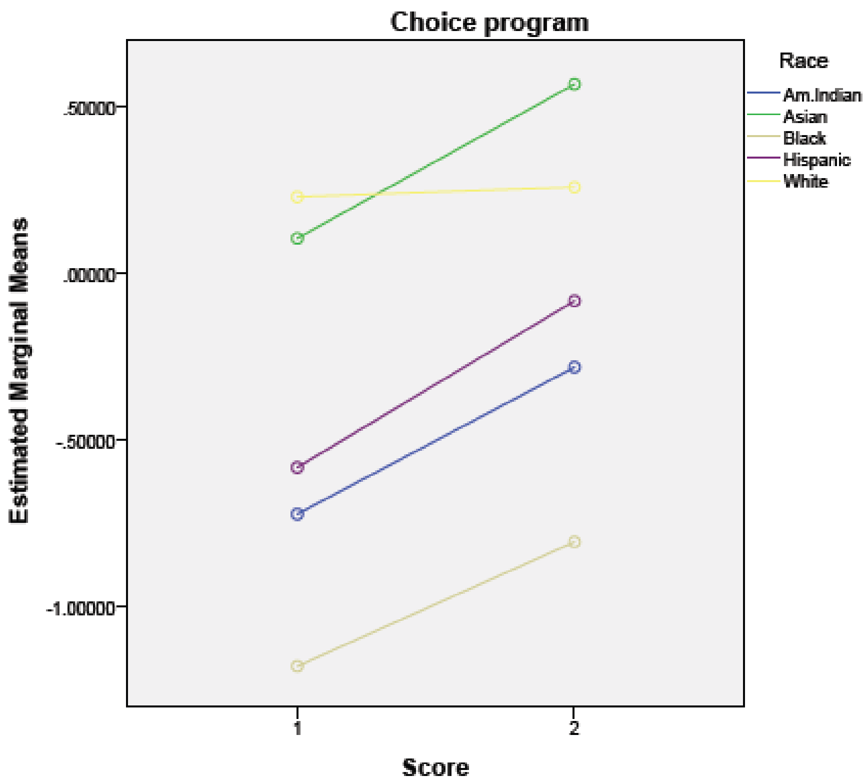

Figure 4.8. Relative Growth by Race/Ethnicity over Time in Schools with Curricular Choice.

As the data show, White students tended to flat-line over time, while all other race/ethnicities tended to improve. Asian students showed the steepest improvement over time, surpassing the White students for the top spot by eighth grade. The test of between-subjects effects (see Table 4.15) was used to further analyze the data to find whether the ANOVA result was statistically significant.

Table 4.15

Comparing Relative Growth in Different Curricular Models by Ethnicity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	9.971	1	9.971	7.116	.008	.007
Race/Ethnicity	311.846	4	77.962	55.641	.000	.173
Error	1492.236	1065	1.401			

The fourth part of this research question concerning race/ethnicity and science achievement scores involved a comparison between curricular models: those that offered no choice, and those that offered a self-segregated choice. This question was meant to compare school district design in examining whether offering curricular choice in middle level science was advantageous for districts' standardized test scores and to examine the overall performance of science students with different races/ethnicities. As shown in Table 4.16, the lowest standard deviation, Hispanic 8th-graders in a school offering choice in curriculum group scores (SD = 19.464) was not greater than twice the standard deviation of the other group, White 5th-grader in schools of choice group scores (SD = 20.376), indicating the homogeneity assumption had adequately been met.

Table 4.16

Test of Between-Subjects Effects by Ethnicity in Schools with No Curricular Choice

	Race/Ethnicity	Mean	Std. Deviation	N
Z score 5th grade	American Indian	674.71	27.849	7
No-Choice	Asian	682.90	24.850	29
School Districts	Black	665.11	23.104	99
	Hispanic	670.17	22.292	53
	White	681.19	22.982	934
	Total	679.26	23.538	1122
Z score 5th grade	American Indian	655.00	---	3
Curricular	Asian	679.89	22.658	97
Choice	Black	649.63	24.128	98
Available in	Hispanic	663.38	24.792	21
School Districts	White	680.49	20.376	527
	Total	675.77	23.817	746
Z score 8th grade	American Indian	706.43	34.597	7
No-Choice	Asian	723.83	26.766	29
School Districts	Black	698.34	26.079	99
	Hispanic	705.32	27.416	53
	White	716.54	25.727	934
	Total	714.53	26.508	1122
Z score 8th grade	American Indian	702.33	22.723	3
Curricular	Asian	732.75	23.663	97
Choice	Black	697.46	23.860	98
Available in	Hispanic	713.81	19.464	21
School Districts	White	725.63	21.091	527
	Total	722.43	24.058	746

The null hypothesis for research question 4 has been rejected in each way thus far, and race/ethnicity continued to be a significant factor when comparing types of curricular models in schools. There was a significant relationship between race/ethnicity and relative growth in science achievement and whether or not the school district offered a choice in science curricula in middle levels. Results showed that there was a statistically significant effect with race/ethnicity, Wilk's Lambda = .989, F (4, 1860) = 5.350, p = .000, partial eta-squared = .011, indicating that there was a small significant effect for the interaction between race/ethnicity and curricular design. Schools that offered a choice tended to show more increases in scores over time with different races/ethnicities than do schools with no choice in science classes. The test of between-subjects effects (see Table 4.17) was used to further analyze the data.

Table 4.17

Comparison of Advanced and Regular Science Students by Ethnicity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	181762602.3	1	181762602.3	192413.932	.000	.990
Race	142439.335	4	35609.834	37.697	.000	.075
Error	1757037.224	1860	944.644			

The next comparison involving race/ethnicity was that of the type of science class taken by students in middle school and the relationship to standardized test scores (n = 2192) over time. In large sample sizes, similarities in the standard deviations can indicate whether homogeneity is met. As shown in Table 4.18, the lowest standard deviation, the regular American Indian group score (SD = 27.430) was not greater than twice the standard deviation of the challenge science White group scores (SD = 17.132), indicating the homogeneity assumption had adequately been met.

Table 4.18

Test of Between-Subjects Effects by Ethnicity and Type of Science Class

Program Choice	Race/Ethnicity	Mean	Std. Deviation	N
Regular Science	American Indian	668.80	27.430	10
	Asian	671.84	23.134	65
	Black	656.16	25.061	188
	Hispanic	667.54	23.380	68
	White	678.54	22.630	1392
	TOTAL	676.16	24.126	1723
Challenge Science	American Indian	683.00	---	1
	Asian	689.35	21.382	75
	Black	669.83	18.357	18
	Hispanic	683.43	20.631	7
	White	695.55	17.132	368
	TOTAL	693.32	18.722	469

The data showed that race/ethnicity remained a significant factor on science growth over time, Wilk's Lambda = .992, $F(4,2183) = 4.646$, $p = .001$. Because $p < 0.05$, there was a significant difference in the scores between race/ethnicities no matter what type of science curriculum was offered. The partial eta squared value was .008, showing the effect of type of science class to be a small one.

The data showed that all race/ethnicities improved over time in advanced classes, but the Asian student group improved the most. The White students and the American

Indian students tended to flat-line, and the Hispanic advanced students end up surpassing the American Indian students. The Black students started very low and improved over time, yet exhibited the lowest scores of the advanced group.

Table 4.19

Changes in Mean Scores over Time by Ethnicity and Type of Science Class

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	159215479.7	1	159215479.7	189237.767	.000	.990
Race	90562.581	4	22640.645	26.910	.000	.055
Error	1563231.094	1858	841.352			

The test of between-subjects effects was used to further analyze the data to find whether the ANOVA result was statistically significant. The data demonstrated (see Table 4.19) statistical difference in race/ethnicity and relative growth in science achievement ($p = .000$, $p < .05$). This suggested that race/ethnicity had an impact on achievement, regardless of the type of instruction they received. The partial eta squared value was .055, showing the effect to be a moderate one.

Further analysis was done using the data to examine relative growth among the differences in race/ethnicity. As seen in Table 4.20, the mean science scores for all race/ethnicity groups increased over time in middle school. However, some increased more than others. While students in the non-challenge science classes increased in relative growth over time, it was not as big as the students who were in the challenge sciences overall. When this data was broken down by race/ethnicity, the numbers showed that some groups exhibited a larger relative growth than others.

Table 4.20

Confidence Intervals Comparing Advanced and Regular Science Class Scores

Program Choice	Race/Ethnicity	Grade	Mean	Change in Mean over time	Std. Deviation	N
Students enrolled in regular science overall	American Indian	5	674.71	+31.72	27.849	7
		8	706.43		34.597	
	Asian	5	682.90	+40.93	24.850	29
		8	723.83		26.766	
	Black	5	665.11	+33.23	23.104	99
		8	698.34		26.079	
	Hispanic	5	670.17	+35.15	22.292	53
		8	705.32		27.416	
	White	5	681.19	+35.35	22.982	934
		8	716.54		25.727	
	TOTAL	5	679.26	+35.27	23.538	1122
		8	714.53		26.508	
Students enrolled in challenge science	American Indian	5	655.00	+47.33	25.515	3
		8	702.33		22.723	
	Asian	5	679.89	+52.86	22.658	97
		8	732.75		23.663	
	Black	5	649.63	+47.57	24.128	98
		8	697.46		23.860	
	Hispanic	5	663.38	+50.43	24.792	21
		8	713.81		19.464	
	White	5	680.49	+45.15	20.376	527
		8	725.63		21.091	
	TOTAL	5	675.77	+46.66	23.817	746
		8	722.43		24.058	

These same results of the scores over time and student race/ethnicity is shown in the plot graph (see Figure 4.9), and ignores the type of science classes students were enrolled in.

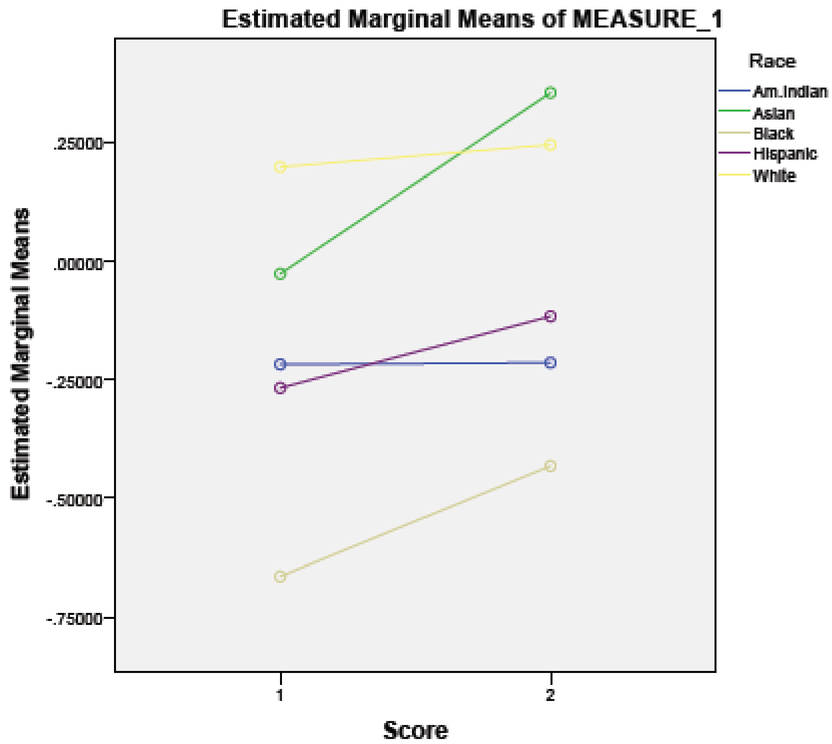

Figure 4.9. Overall Science Achievement Scores over Time by Race/Ethnicity.

The steeper lines indicate more relative growth. This implies that the relative growth in science with vary among different races. Asian students tended to show more relative growth than the other races (M = +46.895), followed by the Hispanic (M = +42.79) and Black (M = +40.40) students. White students showed relative growth over time (M = +40.25), but their scores started high and ended high over time. The Asian students started with scores lower than the White students, but during middle school surpassed the White group. Overall, the group with the least relative growth in science were the American Indians (M = +39.525) when compared to the four other groups.

Confidence intervals showed estimates of 95% of the true population. As shown in Table 4.21, advanced science students improved more than regular science students; however, race/ethnicity was a statistically significant factor in relative growth in science.

Table 4.21

Overall Enrollment into Advanced Science Classes by Ethnicity in Middle Schools

			95% Confidence Interval	
Science Class	Mean	Std. Error	Lower Bound	Upper Bound
Regular Science	-.457	.062	-.579	-.335
Advanced Science	.227	.077	.077	.377

Finally, enrollment information was also surveyed using the data in this study. Students who chose to enroll in challenge science varied by race as well, as seen in Table 4.22. Asian students chose challenge science most of the time when given a choice. Half of the Black student population chose challenge science over regular science; Hispanic and White students were less eager to choose the challenge science class. The American Indian sample size was too small to be reliable on this point (n = 10).

Table 4.22

Comparing Race/Ethnicity and Enrollment in Advanced Science Classes

Race/Ethnicity	N = students enrolled in challenge science	Percent
American Indian	3	30%
Asian	97	77%
Black	98	50%
Hispanic	21	28%
White	527	36%
Total	746	40%

Research Question 5

The fifth research question investigated the relationship between free/reduced lunch status and relative growth in middle school science. Although there are several studies (Hair, Hanson, Wolfe et al., 2015; Jyoti, Frongillo, & Jones, 2005; Mertens & Flowers, 2003; Munoz & Dossett, 2001,) that show financial hardship has an adverse effect on learning in general, this question was meant to study the relationship between free/reduced lunch status specifically on science growth in middle level learning. Hypothesis 5_{null} stated that there is no relationship between relative growth in longitudinal science achievement and free/reduced lunch status. Only three of the five schools in this study provided this statistic to the researcher (two large suburban schools and one small rural school). This research question was addressed in four parts: First, whether there was a relationship between FRL status and relative science academic longitudinal growth overall without regard to other factors; second, whether there was a relationship between science academic growth and the type of curricular model for science program on the FRL population; third, whether there was a relationship between FRL status and relative science academic growth in schools that offered a choice in science curriculum; fourth, whether there was a relationship between FRL status and relative science academic growth in students who are in schools with the same type of science class mixed at random.

When taking the entire pool of eligible student data in this study, homogeneity was assumed with similarities in the standard deviations, as shown in Table 4.23. Because of the large sample size in this portion of the study (n = 1868), the lowest standard deviation, the 5th-grade non-FRL group (SD = 22.131) was not greater than twice the standard deviation of the 8th-grade student group getting FRL assistance (SD = 24.964), indicating the homogeneity assumption had adequately been met.

Table 4.23

Test of Between-Subjects Effects for Ethnicity and Type of Science Class

	Free/Reduced	Mean	Std. Deviation	N
Z score 5th grade	No	680.76	22.131	1365
	Yes	670.02	25.977	503
	Total	677.87	23.705	1868
Z score 8th grade	No	721.72	24.986	1365
	Yes	706.74	24.964	503
	Total	717.69	25.842	1868

Results showed (see Table 4.23) that there was a small significant effect in relative growth in science learning with students under the category free/reduced lunch status, Wilk's Lambda = .999, (1, 1858) = 2.177, p = .000. Because $p < 0.05$, there was a significant relationship between the relative growth of science students in middle schools and whether they were in the category of free/reduced lunch status; therefore the null hypothesis H5null was rejected (see Figure 4.10).

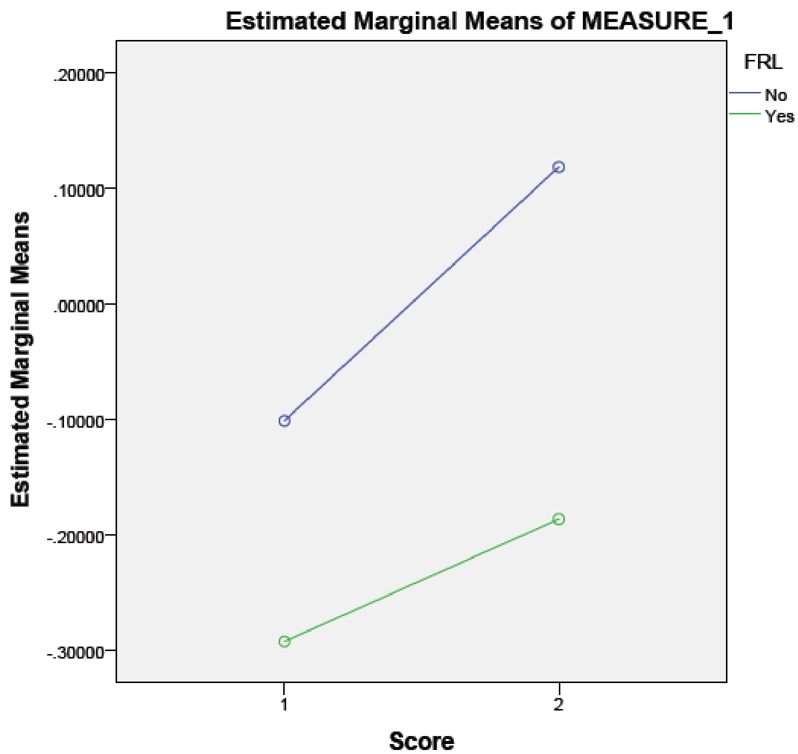

Figure 4.10. Overall Science Achievement Scores over Time in FRL and Non-FRL Students

The test of between-subjects effects (see Table 4.24) was used to further analyze the data to find whether the ANOVA result was statistically significant. The results show there was a statistical difference in relative growth in science between students on the free/reduced lunch program and those that were not ($p = .015$, $p < .05$). This implies that students from homes needing financial assistance had a lower relative growth in science than those that do not need assistance, although the effect was small.

Table 4.24

Comparing Relative Growth in Science with FRL Status and Type of Curricular Model

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	4.633	1	4.633	3.178	.075	.002
FRL	40.012	1	40.012	27.450	.000	0.015
Error	2711.156	1860	1.458			

The second part of the research concerning students from financially-stressed homes investigated whether there was a relationship between science academic growth and the type of curricular model for science program on the FRL population. One model offered self-selected classes consisting of advanced and regular science, and the other model offered all students the same science class heterogeneously mixed at random. Homogeneity was assumed with similarities in the standard deviations. If the lowest standard deviation in one group is not more than twice as large as the standard deviation in the other group, homogeneity is met. As shown in Table 4.25, the lowest standard deviation, the 5th-grade group scores within a program-choice school who were not FRL participants (SD = .87215990) was not greater than twice the standard deviation of the 8th -grade non-FRL participant group scores (SD =.84534431), indicating the homogeneity assumption had adequately been met.

Table 4.25

Comparison of School Science Program Choice and FRL Status on Achievement Scores

	Program Choice	FRL Participants	Mean	Std. Deviation	N
Z score 5th grade	No	No	.0663049	.97893404	760
		Yes	-.1264910	1.00819610	362
		Total	.0041016	.99212549	1122
	Yes	No	.0685618	.87215990	605
		Yes	-1.0490526	1.02989350	141
		Total	-.1426763	1.00386216	746
	Total	No	.0673052	.93278538	1365
		Yes	-.3851017	1.09490366	503
		Total	-.0545153	.99915173	1868
Z score 8th grade	No	No	-.0412169	1.07256746	760
		Yes	-.3839299	.99074540	362
		Total	-.1517892	1.05863060	1122
	Yes	No	.3567470	.84534431	605
		Yes	-.6656488	.98754516	141
		Total	.1635060	.96076462	746
	Total	No	.1351701	.99784432	1365
		Yes	-.4629008	.99694463	503
		Total	-.0258736	1.03203468	1868

When the relationship of FRL status and type of curriculum model was examined, results showed that there was a statistically significant effect among FRL students, Wilk's Lambda = .994, F (1, 1864) = 11.018, p = .001, partial eta-squared = .006, indicating that there was a significant effect for the interaction between score and program choice, and that score changes in scores from time 1 to time 2 were dependent on the FRL status and program choice, although the significance was small (see Figure 4.11).

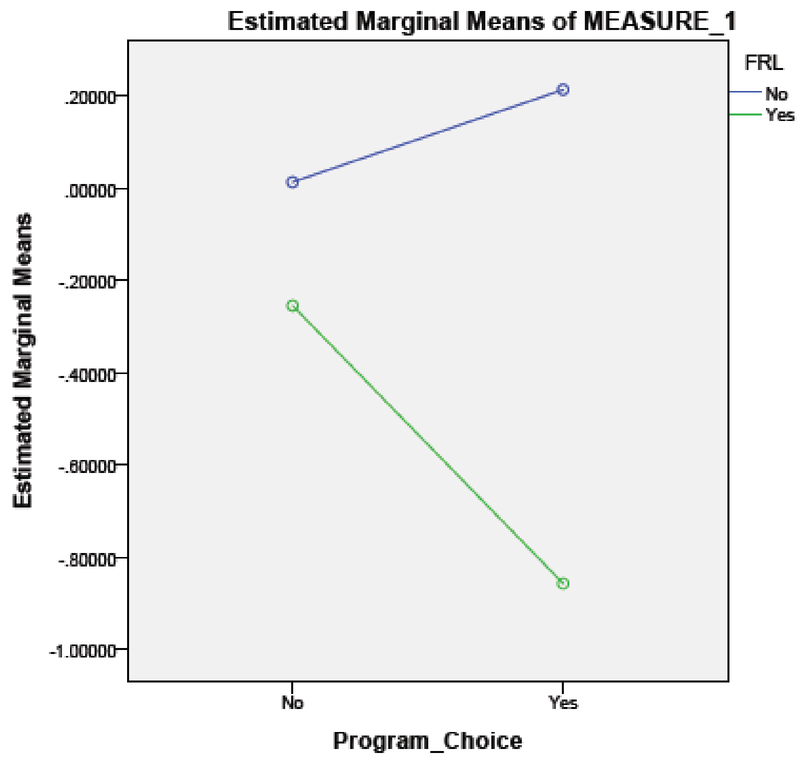

Figure 4.11. Comparing District Program Model and FRL Status on Achievement Scores.

The data showed a 3-way interaction between science program choice, FRL status, and achievement scores. Among students who were not FRL participants, the scores increased with program choice. However, among students who were FRL participants, the scores decreased with program choice, controlling for influence of the sub-analysis. Although the null hypothesis was rejected in this situation, the effect was so small that it was not practical to base curriculum re-alignment on this factor alone. To further analyze the data for significance, the between-subjects effects table (see Table 4.26) provided results for each dependent variable.

Table 4.26

Test of Between-Subjects Effects for FRL Status, Science Scores, and Science Program

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	122.810	1	122.810	73.808	.000	.038
Program Choice * FRL	100.381	1	100.381	60.329	.000	.031
Program Choice	25.208	1	25.208	15.150	.000	.008
FRL	279.117	1	279.117	167.749	.000	.083
Error	3101.510	1864	1.664			

The third part of the research question regarding FRL students and science achievement scores investigated whether there was a relationship between FRL status and relative science academic growth in schools that offered a choice in science curriculum. Students self-segregated into either advanced or regular science classes in this model (n = 746). The purpose of this question was to compare whether there was a social effect in this curricular model that affected children from financially-stressed homes.

As shown in Table 4.27, the lowest standard deviation, the 8th-grade non-FRL participant group score (SD =.84534431) was not greater than twice the standard deviation of the 5th-grade non-FRL participant group score (SD = .87215990), indicating the homogeneity assumption had adequately been met.

Table 4. 27

Comparing Relative Science Growth in FRL Students in Schools with Curricular Choice

	FRL	Mean	Std. Deviation	N
Z score 5th grade	No	.0685618	.87215990	605
	Yes	-1.0490526	1.02989350	141
	Total	-.1426763	1.00386216	746
Z score 8th grade	No	.3567470	.84534431	605
	Yes	-.6656488	.98754516	141
	Total	.1635060	.96076462	746

Results showed that in schools that allow students to choose between advanced and regular science classes, there was a statistically significant effect concerning FRL students, Wilk's Lambda = .846, F (1, 744) = 135.790, p = .000, with a partial eta squared of .154 showing a medium effect. The plot graph (see Figure 4.12) shows the relationship between FRL status and science growth in schools that offered a choice in curriculum. In this comparison, the null hypothesis was rejected.

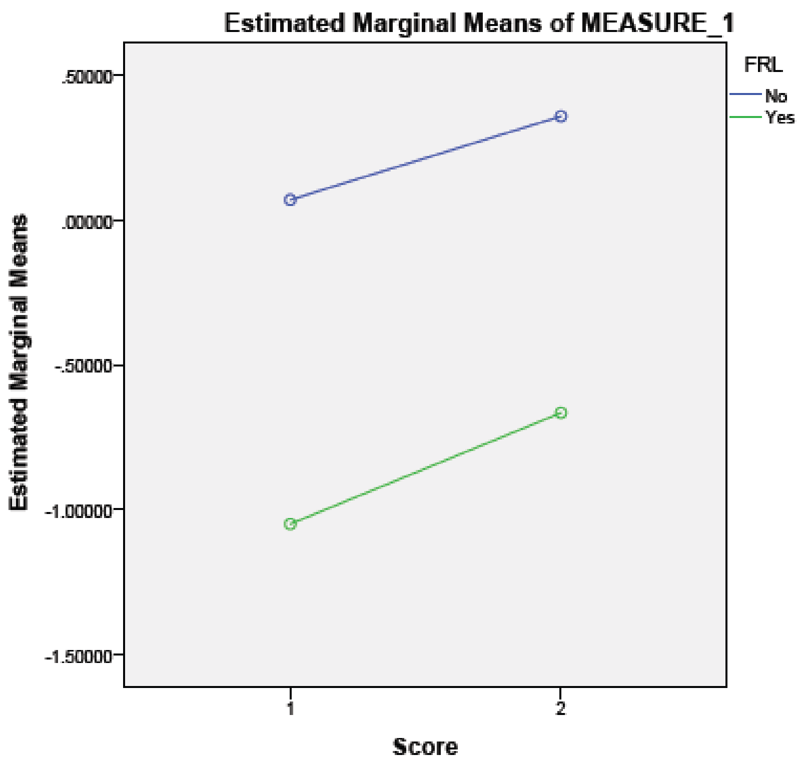

Figure 4.12. Science Scores by FRL Status in schools with Curricular Choice

Table 4-39: Comparing Relative Growth in science in choice schools and FRL status

The scores showed an increase overall among all students; however, the FRL students began behind the non-FRL students and did not get close to catching up.

The test of between-subjects effects (see Table 4.28) was used to further analyze the data to find whether the ANOVA result was statistically significant. The data showed that difference in performance may be enough to suggest that a choice option was really better for the FRL population than non-choice curricular design.

Table 4.28

Comparing Relative Science Growth in FRL and Non-FRL Students in Schools with Curricular Choice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	95.055	1	95.055	68.343	.000	.084
FRL	261.841	1	261.841	188.258	.000	.202
Error	1034.801	744	1.391			

The fourth part of the question regarding student FRL status and science achievement scores examined whether a relationship existed in schools with no choice in science curriculum. This part of the investigation was meant to discover whether keeping students in heterogeneous groups in schools with no curricular choice would have an effect on the relative growth of students from financially-stressed homes.

When sample sizes are large, as in this study, homogeneity is assumed with similarities in the standard deviations. If the lowest standard deviation in one group is not more than twice as large as the standard deviation in the other group, homogeneity is met. As shown in Table 4.29, the lowest standard deviation, the 5th -grade non-FRL group score (SD = . 97893404), was not greater than twice the standard deviation of the 8th-grade FRL group score (SD = .99074540), indicating the homogeneity assumption had adequately been met.

Table 4.29

Comparing Relative Growth and FRL Status in Schools with No Curricular Choice

	FRL	Mean	Std. Deviation	N
Z score 5th grade	No	.0663049	.97893404	760
	Yes	-.1264910	1.00819610	362
	Total	.0041016	.99212549	1122
Z score 8th grade	No	-.0412169	1.07256746	760
	Yes	-.3839299	.99074540	362
	Total	-.1517892	1.05863060	1122

In this portion of the research question concerning the relationship between FRL status and science longitudinal growth in a setting where all students are randomly assigned to the same type of heterogeneously-mixed science class, the data showed significance Wilk's Lambda = .940, F (1, 1120) = 71.698, p = .000, partial eta-squared = .060, indicating a moderate effect. As shown in Figure 4.13, both FRL and non-FRL students tended to decline over time as well.

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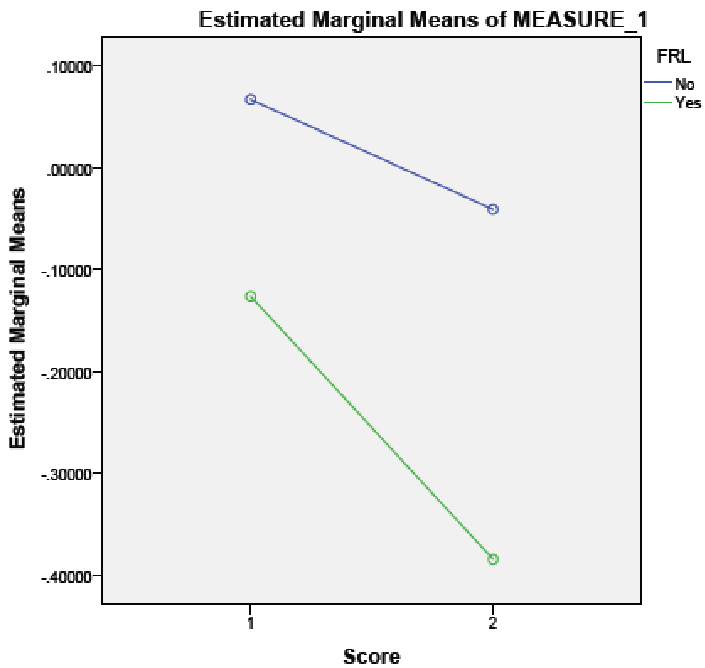

Figure 4.13. Science Scores by FRL Status in Schools with No Curricular Choice.

As seen in the data, the differences in mean scores showed a negative change from time 1 to time 2 in schools with no science curriculum choice, which is especially true for the FRL population, on a steeper drop than non-FRL students. Scores were more likely to increase in schools that offered a choice in science curriculum overall; therefore the null hypothesis was again rejected. To further analyze the data, a test of between-subjects effects (see Table 4.30) showed results for other variables.

Table 4.30

Test of Between-Subjects Effects on FRL Status and Science Achievement in Schools with No Curricular Choice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	28.879	1	28.879	15.650	.000	.014
FRL	35.159	1	35.159	19.053	.000	.017
Error	2066.709	1120	1.845			

Research Question 6

The final research question in this study examined the likelihood of the science performance category, assigned to each score that students earned, changing over time. Students taking the MAP test are assigned one of four performance categories; from lowest-achieving to highest they are Below Basic, Basic, Proficient, and Advanced. On this research question, a Chi-Square test for Independence was used to discover if there was a relationship between science curricular choice and performance category label. This test was meant to discover the likelihood of students to stay in the same performance category over time under different curricular treatments. Assumptions for the Chi Square test are that the variables are ordinal or nominal, and that the variables consisted of two or more categorical independent groups. Both assumptions are met in this test.

A chi-square test of independence was performed to determine the likelihood of students moving from one MAP category to another, and whether the movement was related to the two types of science classes in which students were enrolled. As shown in Table 4.31, a significant interaction was found X^2 (4, N = 3134) = 19.958, $p < .05$; therefore the $H6_{null}$ was rejected.

Table 4.31

Chi Square Test of Independence between Type of Science Class and MAP Level

Chi-Square Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi Square	19.958	4	.001
Likelihood Ratio	21.733	4	.000
Linear-by-Linear Association	14.113	1	.000
N of Valid Cases	3134		

The data showed that students enrolled in regular science classes were more likely to change MAP category levels, and tended to move in a downward direction over time. Students enrolled in advanced science classes tended to stay in the same categories from time 1 to time 2 (see Table 4.32).

Because $p < 0.05$, the research hypothesis stating that there is no relationship between the type of science class a student was enrolled in, and their performance category was rejected. The strength of the significance was shown to be a small one; therefore the null hypothesis H6 was rejected. The number of students enrolled in regular science classes through middle school instead of advanced science classes tended to change MAP category levels more than expected, and more than those in challenge science classes. Moreover, the changes for those in regular science classes tended to be in a downward direction over time. Specifically, the data showed more than expected (2.1), (3.0) moved to lower categories, while most stayed in the same MAP achievement category. Some regular science students did move up (1.2), but not as many went in a positive direction. For

Table 4.32

Cross-tabulation between 5th and 8th Grade MAP Level and Type of Science Class

Level Change		Science Class Type Regular	Advanced	Totals
.-2.00	Count	17	1	18
	% within level change	94.4%	5.6%	100.0%
	Adjusted Residual	2.1	-2.1	
-1.00	Count	465	135	600
	% within level change	77.4%	22.6%	100.0%
	Adjusted Residual	3.0	-3.0	
0.00	Count	1403	546	1949
	% within level change	72.0%	28.0%	100.0%
	Adjusted Residual	-.7	.7	
+1.00	Count	373	179	552
	% within level change	67.6%	13.3%	100.0%
	Adjusted Residual	-2.8	2.8	
+2.00	Count	13	2	15
	% within level change	86.7%	13.3%	100.0%
	Adjusted Residual	1.2	-1.2	
Total	Count	2271	863	3134
	% within level change	72.4%	27.6%	100.0%

students enrolled in challenge science classes, the data showed less than expected movement to lower categories (-2.1), (-3.0), while more than expected positive movement (.7, 2.8) occurred to higher categories. However, there was less than expected movement to the top category from students in the advanced science classes (-1.2), although it was slight. Overall, more changes in MAP achievement category occur with students in regular science classes (72.4%) than those students from advanced science classes (27.6%). However, the total numbers indicate that although small shifts occur in students from both types of science classes, most students still tend to stay at the level category regardless of the type of science class instruction they had. The overall pattern is that students enrolled in regular science have a higher chance to move downward and decrease in MAP achievement category level, and students enrolled in advanced science classes have a higher chance of moving upward and increasing in MAP achievement category level.

Additionally, the researcher investigated the likelihood and direction of students in a MAP category moving into another MAP category through cross-tabulation without regard to the type of science instruction. The Chi-square test to investigate a relationship between the four categories across time without regard to type of science instruction showed that there was a significant relationship between the first MAP category assigned to students at time 1 and the MAP category at time 2 (9) = 2076.198, $p = .000$. Because $p < 0.05$, there was a significant relationship, although the effect was a small one; therefore the null hypothesis H6 was still rejected (see Table 4.33).

Table 4.33

Chi Square Test of Independence Comparing MAP Level Relation from Time 1 to Time 2

Chi-Square Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi Square	2076.198	9	.000
Likelihood Ratio	1920.360	9	.000
Linear-by-Linear Association	1455.785	1	.000
N of Valid Cases	3134		

As seen on the Level 5th-8th cross-tabulation table (see Table 4.34), most students tended to stay in the same MAP performance category over time through middle school regardless of science instruction or curriculum arrangement. As the data showed, 50% of science students in the lowest performance category, Below Basic, stayed in that category.

Table 4.34

Cross-tabulation between 5th and 8th grade MAP Levels and Change in Levels over Time

Level at 5th grade (time 1)		Level at 8th grade (time 2)			
		Below Basic	Basic	Proficient	Advanced
Below Basic	Count	29	25	4	0
	% Within Level 5th	50.0%	43.1%	6.9%	0.0%
	Adj. Residual	19.8	3.7	-6.2	-4.6
Basic	Count	73	506	287	11
	% Within Level 5th	8.3%	57.7%	32.7%	1.3%
	Adj. Residual	9.5	29.2	-10.3	-20.0
Proficient	Count	4	167	833	239
	% Within Level 5th	0.3%	13.4%	67.0%	19.2%
	Adj. Residual	-7.7	-10.1	17.8	-7.4
Advanced	Count	0	14	361	579
	% Within Level 5th	0.0%	1.5%	37.8%	60.7%
	Adj. Residual	-609	-18.8	-7.1	28.8
	Count	106	714	1485	829
Totals	% Within Level 5th	3.4%	22.8%	47.4%	26.4%

Those students in the Basic category at time 1 (57.7%) tend to stay in that same category across time. Likewise, most students in the Proficient category (67.0%) stayed in that category, and most students in the advanced category in fifth grade tested as advanced by the time they took the test in 8th grade (60.7%). Both ends of the MAP categories tended to stay where they started. Below Basic students tended to stay low, with very few moving up to proficient or advanced. With the Basic students, the data showed that movement up to higher levels was not very common. The proficient students in fifth grade showed movement that was mostly either one step up or one step downward, if there was movement. Finally, the Advanced students sometimes slipped down a level, but did not tend to move down more than one level. Overall, students generally remained in the same performance category through middle school regardless of the type of science class instruction or the type of middle school curricular model.

Overall Findings

Relationships between science academic growth and curriculum choice, gender, race/ethnicity, and free/reduced lunch status were examined in the comparison of longitudinal data of middle school students from five different school districts.

The first question in this study was to find whether or not there existed a relationship between school districts' science curricular design and relative growth in science. Two large suburban schools and one smaller rural school offered a choice between advanced science and regular science in their curricula during middle-school years from 6th to 8th grade. All students had free choice in deciding which type of science class to take each year, with no school in this study imposing a prerequisite nor teacher recommendation. One large suburban school and one smaller rural school did not offer a choice, having each student enroll in the one course offering for regular science at those grade levels in middle school. The data showed that there was a small but significant effect for greater relative growth occurring in schools that offered a choice in curriculum. In addition, the data showed an overall slight decline in relative growth in science when no curricular choice existed. The researcher rejected the null hypothesis on research question 1.

The second question in this study was to further investigate whether there was a relationship between relative growth in science and the type of science class students chose in those districts that offered a choice at middle level. The data showed that students who enrolled in regular science in schools that offered a choice of science classes had an overall increase in science academic skills as measured by the MAP test scores; however, it was a small increase compared to their peers in advanced science classes. Students who enrolled in advanced science had an overall increase in science academic skills and at a faster rate than their regular peers. There was a significant relationship between the type of science chosen in school districts that offered choice in science curriculum and relative science growth, although it was small. It is interesting to note that in this portion of the data, the mean test start point (fifth grade science score) for those who chose regular science was already lower than the mean start point for those who chose advanced science, hinting that factors other than curricular choice may have been present. The null hypothesis for question 2 was rejected.

The third question in this study was to examine the relationship between gender and relative growth in science. Results showed that there was no significant relationship between gender and science academic growth overall without regard to other factors. Both males and females increased in growth over time; however the males started a bit higher and ended a bit higher than the females. Gender and type of science curriculum design were examined, showing that there was a significant relationship between gender and science achievement scores in schools with no choice in science curricula at middle level.

However, there was a small significant relationship between gender and science achievement in schools that offered two types of science classes at middle level, showing that females start lower but gain faster than males. Females still never caught up with males in both types of schools, but the difference was more pronounced in schools that offered a choice.

The fourth question in this study was to investigate the relationship between race/ethnicity and relative growth in science. The data showed significance between race/ethnicity and science achievement scores overall with no regard to other factors. Students identifying themselves as Asian showed the biggest increases in achievement scores over time, surpassing White students by time 2 (eighth grade), who were the highest group at time 1 (fifth grade). Hispanic students and Black students also increased over time, but not as much. Those students identifying as Native American showed the least amount of growth; however, since the sample size for this ethnic group was very small (n = 10) the result may be unreliable. In schools with no curriculum choice, race/ethnicity was a significant factor in science achievement scores. In schools that offered a curricular choice in science, there was a significant relationship between race/ethnicity and science achievement scores, although small. In choice schools, all race/ethnicities improved over time, but some improved faster than others. When examining the relationship between race/ethnicity on science curricular model, there was a moderate significance, showing that schools that offered a choice in science curriculum at middle levels produced greater improvements among all races/ethnicities, although black students started and ended lower in both types of curricular models. In addition, there was a significant relationship between race/ethnicity and the type of science class, showing that the change in mean scores improved more for all groups when students were enrolled in advanced science, although all scores improved over time in all subsets. Also of interest was the number of students from each race/ethnic group that aspired to a more challenging science class. In school districts that offered a choice in science classes, more Asian students (77%) chose advanced science when compared to the average percent (40%). Black students also chose to enroll in advanced classes (50%) more than average, and only 36% of White students and 28% of Hispanic students chose a more challenging science in middle school compared to the norm of all students.

The fifth question in this study examined the relationship between students from financially-stressed homes, as measured by participation in the FRL program, and relative growth in science. The overall results without regard to the type of curricular design or science class showed that students in the free/reduced lunch program were not progressing at the same rate as those that were not in that program, confirming a statistically significant connection, although small. When comparing the effect of curriculum design on the FRL population and their science achievement scores, there was a small significant effect showing that the FRL students decreased in scores within schools that offered curricular choice, while their non-FRL peers gained more quickly in those schools. FRL students still decreased over time within schools that offered no choice in science middle-school curriculum, but not as quickly as they did in choice schools. For students in schools that offered a choice, FRL participants who enrolled in advanced science improved but not as quickly as in the non-choice schools. The data showed that most FRL students did not choose advanced science classes when offered a choice. In schools that offered no choice in science classes, there was a moderate significance between FRL status and science achievement. FRL students in regular science classes in schools with no choice declined as they did in schools with a choice, but not as fast, but still faster than non-FRL students. These results underscored previous research suggesting that students from financially stressed homes were not as likely to succeed academically as those students who were from financially stable environments. This study that is specific to science education is in agreement with previous research claiming that children from financially stressed homes tend to have lower overall academic gains.

The last research question investigated the likelihood of academic performance category, assigned by the state standardized test score, to change over time. Of the four assigned category labels: Below Basic, Basic, Proficient, and Advanced, students tended not to change categories over time. Of those students in the lowest academic category (Below Basic) in time 1 (fifth grade), 50% of them remained in that category by time 2 (eighth grade) at the end of middle school, regardless of the type of science class they were in. The data showed that 57.7% of students in the Basic category at time 1 remained in that same category at time 2. Results for Proficient fifth-graders showed that 67% of them remained in the same category at the end of eighth grade. Of Advanced student at time 1, 60.7% remained in that same category at time 2. Additionally, the researcher investigated whether there was a relationship between the type of science class students were in and changes in performance category. While there were some movements in both the increasing and decreasing directions, overall there was a pattern that showed that students enrolled in regular science classes had a higher chance of changing categories in a decreasing direction and those enrolled in advanced science had a higher chance of changing categories in an increasing direction. However, the overall data showed that the type of science class had no statistically significant relationship to the category assigned by standardized achievement test scores.

In summary, the researcher's findings showed that school districts that offered a choice in curriculum may be beneficial to the student body as it pertains to relative academic growth in science, yet the amount of significance is so small in most cases that it may be impractical. Attention and instructional support for minority groups is needed for overall success, especially for the students in the FRL population. It is important to note that in schools that offered the differentiated science curriculum, the students who chose the lower track in regular science still tended to drop off in their relative growth, so while adding science choices can benefit some, it may hurt others.

Other issues are at play in regard to relative growth in science. Gender appeared to play no significant role in relative science growth; females tended to start and finish at slightly lower scores overall than their male counterparts. This finding is in agreement with recent research that shows no gap between males and females in science (Quinn & Cooc, 2015) or math (Voyer & Voyer, 2014) and are in some cases outperforming males in STEM classes.

Race/ethnicity was a significant factor in the relationship to science academic growth, with minorities starting and finishing below White students, except for Asian students, who started behind White students and surpassed them by the end of eighth grade science. Asian students' higher achievement rates in STEM classes supported previous research (Else-Quest, Mineo, & Higgins, 2013). A significant achievement gap existed between African American pupils and White pupils, and these findings were consistent with current research (Quinn & Cooc, 2015, Rumberger & Palardy, 2005). Although Black students showed science growth over time, the start and end points were still far below the other race/ethnic groups despite the type of science class they participated in.

There was a significant relationship between free/reduced lunch program participants and their relative growth in science, which is aligned with research concerning students from financially-stressed homes and their difficulties in academic settings (Bradley & Corwyn, 2002; Pratt, Tallis, & Eysenck, 1997; Zuena et al, 2008). Despite the curricular model, this study showed that FRL students declined over time in science.

Finally, the likelihood of a student changing out of their fifth-grade MAP performance category was small, no matter the category. Most students showed a tendency to level off through middle school, not changing their performance category and not making major gains or losses, which is similar to recent news reports of science standardized test results in the U.S. stagnating (Kerr, 2016). There are some movements between performance categories in both regular and advanced science students in both increasing and decreasing directions; however, those students in regular science classes showed less chance of moving in a positive direction than their advanced science counterparts. The findings of students who chose the lower track (regular science) tending to perform significantly worse than their advanced peers aligns with studies that show self-efficacy in middle school teens as a major factor in their academic achievement (Anderman & Young, 1994; Diseth, Meland, & Breidablik, 2014; Jansen, Scherer, & Schroenders, 2015).

CHAPTER 5

DISCUSSION

The purpose of this study was to determine if and how offering more curricular choices in middle school science was impacting student science achievement. In addition, this study evaluated the relationship between relative growth in middle school science students and other factors such as race, gender, free/reduced lunch status, and the type of science class selected in schools that offered a choice between regular and advanced science. The longitudinal nature of this study was appropriate to measure relative growth in the core area of science for students with and without the treatment of a differentiated science curriculum.

It is important to evaluate science achievement for a number of reasons. Personal awareness of science and its impact on our daily lives is important for general information and welfare. Our future competitiveness as a country relies on home-grown scientists to create opportunities for economic and educational growth. Science education leads to careers in health and security of various types, and those jobs may go unfilled or move overseas if science education is not strong. Science knowledge creates innovators for the future. Marincola (2006) pointed out that even the democratic process is at risk when misinformed and naïve voters make decisions for themselves when they lack general scientific knowledge. Understanding the best practices for encouraging interest in science and quality instruction is imperative for a strong foundation of knowledge leading to positive societal impacts.

The research questions were designed to explore the relationship between curricular choice in middle level science classes and achievement outcomes over three years as measured by the Missouri Assessment Program state standardized tests. Before making adjustments to the protocol in a school district, officials need to make purposeful efforts to gain insights into their ideas. This study adds to the body of knowledge for consideration by school officials. The discussion that follows addresses the findings of each of the research questions.

Research Question 1: Middle School Science Curricular Design

Comparisons in science achievement scores from two different curricular designs were made to determine their efficacy. While some schools offered self-selected science curricular choices through middle school, others did not. The data in this study showed that students from the school districts with the differentiated curricular design scored statistically higher overall than those from traditional schools with one type of science class per grade level. Before school district leaders consider a redesign of their middle-level science curriculum, it must be emphasized that the effect size (.016) was so small that it may not be practical, nor is it guaranteed to produce higher overall standardized test scores. Other factors may be present that may be the actual causes of this trivial difference in scores.

Overall attitude toward science may have an effect on test scores (Germann, 1994), and it is logical to assume that those students who chose to enroll in advanced science would naturally have a more positive attitude and thus better scores on standardized tests. For example, the overall increase shown for differentiated schools may be due to the top students achieving better results, thereby skewing the school results in an upward direction. Likewise, Van Houtte's differentiation-polarization theory, in which students divide themselves into pro-school and anti-school cultures, could be manifesting itself by having the top pro-school students producing more effort to be on top, driving scores further up than they would otherwise be in a mixed-ability randomized classroom setting.

In addition, the attitude of teachers toward top students may be contributing to the effect, as in a study (Van Houtte, 2006) showing that teacher attitudes are different towards pupils based on personal judgments on the teachability of those students, which may affect attitudes toward science, and in turn, affect their grades and effort. Other teacher characteristics may be influencing these scores. Wayne and Youngs (2003) noted that teachers who scored higher on their teacher licensure exams were more likely to produce scholars with higher standardized test scores. This study did not consider any teacher characteristics which may have affected the outcome.

Other than increasing interest in the sciences or standardized test scores, some school leaders have posited that offering advanced classes at the middle level will eventually create more interest in advanced placement classes at the high school. While that deduction seems logical on its surface, it may not be complete. Enrollment in advanced classes subsequently at the high school is not a perfect corollary to higher achievement in those classes. A study by Glaude-Bolte (2010) suggested that enrollment in middle school challenge science did not correlate with higher advanced placement exam scores in high school. Another recent study concerning reading comprehension, with students grouped homogeneously, showed a statistically significant improvement that was only temporary, having no statistically significant differences over time (Liddell, 2016). Even when students have the freedom to select their tracks in schools that offer a choice in curriculum, these effects are noteworthy.

Finally, studies show various conclusions as to whether ability-grouped classes are beneficial. Similar to the findings of this research question, other studies (Feldhusen &

Moon, 1992; Kulik & Kulik, 1982), showed ability grouping to be beneficial to student achievement. Gifted students especially tended to benefit when grouped with their high-ability peers (Rogers, 1993; Vogl & Preckel, 2013). Yet, some studies (Anderson, 2012; Steenbergen-Hu, Makel, & Olszewski-Kubilius, 2016), stated that ability-grouped students showed no relation to academic gains in middle school. Hallinan (1992) suggested that these positive effects are not equal in all school settings. Vroom's Expectancy Theory is affirmed by the advanced group, following expectations of higher grades for the intrinsic reward of feeling more academic, and extrinsic rewards of status or praise from parents.. Because, as in this study, the number of academically talented students and/or students that chose to enroll in advanced science tended to be smaller than the rest of the population at large, policymakers need to keep the numbers of potentially improved students in context.

Research Question 2: Within-school Effects of Curriculum Choice

Comparisons in science achievement scores from students who attended schools with different curricular choices were made to determine whether the student experienced a social effect on their performance. While all students in this study were permitted to choose their science class from two offerings without prerequisites, this research question examined the effect of self-segregating into regular and advanced groups. The data showed that students in advanced science classes performed better than those who chose the regular science classes, and the advanced group showed more relative growth over time, although the effect was small. This result is in alignment with similar studies showing that advanced students perform better on testing (Ireson & Hallam, 2009; Leow, Marcus, Zanutto, & Boruch, 2004).

Because students chose the basic or challenge science classes without a prerequisite, the effect may be due to an intrinsic trait, such as self-efficacy, rather than the availability of curriculum choice. Psychologist Albert Bandura (1982) defined self-efficacy as one's beliefs in their ability to succeed. It is logical to deduce that students who choose a more challenging class will possess greater self-efficacy and determination to succeed. Previous studies (Cassidy, 2015; Martin & Marsh, 2006) suggested that strong student self-efficacy is a predictor in higher academic motivation and performance, especially in middle school students (Liu, Pei-Hsuan Hsieh, Cho, & Schallert, 2006). Murphy and Alexander (2000) stated that self-efficacy is strongly related to motivation, while another study (Romero, Master, Paunesku, Dweck, & Gross, 2014) found that middle-school students who believed that intelligence could be developed over time were more likely to have higher achievement scores and were more likely to enroll in advanced classes. The effect in this research study was small between advanced and regular science growth and achievement scores, yet it reveals that there was a difference for the group of students who challenged themselves.

Another term used in education is grit, which is related to self-efficacy. Grit is the passion and perseverance for achieving goals (Duckworth, Peterson, Mathews, & Kelly, 2007) and may be the reason for the differences shown in the data. Students who choose advanced science classes may be achieving higher scores due to their grit, and not because of the advanced curriculum. It stands to reason that students who wish to challenge themselves in an advanced class will tend to have more willingness, a better attitude, and more perseverance than average students. Those traits may be what causes the small effect size between advanced science and regular science class achievement results, rather than the curriculum treatment. Weiner's Attribution Theory seems plausible in this study, as the students in the advanced classes seem more motivated to perform well, which bolsters their self-esteem. Duckworth (2013) found that grit and talent were not related, and that the grittier students actually performed better than naturally talented students. Therefore, the higher achievement of the advanced group in this study may be completely unrelated to their perceived talent or to the fact that they were in a school that offered a choice in curriculum.

Yet another possible reason for the differences among students in the same school with different types of science classes is peer effect. According to Epple and Romano (2011), peer effects play a conspicuous role in education by the actions and performance of peers on one another. Perhaps the advanced science students in this study performed better because they were surrounded by a majority of like-minded peers who exhibited more self-efficacy and grit, and perhaps possessed more talent than the population at large. Studies suggest that peer achievement has a positive effect on growth (Hanushek, Kain, Markman, & Rivkin, 2003), and that all students benefit from proximity to higher-achieving classmates. This is in agreement with Bandura's Social Cognitive Theory, which focused on the impact of other students on the learning of the individual (1994), as well as Vygotsky's Social Development theory, which claims that social interactions with peers affect learning.

The importance of student interaction should be considered for policymakers before implementing curricular changes. Social connections, especially among middle school students, should be seriously examined in decision-making concerning curriculum. Middle school students' motivation to succeed and academic competence has been found to have a positive relationship with supportive social networks, even surpassing the influence of parents (Marchant, Paulson, & Rothlisberg, 2001). Ansbacher (1968) stated in a previous study that students' main purpose in the classroom is social acceptance, whether the student is well-adjusted or not, over achievement goals. Other studies showed that peer effect is significant in achievement outcomes (Burke & Sass, 2006; Kang, 2007; Thrupp, Lauder, &

Robinson, 2002), and especially beneficial when the group are high-achievers (Burney & Beilke, 2008; Chou, Liu, Lin, & Liu, 2015; Preckel, et al., 2017). A study of adolescent gifted students found that while they prefer high-achieving peers in class, they also value the social diversity found in mixed-ability classes (Adams-Byers, Whitsell, & Moon, 2004). Friendships in general are a predictor of middle-school academic achievement (Wentzel, Barry, & Caldwell, 2004), showing that students without a strong friend base exhibit lower performance. Some studies state that ability grouping does show a positive effect for the academically talented students, yet it also tends to bring down the mid- and low-ability students further (Clotfelter, Ladd, & Vigdor, 2015; Hallinan, 1994; Hoffer, 1992; Piopiunik, 2014), harming them academically.

Additionally, other studies show negative peer effects on average achievers who are grouped with low achievers (Lavy, Silva, & Weinhardt, 2012; Nomi, 2012; Paserman & Schlosser, 2012), which could be the reason for the lower performance and growth in the regular science group in this study. Also, mainstreaming IEP students as required by law has been shown to bring down the regular education students when heterogeneously grouped (Fletcher, 2009). Although this research project did not involve IEP student data, IEP students were in classrooms with the students whose data is in this study, and therefore could have been a factor in their performance. Students who misbehave more often tend to be in lower ability groups (Finn & Rock, 1997) and have been shown to bring down the performance of the other students in their classrooms (Lavy, Paserman, & Schlosser, 2012). Therefore, the small effect reported from this study concerning students who chose regular science and their lesser academic performance may be due to the influence of lower peers in the classroom and negative peer effect.

Also worth noting is the possibility of instructor bias. This study did not collect data on the individual science teachers in this study, but teachers can have a direct impact on student performance. Because the effect size for this research question was small between academic performance and the types of science instruction in the schools, teacher-student relationships may factor into these results. Kelly and Carbonaro (2012) found that teacher expectations vary with the type of class track in that those students in higher ability groups are expected to perform better. Another study (Van Houtte, 2006) found that staff will show lower expectations of success for less academically-oriented students than for those who are more academically inclined. Although the groups in this study self-divided themselves into regular and advanced science, teacher effect cannot be ruled out as a factor in the performance growth differences.

Social concerns may have contributed to students' enrollment choice in science class, other than ability level, motivation, or interest. Depending on the enrollment process at each location in this study, some students had their enrollment choices more openly available, and therefore may have been in a class that was not well-suited for their abilities, motivation, or interest. Testa (2010) found that some students chose the lower tracks when given a choice because they thought the advanced option would make them appear nerdy. Bursztyn and Jensen (2014) found that students in a non-honors class were 25% less likely to sign up for honors courses when the decision was made public, suggesting that peer pressure may be a factor in enrollment choices and could have been an influence in this study.

Also, parental involvement plays a major role in curricular choices during early adolescence (Eccles & Harold, 1993) and how students perform in school. This study did not take into account parental influences, although they exist, and may have contributed to the differences shown in this study. Catsambis (2001) found that parents with high expectations and consistent encouragement for their children's academic success in middle school correlated with subsequent academic success. Parents with higher education levels tend to have children who enter the higher tracks (Useem, 1992) and tend to influence their children's preferences for course enrollment. In schools of choice, a student's curriculum plan may not match up with their parent's expectations. Rutherford (2012) found that young adolescents whose academic expectations did not match their parents' expectations showed lower well-being scores and more stress, which may affect academic performance. Parents' beliefs were more directly related to their children's self-concepts and expectations than they were to past academic performance (Eccles-Parsons, Adler, & Kaczala, 1982); therefore parents of the students in this study may have influenced those students about which type of science to take and how well they performed, which could account for the differences in performance shown in this study's results.

In summary, the differences in relative growth and achievement in science between two different types of science class offerings in the same school through the middle-school years were found to be significant in this study. However, that significance is a small effect and could be due to factors other than the presence of curricular choice options at middle level. Peer effect, parental influences, and the students' own intrinsic motivation traits as factors cannot be ruled out as consequential when comparing advanced and regular science groupings.

Research Question 3: Gender and Science Academic Performance

The third research question was meant to examine a relationship between gender and relative growth in science during middle school years. STEM fields are predominantly male, and this research question attempted to find a connection to lower numbers of females choosing careers in science. The researcher approached this query from three directions, comparing genders and science achievement overall without regard to other factors; gender comparison within only the no-choice school districts; and gender comparisons within the school districts that offered a choice differentiating between regular and advanced students.

First, the data showed that overall, there was no significant difference between the genders in science academic growth in middle-school, without regard to the type of science curricular design in place or which science class the students had chosen. This finding is in agreement with other research (Kiran & Sungur, 2011; Ngila & Makewa, 2014; Quinn & Cooc, 2015; Shapka, Domene, & Keating, 2006), which reported that there was no significant difference between genders and performance in STEM topics. Fox and Cater (2015) even suggested that females scored higher than boys in a study on science interest and competence in young adolescents. Boyd (2013) found that there was no difference in the achievement scores between single-gender and mixed-gender science classes, further suggesting that the gender gap is closing.

The researcher also investigated whether there was a gender effect in both types of curricular models to discover whether differences in gender existed in science achievement. In school districts with no choice in science class at middle level, where all students were randomly appointed to heterogeneous mixed-ability science classes, this study also found no significant differences in science growth and achievement between males and females. Another study of interest concerning gender differences in middle school students (Lavy et al., 2012) showed that girls benefitted from academically-advanced peers while boys did not. While the closing of the gender gap is welcome news, the results of this study, although not statistically significant, showed that boys started higher and ended higher in performance scores over time than the girls did, although the growth was similar.

However, in only those school districts that offered curricular differentiation between advanced and regular science, this study showed that there existed a statistically significant difference, although small, in science achievement and growth over middle school between the genders. This significance is in agreement with studies that also suggest significant differences in performance in science and gender exist (Lee & Burkham, 1996; Oluwatelure, 2015). This phenomenon may be connected to the findings by Ayalon (2006) that showed boys choose advanced science courses more than girls, or the idea that self-concept is stronger in males than in females when it comes to STEM courses (Sax, Kanny, Riggers-Piehl, Whang, & Paulson, 2015). In summary, the fact that gender did not factor into achievement scores in this study overall shows our public school culture is moving in a positive direction. Yet, it was a factor in schools with a curriculum choice, so gender equality studies in science education should continue to be a topic of investigation.

Research Question 4: Race/ethnicity and Science Academic Performance

The fourth research question was meant to examine a relationship between race/ethnicity and relative growth in middle school science performance. Careers in STEM fields in the United States are populated predominantly by White males (Douglas-Gabriel, 2015), and this research question attempted to find a connection to lower numbers of minorities choosing careers in science. The researcher examined this point in six ways.

First the researcher examined a relationship between race/ethnicity and relative growth in science overall, without regard to curricular design or science class enrolled in, from longitudinal data in middle schools. The data showed a moderate significant interaction between race/ethnicity and science achievement, in agreement with previous studies exposing a science achievement gap among race/ethnicities and middle school performance (Catsambis, 1994; Hanushek, Kain, & Rivkin, 2009; Wenglinsky, 2004). Although all race/ethnicities improve from 6th to 8th grade regardless of curricular circumstance, White and Asian students start higher and end higher than the other groups; Black students started and finished with the lowest achievement scores, and Hispanic student started low, with their increase in the middle grades significant. This finding agrees with Quinn and Cooc (2015), noting that the achievement gap between White and Hispanic students narrows over time, yet still doesn't close.

The second part of this research question examined the relationship between race/ethnicity and science achievement specifically in schools that offered no choice in curriculum, in which students were randomly distributed in mixed-ability science classes. Again, there was a statistically significant interaction between race/ethnicity and science achievement, although the effect was small. The data showed Asians were the only group that improved over time in this setting, while all other groups declined slightly. This agrees with studies that show Asians excelling in STEM courses (Chen & Stevenson, 1995; Peng & Wright, 1994; Schneider & Lee, 1990).

The third part of this research question examined the relationship between race/ethnicity and science achievement specifically in schools that offered curricular differentiation, so that students could select which science class to take each year in middle school. This aspect of the race/ethnicity investigation was meant to discover whether there was a relationship between race/ethnicity and curricular setting and its possible influence on science achievement. The data in this study showed that there was significance, although small. This study showed White students' growth tended to flat-line, with very little improvement over time in this type of curricular design when compared to the other groups, who all improved, although at different rates. The phenomenon of White students leveling off while other groups continue to improve was surprising, but may be related to findings from a previous study suggesting that students in middle grades tended to lose interest in science (Haladyna, Shaughnessy, & Shaughnessy, 1983).

The fourth part of the race/ethnicity investigation concerning middle school science performance and growth concentrated on the comparison of educational settings. While two of the schools in this study had no curricular differentiation in science, three of them did offer students a choice between advanced and regular classes. This part of the research was to analyze the impact of curricular design on race/ethnicity and science achievement. The data revealed a moderate significance between the two school settings when it came to science achievement and growth over time. Schools that offered a choice in curriculum had a more positive academic effect on race/ethnic groups overall when compared to schools with no choice in science curriculum. Perhaps the idea that students are in control of their own academic enrollment choices gave them a feeling of control that fostered self-efficacy. In a past study (Dauber, Alexander, & Entwisle, 1996), researchers found that nonacademic factors influenced middle school placement in classes in schools that had prerequisites. However, the schools in this study were designed to let students choose their curricular path, which may have had an empowering effect. Supporting this view of curricular choice is a study from Terwel (2005), which pointed out the benefits of self-selected choices in curriculum, but also added that in the best situations, students needed to feel that their culture, knowledge, and experience were valued in the higher ability groups.

The fifth part of the examination of the relationship of science curriculum and race/ethnicity on middle school science performance and growth concentrated on the comparison of the two different curricular choices in this study. Students chose to enter either advanced science or regular science through their middle-level years. This part of the research was meant to analyze the impact of curricular choices on race/ethnicity and science achievement. The data revealed a moderate significance between the two types of science classes concerning science achievement and growth over time. Specifically, those students in the advanced classes in all race/ethnic groups improved more than those groups in the regular science classes. This effect is shown in a previous study (Card & Giuliano, 2016) that showed significant gains for Hispanic and Black students who were in high-ability classes. The data showed Asian students surpassing White students from 6th to 8th grade in overall science growth and achievement scores.

However, in regular science classes, White and Native American students tended to flat-line with very little improvement over time. Although Hispanic students improved at a better rate than other groups, they did not catch up to the achievement of White or Asian students. Black students started low and improved over time, yet still ended lower than the other groups. This is similar to Card and Giuliano's (2016) study reporting that high-ability minority students in regular classes tended to underperform, possibly due to teacher expectation effects and negative peer pressure. This brings in the idea of stereotype threat (Steele & Aronson, 1995), which states that there is a risk of confirming negative stereotypes about their social group, and that Black students are particularly susceptible. Although the students that chose regular science had the benefit of choice that may have empowered them, stereotype threat remains a phenomenon among minorities, and may be an influence on the low scores of the regular classroom students.

Finally, the last segment of the race/ethnicity investigation concerning middle school science performance and growth concentrated on the comparison of enrollment patterns across the participating districts. This part of the research was meant to analyze the choices students from different racial/ethnic groups made for themselves. In the three participating schools that offered curricular differentiation between advanced and regular classes, data showed that Asian students chose to enter advanced classes far more than the other race/ethnic groups. This is similar to recent research findings (Muller, Riegle-Crumb, Schiller, Wilkerson, & Frank, 2010) that showed Hispanic and Black students being underrepresented in enrollment in advanced science classes. However, in this study, half of the Black students chose to enter advanced science classes through middle school, which implies that they may not be experiencing a standard level of stereotype threat. All other groups in this study chose advanced science far less than the Asian and Black students, as a percentage. Although the high numbers of Asians enrolled in advanced science classes is supported by previous research (Goyette & Xie, 1999; Hao & Bonstead-Bruns, 1998; Oishi & Sullivan, 2005), the large percentage of Black students enrolling in advanced science goes against past studies that showed Black students as being underrepresented in challenge courses (Ford, 2010; Ford, Grantham, & Whiting, 2008). Perhaps there is a paradigm shift underway concerning Black students and their response to historical marginalization. This idea is supported by Chambers and McCready (2011), who found that African-American students are “making space” for themselves, mediating their own responses to institutional biases, sometimes going against convention. However, it is important to note that although the percentage of Black students in this study chose advanced classes in middle school more than the White, Hispanic, or American Indian groups, Black students continue to be marginalized when it comes to academics (Davis, 2003; Solorzano, Ceja, & Yosso, 2000; Walton & Cohen, 2011). Unlike the schools in this study, the protocols in place for curriculum differentiation often include prerequisites and may employ bias toward minority groups. Although the results of this study showed curriculum differentiation to be beneficial for all race/ethnicities, policymakers need to be aware that the process of differentiation, if not carefully implemented, can sometimes lead to de facto segregation (Bankston & Caldas, 1996). In summary, although enrollment patterns in advanced classes showed positive inclinations in this study for Asian and Black students, more needs to be done to increase interest in science challenge classes for other groups while continuing the positive trend among Asian and Black students.

Research Question 5: Free/reduced Lunch Students and Science Academic Performance

The fifth research question investigated the relationship between free/reduced lunch status and relative growth in middle school science. Free/Reduced lunch status is made available for students of families that are near or below the poverty index, making the focus of this portion of the study about the relationship of those stressors on student science performance and growth. Many researchers have agreed that students from financially-stressed situations continue to perform lower than non-financially-stressed peers. This question was addressed in four different ways to understand the relationship to curricular differentiation.

First, an overall comparison between FRL students and non-FRL students and their relative science growth and middle-school science achievement scores was made, regardless of curricular treatments. The data showed there was significance between these groups of students, although the effect was a small one. FRL students started much lower and ended much lower in science growth over middle school in this study, and although both groups generally improved, the FRL population's growth rate was much slower than that of non-FRL students. This result was in agreement with many studies of financially-stressed students and their academic performance, due to unmet social needs, parenting issues, and health care, among other concerns (Williams & Noguera, 2010). Stereotype threat was also in place with the less-fortunate students (Croizet & Claire, 1998). This data showed that many factors, other than science treatment, impair the general academic abilities of FRL students.

More specific to curriculum treatment, the researcher then investigated the relationship between science academic growth and the type of curricular model for science program on the FRL population. This comparison examined the relationship between schools that offered a choice in curriculum and those that did not. The result of the data showed that FRL student did not thrive in schools with curricular choices in science. In fact, the FRL students declined in both types of schools, but the rate of decline in the schools with science class choice was a much deeper drop over time. This data aligned with

Ayalon (2006), finding that curriculum differentiation has a detrimental effect on low-socioeconomic students. The data also showed that a majority of the FRL students in this study enrolled in regular classes when a choice was presented to them, where expectations tended to be lower. This is analogous to Calarco's (2011) study concerning poor students, who fell behind their financially stable peers due to social interactions in the classroom. Friere (1970) suggested that marginalized people need to have access to education to ensure their own liberation from being oppressed. Disadvantaged students are more susceptible to low expectations because they are less likely to have support from their homes (Mayer & Jencks, 1989). The issue at hand is whether marginalized, poor students will understand the value of educational opportunities as a way to liberate themselves, even when they are subjected to low expectations.

Third, the researcher investigated whether there was a relationship between FRL status and relative science academic growth in schools that offered a choice in science curriculum. The data was significant in differentiated schools, with a moderate effect, showing that in these schools, the FRL students improved whether they were enrolled in advanced or regular science. However, the FRL students did not show as much growth over time as the students from financially stable homes, and the rate of growth was much slower. Also, the FRL student began at a lower score and ended at a lower score through middle school science than their non-FRL peers. Perhaps this result was due to the social influences of regular classes on FRL students, as mentioned in Calarco's (2011) study suggesting that cultural differences between the poor and non-poor students cause the poor to fall behind due to social interactions. Students who chose regular classes in schools that offered a choice tended to have lower self-efficacy (Alldred, 2013; Boardman & Robert, 2000), which could influence the motivation of the FRL student in regular science classes. Students from low-socioeconomic situations tended not to enroll in advanced classes (Friend & Degen, 2007). This agrees with Horn (2013), who stated that opportunity inequity with students from lower socioeconomic families increased as they got older, starting in lower academic tracks, and tending to stay in those low tracks. The growth of the FRL population was present in schools with curricular choices, although it was far less than that of non-FRL peers. The science achievement and growth of FRL students would improve with development of self-efficacy traits and motivation, and could lead to enrollment in advanced classes.

Finally, the researcher approached the relationship of FRL status and science academic growth of students who are in schools with no curricular differentiation, mixed at random. For these FRL students, the relationship between academic achievement and no choice in science classes was significant, with a moderate effect. The data showed them declining in science achievement through middle school faster than the decline that also existed with non-FRL students. While it is undetermined exactly why there was a decline for all students in this curricular design, it is clear that the FRL students were at the greatest disadvantage in this case. There may be other factors at work in the no-choice school that made the difference. More mental and/or physical abuse happens to students from financially-stressed homes (Cancian, Slack, & Yang, 2010; Kinard, 2001) due to parental stress or poor mental health. Lower achievement scores in economically disadvantaged students can also be caused by poor ability to regulate attention (Howse, Lange, Farran, & Boyles, 2003). Although there are many factors that could cause the scores to decline for students in this curricular model, there is compelling evidence (Becker & Luthar, 2002;

Carman & Zhang, 2012; Lynne, Graber, Nichols, Brooks-Gunn, & Botvin, 2007) that points to peer effects that impair academic potential in non-advanced classes.

Research Question 6: Science Academic Performance Categories and Curriculum

The final research question in this study examined the likelihood of the science performance category assigned to each score that students earn changing over time. Students are assigned one of four performance categories; from lowest-achieving to highest they are: Below Basic, Basic, Proficient, and Advanced. While there were some movements in both the increasing and decreasing directions, overall there was a pattern that showed that students enrolled in regular science classes had a higher chance of changing categories in a decreasing direction while those enrolled in advanced science had a higher chance of changing categories in an increasing direction. However, the overall data showed that the type of science class had no statistically significant relationship to the category assigned by standardized achievement test scores. Students also tended to stay in their science test category that was assigned on the 6th grade science test regardless of the curricular treatment. This result implies that the different classes may affect the growth of students. However, due to the self-efficacy and grit that tend to be higher (Duckworth & Gross, 2014; Pajares, 1996; Steiner-Adair, 2013) in those who enroll in advanced classes, these findings are not unexpected.

Recommendations

Science education is important for a number of reasons that justify research about its improvement. Science helps us to understand our environment and everything in it, as well as being the foundation of many major careers. Some of those paths are necessary for innovation and discovery, and many contribute to the economic stability of our nation.

While interest in science careers continues to wane, it is in the best interest of the nation to investigate the reason for this lack of interest. One fundamental concept in the quest to encourage science interest and achievement is the study of science curriculum treatments on younger adolescents. This study adds to the body of knowledge about science education and the relationship between curriculum design and science achievement.

Students in science classes need interventions to lessen any negative effects of middle-school curriculum treatments. The results of this study support curriculum differentiation at the middle level. Ability grouping based on student choice seems to improve grades, yet it harms the low achievers. Prior to enrollment choice, which tends to stay rigid, students preparing to enter middle school should be presented with an extensive program that promotes self-efficacy and the characteristics of grit before they reach middle school. Furthermore, those students should be exposed to the scientific information behind neuroplasticity, so that they can understand the reasoning behind growth potential, helping them understand that their potential successes are largely under their control. Neuroplasticity is the concept that our experiences can change our brains, and that our growth potential is not fixed (Tokuhama-Espinosa, 2008). Neuroplasticity training goes hand-in-hand with self-efficacy and has the potential to instill higher expectations in students' own abilities. Low-achieving students should be in smaller classes for better attention, while school leaders need to make sure that they are mixed in with high-achieving peers who choose to be in regular classes. All levels of classes should try to be as heterogeneously mixed as possible, as the data show, for more positive academic outcomes for all. During the enrollment process for all students, counselors and school officials must maintain confidentiality, so that low achievers will be more likely to attempt advanced classes. Friendships matter, and they have an effect on middle school student achievement. Simpson and Oliver (1990) found that positive experiences in science impacted subsequent success in the class. Further research to discover ways to promote those positive experiences, while controlling for the negative, can help teachers guide students to more constructive outcomes. The social aspect is extremely important in middle grades; therefore research into collaborative programs needs to continue to optimize the chance at students building relationships with peers in a positive environment, while promoting science.

Students from financially-stressed homes need neuroplasticity interventions more than other groups due to the lack of support they tend to receive at home. In addition, a buddy system, in which students in poverty are teamed up with a faculty member, may help those students feel support they may be missing. Socioeconomic status of the school as a whole is a predictor of student achievement (Hoover-Dempsey, Bassler, & Brissie, 1987; Sirin, 2005), which is interesting information, but it is difficult to attempt to remedy without a systemic paradigm shift. Early intervention with FRL students is beneficial for their academic success (Brooks-Gunn & Duncan, 1997). Students from low socioeconomic situations should have school-based interventions that involve the parents to help their academic achievement (Benner, Boyle, & Sadler, 2016). The students in poverty, as well as disruptive students, need to have additional motivation to perform. Students with consistent behavior problems need to be removed from the regular education classroom temporarily so their actions do not negatively impact others (Figlio, 2005). Perhaps a program with a time-out style classroom staffed with adults can work one-on-one with them to not only help them focus but engage with them (Finn & Rock, 1997) to increase motivation. More research needs to be done to examine how to motivate at-risk and distruptive students.

Although the Americans with Disabilities Act allows for special education students to be in the "least restrictive environment," there is evidence that they may be bringing the achievement of non-IEP students down (Fletcher, 2009). Although it is controversial to, this point should be addressed. A compromise between obeying the law and causing the least possibility of harm to the regular education students should be pursued, which may be as easy as maintaining a maximum number of IEP students in a regular classroom. Currently, at least one of the school districts in this study maintains no limit on the number of IEP students in middle school science classrooms. One science teacher in that district had 14 IEP students and no special education aide (personal communication, Jane Smith*, 2016).

Encouragement to minority students and females to enter advanced classes should continue. According to this study, these students are willing to challenge themselves but their endeavors may be affected by an achievement gap that began before middle school. Integration of cultures into the classroom has been shown to be beneficial for students (Wells, Fox, & Cordova-Cobo, 2016). School leaders should attempt culturally-mixed classroom settings when possible. Extra efforts should be in place prior to middle school for females and minorities to picture themselves in a science profession. Self-efficacy training and neuroplasticity training, as mentioned before, may help in closing these gaps. Additionally, Faris (2009) showed that multiculturalism in the classroom increased positive attitudes in the classroom. Therefore, maximizing cultural heterogeneity in the classroom may help improve overall achievement outcomes.

Concerning middle-level teachers, especially the science teachers, sensitivity training about cultural differences should be in place to address possible biases that may impede students. Teachers who are trained in how to teach the aforementioned self-efficacy and neuroplasticity can impart that knowledge to help motivate all students to reach their potential. Teachers need to have an understanding on how their expectations affect their various students; this information could be included in professional development and teacher-training programs to help eliminate bias. Teachers need to understand and be informed of ways to improve students' attitudes towards science. Driver, Leach, Miller, and Scott (1996) suggested that students with negative attitudes towards the subject will become less scientifically literate over time. Similarly, Simpson and Oliver (1990) found that primary school students with negative attitudes toward science tend to avoid it in later years and are less likely to choose a career in science. Based on this, teachers need to be specially trained to promote positive attitudes in science, concentrating on the enjoyment of discovery and attaining new and interesting information, along with engaging activities. Lastly, but most importantly, science teachers must be well-trained in science knowledge from their teacher-training programs, with a firm understanding of content and pedagogical aspects of the position.

Implications for Practice

The purpose of this study was to investigate the relationship between curricular differentiation and science achievement in middle school students. Although statistically significant, the effect of the curriculum treatment was so small that offering two courses for science in middle schools may not be of practical importance by itself. Standardized achievement scores showed minimal improvement in school districts with differentiated curriculum, even as students chose for themselves between two science offerings without requirements or prerequisites. Although high-stakes testing is important to school districts, the learning process is a priority. In this research, three implications for practice were derived from examining the longitudinal data: The importance of science teaching methods, the efforts needed to address persistence academic gaps among races, and the importance of peers in learning.

First, teachers are extremely important in student learning (Simpson & Oliver, 1990), and can affect students in multiple ways. Along with being caregivers, facilitators, communicators, and instructors, teachers should be trained in methods of engagement of science students. Abdi (2014) found that inquiry-based instruction improved science achievement scores as well as increased interest among students. Technology use in STEM classrooms improves academic achievement (Delen & Bulut, 2011), and hands-on activities and lab experiences significantly improve science learning (Stohr-Hunt, 1996; Bilgin, 2006). This study included students from districts that offer differing opportunities to take advantage of such instructional enhancements. Yet, schools that can engage students with these methods may see positive results in science achievement and interest.

Second, results from this study show evidence of achievement gaps among races in science. Many school districts have already implemented cultural sensitivity training for teachers and extra-curricular activities to promote inclusion, yet more can be done to highlight diversity and encourage minority participation in science. Faris (2009) states that learning should be supported by a multicultural education program for optimum positive effects on science achievement. Clearly, teacher training is only a starting place to grow a multicultural approach to science instruction. Efforts to increase female and minority representation in STEM activities and programs should begin prior to middle school. Studies show that participation in such programs increases science interest in subsequent years (Sahin, 2013). Extra-curricular science activities can lead to higher achievement scores (Souitaris, Zerbinati, & Al-Laham, 2007). Programs such as clubs and school-sponsored science contests that specialize in promoting under-represented groups can increase interest in science and contribute to closing achievement gaps. Because of the longitudinal nature of this study, gaps were easily apparent. Black and Hispanic students started lower and finished lower than other races through middle school science testing, although a higher percent of both groups were interested in advanced science classes overall. Education programs in science, and in general should include concerted efforts to promote multiculturalism in the classroom. It is worth noting that 41 various data points in this study had to be ignored due to discrepancies in self-reporting students' race on standardized test forms. While some students chose "Black" for their race in 5th grade, the same students chose "Other" in 8th grade. Some students chose "White" in 5th grade, and the same students chose "Hispanic" in 8th grade. Other curious race reporting occurred as well. This self-reported confusion may signal a systemic need for improving cultural diversity and awareness in schools, which may in turn increase academic performance for all students.

Another implication for practice is for pedagogical leaders to appreciate the role of peers and friendships in student motivation and achievement. Students tend to choose friends of similar ability levels, which may be beneficial to some and detrimental to others (Flashman, 2012; Gremmen, Dijkstra, Kornelis, Christian, & Veenstra, 2017). The schools in this study that offered two choices in science per grade level allowed students to choose their challenge level. Students may choose a class to increase the chances that they will stay within their peer group instead of for instructional content of the class. When high-achievers are grouped together in advanced classes, it benefits them, but also causes the low-challenge classes to have fewer students to model higher academic aspirations. Peers are significantly involved with individual achievement (Lynch, Lerner, & Leventhal, 2013). Burke and Sass (2008) found that peer effects are stronger at the classroom level than the grade level. The strength of peer influence should not be underestimated, and is worthy of more study. It is evident that allowing students to choose their science class when presented with a choice will involve students' consideration of the placement of their friends as well. The importance of friendships and peer group on academics is key to understanding motivation in the classroom.

Future Study

Very little information exists concerning the effects of differentiated curriculum on middle schools students. Further research is needed to increase understanding of the consequences of the practice, especially on science students. Triangulating achievement scores with surveys and observations may benefit research in that area (Gamoran, 1989).

One goal of improving science education is to increase the number of students who pursue science careers, especially from under-represented groups. Utilizing extra-curricular science activities and cross-curricular science offerings may help bring about science career interests (Dabney et al., 2012). Further research is also needed to see whether and to what degree enrollment in advanced science classes actually leads to science careers. Perhaps an investigation of those already in science careers would inform the pedagogy in ways to promote science.

In researching curriculum methodology and student achievement, other factors arose that can add to information concerning academic success. More information is needed on the support students need and get from home, and how it affects their academic performance, especially in middle school. The family influence on fostering student interest in science can be related to parent education level (Dabney, Tai, & Scott, 2016), but there may be more to the parent-school connection to help students have a positive attitude about science. In addition, some middle schools offer more academic credit, called "weighting," to some classes to show that they are of more value. More information into the effects of weighting science classes in middle school, and how that practice affects academic achievement, would be beneficial.

Racial/ethnic differences in academic achievement persist, although the gap seems to be narrowing for females in science. Further research into ways to promote science interest in these under-represented groups is necessary for equity in the workplace. More research into the phenomenon of Asian students outperforming other groups in science would be beneficial in the understanding of cultural differences and their effect on academic achievement. Further investigations into the relatively low number of affluent students entering advanced science classes would be helpful in understanding student motivation.

The role of parents in middle-school achievement needs further review. Harris and Goodall (2007) found that parental engagement in the home benefited student achievement. Alrehaly (2011) found that many parents had no intention of influencing their child's choice of college major and made no serious attempts to be involved in science discussions. Perhaps it would be beneficial for schools and communities to offer more information about science-specific careers. Research into the home-school connection is needed to recognize the attributes of parental involvement.

Additional examinations of science education and the effects of district policies on academic achievement are necessary for the improvement of instruction. Research into the effects of offering weighted classes or other incentives would be beneficial for understanding students' motivation in science classes. Cultivating high expectations for all students while providing equal opportunities to involve them in rigorous science content is necessary for optimum academic growth.

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APPENDIX A

TYPES OF INSTRUCTIONAL DIFFERENTIATION

Table A1

Types of Instructional Differentiation

Type	Description
Ability Grouping	Also known as Homogeneous Grouping, or Setting, pupils are placed in subject area classes on the basis of a test of their general aptitude for that particular subject. (This varies only slightly from Differentiated Curriculum in that Ability Grouping will have the same curriculum as the advanced classes but instruction will vary based on abilities of the group). *Example: A group of students in a science class are put together based on similar test scores in that subject.*
Tracking	Also known as Streaming, pupils are placed in classes on the basis of a test of their general ability, and they remain in their 'track' for most, if not all, subjects for a year or longer. *Example: A student qualifies for the advanced track, and for the rest of the year, if not longer, he will be in all of the advanced class offerings.*
Differentiated Curriculum	A school offers two or three different classes with varying degrees of difficulty and enrichment in a particular content area, and pupils qualify for those classes based on a test or general attainment in that subject. It is done on a subject-by-subject basis. (This varies only slightly from Ability Grouping in that Differentiated Curriculum will have two different course curricula for a grade level). Example: *A struggling math student qualifies for Pre-Algebra instead of Algebra and will be enrolled in the lower-level pre-algebra, although he may excel at other subjects and is otherwise enrolled in advanced classes.*
Differentiated Instruction	Also known as Within-Class Ability Grouping, pupils are grouped within a mixed-ability class on the bases of ability. Sometimes assignments will vary between groups based on abilities. *Example: A student who excels in History within her class is placed in a group of other high-achievers, so assignments are enriched frequently and are more challenging than the other groups in the room.*
Mixed Ability	Also known as Heterogeneous Grouping, pupils are sorted at random, or are placed together based on factors other than academic performance, such as social relationships, for the purpose of achieving a range of abilities within one class. *Example: A student is placed randomly in a science class.*

APPENDIX B

TYPES OF RESEARCH METHODS MENTIONED IN LITERATURE REVIEW

Table B1

Types of Research Methods Mentioned in Literature Review

Research Method	Definition	Pros/Cons
Meta-Analysis	Statistically combines the results of several studies to investigate a central tendency	Enables understanding of trends; Relies on published studies; sources of bias are not controlled.
Longitudinal Study	Studies done over time with a sample group	Observational; Shows causal relationships over time; may be less powerful than experiments.
Regression Discontinuity Analysis	Shows causal effects of interventions using pre and post tests	Unbiased, but can have a statistically lower power than a random sample

APPENDIX C

RESEARCH ARTICLES FOR LITERATURE REVIEW

Table C1

Research Articles for Literature Review

AUTHOR	ARTICLE	HYPOTHESIS	INSTRUMENTS	METHODOLOGY	FINDINGS
Abadzi (1985)	Ability grouping effects on academic achievement and self-esteem: Who performs in the long run as expected? The Journal of Educational Research, 79(1), 36-40.	High ability-grouped students learn more, while low-ability grouped students learn less.	Iowa Test of Basic Skills (ITBS) scores separated students into groups. Achievement was then measured with ITBS and the CAT (California Achievement Test) scores. A self-esteem inventory was also used.	Regression-discontinuity analysis on students grade 4-6 in a large Texas school district; Students were tested pre- and post-grouping, using the NCE (Normal Curve Equivalents). 8 Randomly-selected schools studied 284 high-ability students and 383 regular-ability students.	High-ability students achieved more and scored higher on self-concept when first grouped, but both of those categories leveled off after the first year. Low-ability students who were in ungrouped classes with high-ability learners showed overall improvement. Students who were grouped in either very high- or very low-ability groups showed less overall achievement gains and no self-concept change.
Slavin (1993)	Ability grouping in middle grade: Achievement effects and alternatives. Review of Educational Research, 57(3), 293-336.	Children who are grouped in ability groups tend to show improvement in learning.	Researcher used achievement data from state standardized test scores to determine which achievement category a student earned: proficient, advanced, basic, or below basic.	This meta-analysis compared data from 27 previous studies as follows: 6 = ability grouping vs. mixed ability 7 = matched I.Q.s and then segregated according to ability 14 = ANCOVA studies between existing groups vs. non-grouped.	The effect of ability grouping on student achievement is virtually zero in overall change of students being placed in the top two categories (proficient and advanced) on standardized tests. Therefore, ability grouping has no statistical advantage over non-grouped student achievement.

Mastropieri et al. (2006)	Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests. Journal of Special Education, 40 (3), 130-137.	Mixed-ability classes that use differentiated instruction can outperform classes who do not; Learning disabled can benefit.	State standardized test scores, and the Stanford Nine Achievement Test were used, along with teacher and student attitude surveys.	K-R 20 reliability coefficients were used to compare experimental group vs. control group, and learning disabled vs. general population. An ANCOVA (Analysis of Covariance) was used to compare data from 13 eighth grade science classes consisting of 213 total students, of which learning disabled n = 44, and ELL n = 35. (109 male and 104 female).	Differentiated instruction in mixed-ability classes improved student achievement scores overall. Learning disabled students and ELL students achieved more and scored higher self-concept ratings in mixed-ability classes that used differentiated instruction techniques than those that did not.
Lleras & Rangel (2009)	Ability grouping practices in elementary school and African-American and Hispanic achievement. American Journal of Education, 115(9), 279-304.	Children who are grouped in the lower-ability groups will learn less, while those in the high-ability groups learn more.	ECLS-K (Elementary Cognitive Learning Survey) which will compare a stratified nationally representative sample of 27,000 children.	This was an early childhood longitudinal study testing in 1st grade and then again in 3rd grade, measuring reading achievement gains of high and low ability grouped students. This test group consisted of 1,636 1st graders, of which African-Americans n = 750, and Hispanics n = 886.	Lower ability groups had smaller gains compared to non-grouped student of low ability; There was no significant difference between the gains of high-grouped students and non-grouped students. Authors conclude that grouping at younger ages perpetuates inequality gaps in education.
Hoffer (1992)	Middle school ability grouping and student achievement in science and mathematics. Educational Evaluation and Policy Analysis, 14(3), 205-227.	When comparing science and math achievement scores, children will learn more in ability groups, and that it increases learning of all students.	LSAY (Longitudinal Study of American Youth) along with parts drawn from the NAEP (National Assessment of Education Progress) achievement tests, and a questionnaire.	Students from 51 middle and senior high schools consisting of 3.116 seventh-graders who were then retested in tenth grade (n = 2,829). A target sample of 60 students was randomly selected. An ANCOVA (Analysis of Covariance) was used.	High-ability group in science had no significant difference to ungrouped science students. Low-ability science students grouped together had a negative effect on achievement compared to ungrouped (same with math). However, high-ability math grouped improved achievement more than ungrouped math groups.

Steenbergen-Hu & Moon (2011)	The effects of acceleration on high-ability learners: A meta-analysis. Gifted Child Quarterly, 55(1), 39-53.	High-ability children learn more, and increased self-efficacy ratings when grouped with other high-ability children.	Researcher used achievement data from state standardized test scores to determine which achievement category a student earned: proficient, advanced, basic, or below basic.	This meta-analysis compared data from 38 previous studies completed from 1989 – 2008 as follows: 15 = measurements of academic achievement; 11 = social-emotional studies; 12 = studies that measured both of these categories. An ANOVA (Analysis of Variance) was used to test for moderators between achievement and social-emotional development.	Accelerated groups had a strong positive impact on achievement. The social-emotional development effects of high-ability groups show a slightly positive effect on self-efficacy. High-ability learners equal or surpass non-grouped students in self-concept. No strong evidence for the moderators of the effects was found.

VITA

Diane Marie Fitzgibbons was born in February of 1963 in Kansas City, Missouri. She is the daughter of Ervin and Betty Glidewell of Milan, Missouri. She attended public schools in south Kansas City, graduating from Ruskin High School in 1981. She began her college work at Longview Community College, then transferred to Northeast Missouri State University (now called Truman State University) in Kirksville. After earning a Bachelor of Science in Education degree, she began teaching high school science classes in Raymore, Missouri, before moving to a middle school in Raytown, Missouri. During that time, she earned a Master's Degree in Education Administration from Central Missouri State University (now called University of Central Missouri) in 1996.

After taking time off to be a stay-at-home-mom in 1997, she returned to teaching in 2000 at Moreland Ridge Middle School in Blue Springs, Missouri. She took a sabbatical from her employment in Blue Springs to serve as an Administrative Intern in the Lee's Summit School District from 2004 to 2005. Ms. Fitzgibbons earned her Education Specialist in Administration from the University of Missouri-Kansas City in 2005 and returned to the classroom in Blue Springs, teaching science at Brittany Hill Middle School. Ms. Fitzgibbons became a doctoral candidate in the Division of Educational Leadership, Policy and Foundations at the University of Missouri-Kansas City, where she earned her Doctor of Education in May 2018. Diane lives with her husband Shawn in Lee's Summit, Missouri, and enjoys hiking, painting, and spending time with her children Wesley, Luke, and Eden.