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Effect of Single-Gender Education on Girls' Success in Math

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Abstract

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MS, Walden University, 2005

BS, Presbyterian College, 1994

Dissertation Submitted in Partial Fulfillment

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Doctor of Philosophy

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Abstract

Prior research suggested that all students were not treated equally in the educational setting and that boys perform better than girls on standardized tests. The purpose of this quantitative study was to examine how class composition affected performance on the math section of the Educational Records Bureau (ERB) test and Preliminary SAT (PSAT) among girls who took single-gender classes and girls who remained in coed math classes. Gender essentialism and gender constructivism are important to the study of single-gender education because the foundation of single-gender education is in understanding brain development to design a classroom that allows for differences to guide the process of learning. Archived data obtained from a private school in the southeastern United States were analyzed using a general linear model univariate and an independent-samples *t* test. Data analysis indicated a significant mean difference in the math ERB scores due to placement in single-gender or coed classes. There was no interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry. Girls in coed classes on average (M = 791.36, SD = 97.50) scored higher than girls in single-gender classes (M = 746.05, SD = 89.31) on the math ERB. Statistically significant results were shown in the examination of PSAT scores due to having been in single-gender (M = 536.80, SD = 84.89) or coed (M = 583.80, SD = 83.54) classes; $t(98) = 2.79$, $p = .006$. The study has positive social change implications because it challenges gender norms about the education of girls in the area of math.

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Chapter 1: Research Problem

Introduction

Research has suggested that all students are not treated equally in the educational setting (Fryer & Levitt, n.d.; King & Gurian, n.d.; Sampson et al., 2014). Sampson et al. (2014) stated that Title IX in 1972 and the No Child Left Behind Act in 2001 were important pieces of legislation that were passed because it was shown that education was not equal for all students across the United States. Title IX allowed women to attend institutions that were historically all male, and No Child Left Behind ensured that all students were receiving a fair education regardless of where their school was located. Both of these acts applied to educational institutions that were receiving federal funding. No Child Left Behind caused public institutions to search for alternative methods to educate students and ensure academic success for all students by requiring institutions to come up with ways to ensure that students were receiving an education that was fair and equal. Public schools started investigating, and in some cases implementing, methods such as single-gender classes that had been used by private institutions for years (Sampson et al., 2014).

The implementation of single-gender classes allowed schools to address concerns such as behavior and the achievement gap between girls and boys in math (Sampson et al., 2014). This achievement gap in math starts in middle school and increases as girls get older (Fryer & Levitt, n.d.). Leahey and Guo (2001) supported other research conclusions and indicated that the difference between girls' and boys' math knowledge can be observed in their performance on the math portion of the SAT. Fryer and Levitt (n.d.) were not able to determine whether the gap was due to changes in standardized test design or the type of school setting (single-gender vs. coed classes). Therefore, more research is needed on the middle school years to determine why there is a gap in math achievement. Chapter 1 contains the background, problem and purpose statements, theoretical framework, and research questions and hypotheses of the study. Chapter 1 also includes definitions, assumptions, limitations, scope and delimitations, and the significance of the study.

Background

Over the past few years, schools have struggled with how to educate all students and ensure that no child is left behind. Single-gender educational research has focused on the impact it has had on boys (Herr & Arms, 2004). Single-gender classes for subjects such as math and science have been examined as a possible solution to the problem of girls' performance in school in these subjects and being underrepresented in careers related to math and science. Song et al. (2017) studied how to increase adolescent girls' participation in math-related careers. Song et al. concluded that schools should contest math gender stereotypes, provide examples to girls of women who are in math-related fields, and teach girls about gender discrimination. Gulnaz and Fatima (2019) concluded that girls started to dislike mathematics by Grade 9 or 10, and teaching and learning were the main causes for their lack of interest. The single-gender environment may be used as an alternative for students to gain confidence in their ability to perform well in the subjects of math and science (Fryer & Levitt, n.d.; Leahey & Guo, 2001).

Mead (2003) and Hart (2015) suggested that single-gender education can fulfill the promise of No Child Left Behind and present no legal issues to address such as Title IX. Single-gender approaches used include an all-girl school, single-gender classes for both genders, or paired single-gender classes on the same campus. Researchers have suggested that this alternative is necessary because girls lose interest in math in middle school and do not take higher level math courses when they get older because of participation in coed math classes (Fryer & Levitt, n.d.; Koppel et al., 2003). Participation in a single-gender math class could change perception of math ability for girls and help with performance on standardized tests (Scogin et al., 2017). Substantial research on the effectiveness of single-gender education on math performance for girls on standardized tests based on the grade in which it is implemented was not found in a review of the literature. Therefore, a gap in the literature was identified. The intent of the current study was to contribute to the literature by examining the effect of math class composition (single-gender or coed) and course taken (Algebra 1 and Geometry) on girls' performance on standardized tests. Three groups can be considered: began in the sixth grade, did not begin in the sixth grade but took one or more single-gender courses, and never took single-gender classes. For the purpose of this study, due to the small sample size of girls who did not begin in the sixth grade but took one or more single-gender courses, single-gender was defined as girls who began in the sixth grade and girls who did not begin in the sixth grade but took one or more single-gender courses.

Problem Statement

Middle school is an important time in the development of girls in understanding math and building confidence (Wiest, 2008). Although single-gender schools may be found at the elementary, middle, and high school levels (Schachter, 2003), there is a lack of research on how girls' achievement on standardized tests in single-gender math classes (i.e., single-gender throughout middle school or at least one semester) compares to that of girls who remain in coed math classes. The gap in the research addressed by this study was on middle school girls who attended single-gender math classes (i.e., single-gender throughout middle school or at least one semester) compared to girls who remained in coed math classes, and their performance on the Educational Records Bureau (ERB) and Preliminary SAT (PSAT) standardized tests. The girls took Algebra 1 or Geometry prior to taking the ERB test in middle school, and all the girls took Geometry or were in Geometry prior to taking the PSAT in 10th grade.

Purpose of the Study

Research on single-gender education has focused on achievement in the subjects of math and science (Sampson et al., 2014). The research has shown that girls underperform relative to boys on standardized tests even though girls may have higher grades in their math class (Ganley et al., 2013). Additionally, there are gender stereotypes about girls and math that are present in coed classes but not in single-gender classes

(Ganley et al., 2013). Furthermore, there is little research that has addressed the performance of students in schools that offered coed classes for math then switched the students to single-gender classes for math.

The purpose of this quantitative study was to examine how class composition affected performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. Research conducted by Piechura-Couture et al. (2011) and Prendergast and O'Donoghue (2014) focused on the achievement gap between boys and girls in math. However, research has not focused on girls in single-gender classes compared to girls in coed classes.

Research Questions and Hypotheses

RQ1: Is there a significant mean difference in the math ERB scores due to having been in single-gender or coed classes?

H_{o1}: There is no significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

H_{a1}: There is a significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

RQ2: Is there a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o2}: There is no significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a2}: There is a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ3: Is there an interaction in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o3}: There is no interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a3}: There is an interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ4: Is there a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes?

H_{o4}: There is no significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

H_{a4}: There is a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

Theoretical Framework

The theoretical framework of this study was based on the arguments presented by advocates of single-gender education, the concepts presented by constructivism about the environment being essential to learning, and gender essentialists' ideas about different predispositions and behaviors for boys and girls. One of the arguments presented by advocates of single-gender education is that the environment should be different for boys and girls because of predispositions and hormones (Gurian et al., 2009). Gender essentialism proposes that males and females have different predispositions and behaviors; these differences are caused by genetics and hormones (Fine & Duke, n.d.). Gender constructivists propose that the environment causes differences. Constructivism was used to examine the environment, and essentialism was used to examine the effect of the single-gender math class or coed math class environment on students' performance on standardized math assessments.

Gender essentialism and gender constructivism are important to the study of single-gender education because the foundation of single-gender education is in understanding brain development to design a classroom that allows for differences to guide the process of learning. Students in a single-gender classroom build on prior knowledge and have a high self-concept about the subject being studied. Single-gender education may be a way to teach girls in certain subjects (Gurian et al., 2009) because they can be taught based on their interests and abilities. In single-gender classes, teachers would have flexibility to meet the needs of more of their students by their design of lessons and activities. School districts have implemented single-gender schools and classes in areas where students struggle academically (Gurian et al., 2009). These schools have seen the achievement levels of girls increase and have expanded single-gender programs from middle schools to high schools (Gurian et al., 2009). However, no study has been conducted comparing student achievement on the ERB taken in eighth grade and the PSAT taken in 10th grade.

Both theories listed relate to the study. Gender essentialism provides an understanding of the differences in the learning styles of males and females based on brain development. Gender constructivists provide an understanding of how the environment can affect the ability to learn and have an effect on performance. A more detailed explanation is provided in Chapter 2.

Nature of the Study

The nature of the study was a nonexperimental quantitative design. This design was chosen because the groups were preexisting and not randomly assigned. The data for the current study were obtained from archived scores from a private school in the southeastern United States. The data consisted of the score on the math section of the ERB test taken by girls in eighth grade and PSAT math assessment taken by girls in 10th grade. The independent variables in this study were class composition (single-gender or coed) and course taken (Algebra 1 or Geometry). The dependent variables were the archived scores on the math section of the ERB and PSAT. The results from this study may help school administrators recognize how they can implement single-gender classes for math as well as the impact that doing so has on the performance of girls in the areas of standardized test performance.

Definition of Terms

The following terms were used in the study:

Educational Records Bureau (ERB): The ERB is a not-for-profit organization that provides assessments that are used by private and public schools. The assessments measure achievement in different subjects. The ERB is offered to students in eighth grade. The students take the section labeled Math 1 and 2 (this is the name given to the math test section, and students get only one score). For the current study, the math assessments of the ERB were used (see https://www.erblearn.org).

Preliminary SAT (PSAT): The PSAT is offered at different times during the 10th grade. It is used as a way to assess student progress and show areas where students need to work prior to taking the SAT (College Board, 2020).

Single-gender education: An educational system in which students are assigned to classrooms based on their gender (Gurian et al., 2009).

Standardized test: An assessment designed to allow students to show how well they understand objectives and demonstrate skills in certain subject areas. The students administered these assessments are compared to other students on a local, state, and national level (Good et al., 2003).

Assumptions

Several assumptions were made for this study. First, teachers were assumed to have been teaching the classes offered based on the curricular plan provided. Second, it was assumed that proper procedures were followed in the administration of the ERB and PSAT and the tests were secure prior to administration. Similarly, it was assumed the environment was comparable for all administrations of the test. Moreover, it was assumed that students voluntarily took the ERB and PSAT, were serious, and tried to perform to the best of their ability. Finally, it was assumed the archived data were properly electronically archived.

Scope and Delimitations

The study was delimited to girls attending and taking single-gender math classes and coed math classes at a single private school. Some of the girls began taking single-gender math classes in sixth grade, while others did not. The scope of this study centered on the effects of single-gender math classes on mathematics achievement on standardized tests. The ERB test is taken in eighth grade, whereas the PSAT is taken in 10th grade.

Limitations

The present study was limited by the use of archived data provided by the school (see Appendix). One limitation was that the educational setting was a single private school. The private school setting provides more opportunities for students compared to public schools, such as smaller class sizes and more individualized attention from teachers. Additionally, the private school student typically has more tools at home such as technology and private tutors. Therefore, the students may be receiving the same instruction in the classroom, but the available resources outside the classroom may contribute to differences in achievement scores when comparing them with each other. However, schools with a similar structure may indirectly benefit from the results. Another limitation was the way in which material was presented by the teacher. It was assumed the teachers were teaching the class offered based on the curricular guide provided for the course; however, the delivery method might have differed based on the teacher.

Significance

Schools and school districts are struggling with how to educate children (Gurian et al., 2009). Single-gender classes are an option being pursued to help students who are struggling academically. Single-gender education, if implemented properly, may provide an environment in which boys and girls are educated based on academic, social, and behavioral needs (Gurian et al., 2009). The gap in research involved understanding how schools can implement single-gender education effectively for girls in math classes and how math scores on tests such as the ERB and PSAT are affected by the single-gender environment when compared to scores for girls in coed classes.

The current study is important because previous research has shown that girls are underrepresented in fields that require a strong math background (Zeid & El-Bahey, 2011). Therefore, it is debatable whether a single-gender environment will foster success for struggling students while increasing the participation of girls in mathematics-related fields. Some potential uses of the findings will be in the application of single-gender classes in educational institutions. Single-gender classes may provide educational institutions with an inexpensive but effective method of helping educate girls in classes such as math, where they typically underachieve. Finally, results of the present study may have an effect on how women view taking math classes and how schools decide to educate their students.

Summary

Schools have struggled for years on how to educate all students. Middle school is a time when educational differences start to develop for students, especially in the area of math. Based on the literature, the achievement gap between girls who took their math classes in single-gender classes versus coed classes has been investigated. However, the effect of such participation (single-gender versus coed classes) on math standardized test performance has not been studied. The single-gender classes provide an environment in which learning can be developed to use the strengths of the learner. The current study measured the differences that the single-gender environment has for the success of girls on standardized assessments.

Chapter 2 presents the literature search strategy and theoretical foundation. Chapter 2 also includes relevant scholarly professional literature. The review focuses on single-gender and coeducational classes, arguments for and against single-gender education, students' perceptions of math, and aptitude tests.

Chapter 2: Literature Review

Introduction

The purpose of this quantitative study was to examine how class composition affected performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. Standardized tests are used annually to analyze student performance. There is a lack of substantial research on schools that offer single-gender classes and how this affects girls on standardized tests—in particular, those provided by the ERB given in middle school and math scores on the PSAT administered to high school 10th graders. Therefore, more research is needed during the middle school years about girls and their performance on standardized tests.

This chapter outlines the relevant scholarly professional literature related to this research study. Section 2 begins with a discussion of the history of education. The discussion of the history of education highlights two important acts related to the education of women. The chapter includes a discussion of how single-gender education fulfills the promise of the two acts. It also includes a discussion of the goal of single-gender education and how the purpose of the study was to examine how single-gender classes and courses taken affect the performance of girls on standardized tests.

This chapter then transitions into a discussion of the literature research strategy, and the chapter continues with a discussion of the theoretical framework for the study. Information is also provided on the argument for and against single-gender education, which includes pertinent studies about single-gender education. Performance differences in math such as variances of performance on standardized tests conclude the discussion of the chapter.

History of Education

Education for men and women was once separate (Kaminer, 1998), and it was not until Title IX was introduced as part of the Education Amendment Act of 1972 that women were allowed to attend school with men. Title IX ensures that gender discrimination will not be present in any educational institution receiving federal money (Otto, 2004). In 2001, No Child Left Behind was passed in the United States to ensure that all students would receive an education, primarily focusing on racial/ethnic inequality (Chudowsky et al., 2010). No Child Left Behind caused public institutions to search for alternative methods to educate students and ensure academic success. Thus, some public schools started implementing single-gender classes. The number of single-gender public schools increased from six prior to 2000 to almost 600 in 2012 (Bowe et al., 2017). Single-gender education can be used to fulfill the promise of No Child Left Behind as long as there are no legal issues to address such as Title IX (Mead, 2003).

The goal of single-gender classes is to ensure academic success and close the widening achievement gap. Math has been viewed for years as a subject that is difficult for girls, and their achievement is lower than that of boys (Prendergast & O'Donoghue, 2014). This achievement gap in math starts in middle school and increases as girls get older, though it is not clear whether the gap is due to changes in standardized test design or the type of school classes offered (single-gender or coed; Fryer & Levitt, n.d.). The literature lacks substantial research on schools that offer single-gender classes and how this affects girls' success in math and on standardized tests, in particular those provided by the ERB given in middle school and math scores on the PSAT administered to high school freshmen and sophomores. More specifically, the literature does not identify how single-gender classes relate to their achievement in math classes compared to coed classes.

The purpose of this quantitative study was to examine how class composition affected performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. In this chapter, the literature search strategy, theoretical foundation of the study, and literature related to single-gender education related to girls' performance on standardized tests taken are explained.

Literature Search Strategy

The articles for this review of the literature were obtained by using the keywords *single-gender*, *single-gender classrooms*, *single-gender classes*, *gender essentialism*, *gender constructivist*, *math classes*, *girls and math*, *standardized tests*, *No Child Left Behind*, *Title IX*, and *middle school.* The databases included Education Source, ERIC, and SAGE Journals. All of the articles selected were peer reviewed. The years searched were from 1985 to the present.

Theoretical Foundation

The theoretical framework for this study focused on the ideas embedded in gender essentialism and constructivism. Gender essentialism proposes that males and females have different predispositions and behaviors caused by genetics and hormones (Fine & Duke, n.d.). In contrast, gender constructivists have proposed that the environment causes differences between genders (Fine & Duke, n.d.). Piaget (1964) proposed the theory of constructivism using the concepts of accommodation and assimilation.

Male and female students are distinctly and naturally different, bringing different skills to the classroom (Skewes et al., 2018). Gender essentialists believe that women are better at nurturing and social interactions, and men are better at problem solving, analyzing, and abstract reasoning (Sikora & Pokropek, 2012). The research focuses on how a change in environment affects performance on standardized tests because of the skills that must be developed and are being nurtured.

Research on single-gender education, such as that of Michael Gurian, has its roots in gender essentialist ideas (Liben, 2015). The only difference between Gurian and other gender essentialists is the wording used to describe how boys and girls learn (Liben, 2015). For example, Gurian referred to the brain rather than the nature of the individual. Gurian’s research is mainly based on brain science and how the brains of males and females develop at different rates and are stimulated differently in certain situations (Liben, 2015). Researchers have used gender essentialism to argue that single-gender education is the answer to issues such as boys needing things that keep them moving in the classroom and an alternative to verbal learning because they are not able to communicate thoughts (King & Gurian, n.d.).

Piaget suggested that there were four main factors associated with development: maturation, experience, social transmission, and self-regulation; all factors relate to cognitive processes. In this educational approach, the teacher and student are responsible for creating an environment that allows for learning that is suited to the individual (Can & Kaymakcı, 2015). In the constructivist learning environment, the teacher allows for differences, promotes creativity, focuses on the process, and explains information so the student can understand it. For example, Ibe (2017) examined how this approach could be used to boost students' biology achievement and found that the classroom allowed students to experiment, discuss, and build on prior knowledge, which led to a higher self-concept in biology and improved achievement. Moyer et al. (1997) found similar results when they examined this approach in a mathematics classroom; the students were able to grasp the concepts using real-world examples to learn the concept of slope.

These two ideas were used in this study because one of the arguments presented by advocates of single-gender education is that the environment should be different for boys and girls because of predispositions and hormones. Changing the environment could engage students who struggle and give girls confidence in subjects they might not normally excel in, such as math and science (Sikora & Pokropek, 2012).

Literature Review

In the literature review, arguments against and for single-gender education, math performance, and aptitude tests were examined. The arguments researchers have made against single-gender education focus on discrimination and stereotyping. Researchers against single-gender education argue that there are few brain differences between the genders and students need to be taught towards their strengths. Researchers for single-gender education argue that strengths are found in the brain differences. Additionally, researchers have concluded that single-gender classes provide an environment in which students are taught towards their interests and strengths. Being taught towards their strengths allows female students to overcome the inequality found in coed classes. In the following sections, single-gender classes and girls' problem solving, reasoning, and math understanding will be defined. The improvement in math understanding has helped girls perform at equal levels to boys on standardized tests.

Single-Gender Versus Coeducational Classes

When reviewing the literature on single-gender education, there is an additional factor that is considered. Single-gender schooling refers to educating males and females in two different schools; my focus is on single-gender classes within a coeducational setting. Single-gender classes can take place in a coed school setting where students attend classes that are designed for members of the same gender (Robinson et al., 2021). Single-gender classes in a coed setting are implemented to help girls with performance and confidence in subjects such as math and science (Robinson et al., 2021). Initial comparisons of single-gender and coed classes involved studies related to physical education. Studies related to single-gender and coed schools have also involved science and math.

Wallace et al. (2020) examined the effect of single-gender and mixed-gender physical education (PE) classes on girls' activity levels. The researchers looked at the hypothesis that girls would spend more time in moderate to vigorous physical activity in a single-gender session in comparison with a mixed-gender session; therefore, girls would show a preference for single-gender PE sessions. Wallace et al. concluded that girls' activity levels were higher in single-gender physical education classes compared to mixed-gender classes. Most of the girls wanted to participate in games in classes where boys were not present. This study is significant to the current study because it supports the findings that girls' participation and confidence levels increase in activities dominated by boys when they are not present.

When competition is focused on the classroom and not on physical educational settings, girls in single-gender classes at single-gender schools compete more than girls at coeducational schools (Laury et al., 2019). The girls in the single-gender environment do not care about the risk involved in competition. The risk for the girls is appropriate, nurtured, and calculated. Based on a study conducted by Wilson et al. (2013), this might be attributed to the fact that teachers teach the girls in a single-gender class at a higher level. The factors that are contributing to this could include a decrease in behavior and classroom management concerns that occur in a coed environment.

Dhindsa et al. (2018) studied attitudes toward science in single-gender schools and coed schools. The study did not examine the attitude towards science in which the classes were in the same school, but focused on different schools. It was concluded that students in seventh grade, regardless of the type of school, all had the same declining attitude towards science. This declining attitude towards science was greater in students in single-gender schools compared to coed schools. The attitudes of boys in single-gender schools declined more than those of girls in single-gender schools.

Pennington et al. (2018) were able to conclude from their study on the effectiveness of single-gender classes in a coeducational school that there was no benefit for male or female students in language and science, technology, engineering, and mathematics (STEM)-related subjects. However, there was a negative impact on girls in single-gender classes compared to mixed-gender classes in non-STEM-related subjects.

Spielhagen (2006) studied how middle school students view single-gender and coeducational classes. It was concluded that girls benefited from the experience; however, there were concerns around emotions. Sixth-grade girls reported more freedom in single-gender classes, and seventh- and eighth-grade girls reported improvement in their grades and more confidence.

Else-Quest and Peterca (2015) studied students in single-gender schools and coed schools. Being in a single-gender school did not harm or help students overall; however, girls in single-gender schools did perform better than girls in coed schools. The researchers noted that there were several factors that could have contributed to this discrepancy in performance, such as lack of access to books, supplies, safety, and stereotyping because the students were from low-income schools. It was suggested by the authors that the study be replicated across different communities. In the community identified for this study, the students have access to extra books, supplies, tutors, and a math lab while in school. Outside of school, the students use other resources such as private tutors from corporations such as Huntington Learning Center, Mathnasium, and Kumon if they are struggling in math class, as well as private tutors from Georgia Tech, Emory, and other area colleges.

Student Gendered Perceptions of Mathematics

There has been a push in education for an increase in the number of girls in STEM careers (Cherney & Campbell, 2011). This push has led to changing how girls are taught in math and science classes. Single-gender education has become an option. Researchers such as Cherney and Campbell (2011) have discovered that girls in single-gender schools score higher on tests than girls in coed schools and have higher self-esteem. Girls in single-gender schools are motivated intrinsically more than girls in coed schools.

Tichenor et al. (2016) examined elementary girls' attitudes towards mathematics in mixed-gender and single-gender classrooms, and their findings supported the study of Cherney and Campbell (2011). The overall results suggested that both sets of girls had positive attitudes towards math. The results also showed that girls in mixed-gender classes started to develop a negative attitude about math, whereas girls in the single-gender classes felt that math was not boring, was relevant, and was useful. The tendency towards a feeling of not being successful in math starts in elementary schools for some girls and continues when they reach middle school (Tichenor et al., 2016).

Kombe et al. (2019) investigated single-gender math classrooms in a coeducational public middle school. The focus of the study was student characteristics, class type, gender domain, and teacher perceptions of gender in mathematics. Girls in single-gender and coeducational classes viewed themselves as positive mathematics learners, and the single-gender environment was positive and supportive.

Van de gaer et al. (2004) studied the effects of single-gender versus coeducational classes and schools on gender differences in language and mathematics achievement. Girls' achievement in math increases in single-gender schools; however, language achievement does not. This study was significant because it examined single-gender classes and schools. According to Van de gaer et al., a single-gender environment is influential in how students view themselves as well as the other gender. Additionally, the single-gender environment leads to differences in academic achievement and experience (Glasser, 2012). For example, research has shown that attending coeducational schools leads to taking higher level science classes due to intellectual and career expectations (McEwen et al., 1997). Sampson et al. (2014) found that male students liked the single-gender classes and grew in their science self-concept; however, female students did not show gains in achievement and had a negative science self-concept. The lack of gain in achievement for the girls can be explained by the lack of confidence girls have in their understanding of subjects such as math and science. The arguments against single-gender education suggest that more studies are necessary to understand why the classes help male students and not female students.

Arguments Against Single-Gender Education

Researchers have made a number of arguments against single-gender education. According to Eliot (2013), single-gender education can lead to discrimination and stereotyping because the students do not have opportunities to learn together. Further, the American Association of University Women (AAUW) does not support single-gender classes because of a fear that there will be a loss in gender equity. Based on the lack of support for single-gender classes from the AAUW, some schools do not use single-gender classes (Merritt, 2019). Additionally, girls who are in single-gender classes do not always look for careers in math and or science. Though there are a few differences between the brains of boys and girls (Eliot, 2011), if students are taught toward their strengths, a natural gap will develop in the weak areas. Separating boys and girls suggests that the brain is hardwired and that students cannot become better in certain areas without this separation. Thus, opponents of single-gender education have argued, schools should be focused on promoting student self-efficacy and not separating the boys and girls (Eliot, 2011). How students view themselves and their academic ability is a factor in performance on standardized tests (Good et al., 2003). For instance, students being told that their brains can grow helps with motivation and achievement (Inzlicht & Ben-Zeev, 2003).

Opponents of single-gender education have also argued that it can lead to gender bias (Martin & Beese, 2016). Gender bias leads to assumptions of what it means to be male or female, expectations placed on students because of gender, and punishment of students who do not follow the traditional gender roles (Martin & Beese, 2016). Boys and girls are similar, and single-gender schools tend to focus on sexism in the classroom and increase gender stereotypes and biases (Martin & Beese, 2016). A single-gender environment is influential in how students view themselves as well as the other gender. Additionally, the single-gender environment leads to differences in academic achievement and experience (Glasser, 2012). For example, research has shown that attending coeducational schools leads to taking higher level science classes due to intellectual and career expectations (McEwen et al., 1997). This is further supported by Sampson et al. (2014), who found that male students liked the single-gender classes and grew in their science self-concept; however, female students did not show gains in achievement and had a negative science self-concept. The arguments against single-gender education suggest more studies are necessary to understand why the classes help male students and not female students.

The purpose of this study was to examine how class composition (single-gender or coed) affects performance on standardized tests. The arguments against single-gender education are important to the study because they suggest being in a single-gender class will not lead to better performance on standardized tests.

Arguments for Single-Gender Education

Researchers who support single-gender schools list the reason as the ability to teach to the biological differences in the brain and hormones that exist between boys and girls (Pahlke & Hyde, 2016). Teaching to these differences, supporters have argued, would allow for students' performance to increase because their strengths are being considered when instruction is being designed by the teacher (Pahlke & Hyde, 2016). Research has also shown that a single-gender environment contributed to girls who were competitive and felt comfortable in the school environment (Choi et al., 2015).

Hart (2015) further confirmed the benefits of single-gender education for students by studying girls in a single-gender versus coed classroom, finding that there were differences in student satisfaction. Piechura-Couture et al. (2011) also concluded that the environment provided by single-gender classes helps reduce representation in special education classes and decreases discipline referrals. Single-gender education recognizes differences in boys and girls, and the need for different teaching methods and activities. Single-gender education might be a way to teach boys and girls in certain subjects such as math and science (Gurian et al., 2009) since the subjects can be taught based on the students' interests and abilities. Teachers can have flexibility in the classrooms to meet the needs of more of their students by their design of lessons and activities. Some of the activities used involve movement in the classroom, varied seating assignments, and objects the students can fidget with. Each learner is different, so it is important to design teaching, learning, and assessments to address the differences (Gouws, 2007). School districts have implemented single-gender schools and classrooms in areas where students struggle academically and have seen the achievement levels of boys and girls increase, leading to an expansion in programs from middle schools to high schools (Gurian et al., 2009). Based on these researchers' support of single-gender classes, this study will build on the research findings that single-gender classes do help the performance of girls.

Michael Gurian, who founded the Gurian Institute, which trains teachers in coed and single-gender schools has conducted research on what girls and boys need in the classroom environment to learn (Gurian et al., 2009). Research has been conducted by King and Gurian, (n.d.) which concluded that girls need classrooms that are quiet with few distractions, less body movement, and allows the girls to communicate their thoughts and ideas verbally (King & Gurian, n.d.). King and Gurian concluded from their study that single-gender education is the answer. Gurian did not use any particular theoretical model in his research on single-gender education and girls.

Liben (2015) describes several aspects of Gurian's ideas. He notes Gurian used gender essentialist ideas that males and females learn differently because of differences in development. Liben also found that the only difference between Gurian and other gender essentialists is the wording used to describe how boys and girls learn. An example provided by Liben is Gurian talks about the brain rather than the nature of the individual.

The purpose of this study was to examine how class composition (single-gender or coed) affects performance on standardized tests. The arguments for single-gender education are important to the study because they suggest being in a single-gender class will lead to better performance on standardized tests.

Aptitude Tests

Scafidi and Bui (2010) examined performance on standardized math tests and found gender similarities in performance. Data were collected from ten states and students in grades 8, 10, and 12. Fifty-one percent of the participants in the study were female. The students were tested on their ability to perform basic math skills such as operations using whole numbers, decimals, fractions, and word problems. A significance level of .001 was chosen based on the number of statistical tests conducted and to control for Type 1 errors. The results indicated girls performed similarly to boys. This study showed that in an environment in which the girls feel confident in their mathematical abilities, they are able to perform at a similar level to boys.

Standardized tests are used annually to analyze student performance. Tests to measure the mathematic achievement of students can be norm-referenced or curriculum based (Schwery et al., 2016). Norm-referenced tests measure broad areas, are not always taken from curriculum, administration procedures are standardized, and administered to multiple students from different educational backgrounds (Schwery et al., 2016). Boys have been scoring higher than girls in the mathematics portion of standardized tests such as the SAT for several years and the difference has been approximately 40 points (Schwery et al., 2016). Information on curriculum based assessments comes from what the students are learning in a particular class and examine student performance at a particular time (Schwery et al., 2016). Low test performance on standardized or curriculum based tests can be attributed to low self-efficacy about mathematical skills and belief about gender differences (Schwery et al., 2016).

Despite the fact that girls tend to have higher grades than boys in class, boys tend to outperform girls on tests such as the SAT test in mathematics (Ryan & Ryan, 2005). Girls in single-gender classes beginning in middle school have improved their standardized test scores (McFarland et al., 2011). Ganley et al. (2013) examined the effect of perceived stereotypes on the performance of girls on mathematic assessments. An equal number of boys and girls from similar backgrounds were used in the study. The study was conducted in three parts; each part was designed to explore the performance at different stages of development in school. Some of the participants were in elementary, middle, or high school. The effect of stereotypes was not found, but girls still underperformed boys on standardized tests. Scogin et al. (2017) examined the effect of participation in an experimental learning program on performance on standardized tests. The experimental learning programs could be using problem based and project based learning. Standardized tests are used annually to analyze student performance. The researchers concluded it could be difficult for some schools to prepare students to meet test expectations and provide learning opportunities students need. The PSAT is a standardized test administered to high school students prior to taking the SAT. Searches did not uncover research examining the PSAT test and students who took single-gender classes. Therefore, it is important to study the effect of class composition on performance on standardized tests.

Summary and Conclusion

Education for women was separate from men originally. Single-gender education recognizes there is a difference in boys and girls, how they learn, and what they need to be successful in school despite what people who are against it might say. Single-gender education promotes gender equity and self-efficacy. A review of the literature revealed a gap in research regarding how schools can implement single-gender education effectively for girls in math classes, and how math scores on tests such as ERB, PSAT, are affected by the single-gender environment. Research has also shown girls are starting to close the gap on performance on aptitude tests and grades in class.

This research is important because the effect of a single-gender class compared to a coeducational class has not been analyzed in relation to ERB, and PSAT. Therefore, it is debatable if a single-gender environment will foster success for struggling students. Single-gender classes may provide educational institutions with an inexpensive but effective method. Additionally, current research may change any negative connotations that women associate with mathematics, and it may transform how schools educate students. Educational institutions may have an option that is inexpensive and works. This research may change how women view taking math classes. It may also change how schools decide to educate their students. Chapter 3 will describe how the current study will examine the effect of single-gender classes on girls' performance on the ERB, and

PSAT. It will also include an introduction, sampling and sampling procedures, the data analysis plan, and a summary of the results.

Chapter 3: Research Method

Introduction

The ERB test is administered to eighth graders towards the end of the school year, after most of the Algebra 1 curriculum has been covered. However, because the class gender composition during sixth, seventh, or eighth grade might have varied, it would be worthwhile to determine how such class gender composition might have affected students' achievement on the math section of their ERB test. Once students are promoted to ninth grade, they may or may not take Geometry. Those students who did not take their Geometry class during ninth grade will take it during 10th grade. In 10th grade, towards the end of the school year, the PSAT is administered to the 10th graders (i.e., those who took Geometry during their ninth grade or are currently taking Geometry in 10th grade). However, because students might have arrived in 10th grade having participated in varied class gender compositions, the question to be answered involves the effect that such class gender composition might have had on their performance on the mathematics section of the PSAT. Therefore, the purpose of this nonexperimental study was to determine the effect that class gender composition might have had on math achievement on the ERB as well as the PSAT between girls who took single-gender classes and girls who remained in coed math classes.

In this chapter, I will explain the research design and the rationale behind it. Second, a detailed explanation of the methodology, which includes the population size, sampling procedures, and method for recruitment of participants, will be presented. Then data collection procedures and operational variables will be discussed. Finally, the threats to validity and ethical procedures will be explained. The chapter concludes with a summary.

Research Design and Rationale

The nature of the study is a nonexperimental, retrospective, quantitative design, which was chosen because the groups were preexisting and not randomly assigned. A 2X2 (two-way) factorial analysis of variance (ANOVA) was used to analyze the data and answer the research questions. The independent variables (factors) in this study were class gender makeup, single-gender or coed, and type of math class, Algebra 1 or Geometry. The two dependent variables were the archived scores on the math section of the ERB and secondly, PSAT math scores.

The examination of standardized test scores using quantitative analysis was supported by Prendergast and O'Donoghue (2014). Prendergast and O'Donoghue analyzed scores based on student gender, type of school attended, and level of enjoyment of mathematics. Females outperformed males even though they enjoyed mathematics less. The authors concluded that further research is needed in the area of school type, coeducational or single-gender, because many of the studies that have been conducted contradict each other.

Methodology

Population

The population was middle school girls who attended or were currently attending a private school. The approximate size of the middle school has varied from 400 to 510 students over the past 12 years, with approximately half the students being girls. Utilizing existing archival data, the participants in this study were girls who were in single-gender classes (i.e., single-gender throughout middle school) or girls who were in at least one semester of a coed class. Criteria for inclusion in the study included the following:

- being enrolled in the school
- being 11 through 14 years of age
- having attended single-gender or coed math classes during the time period
- for participants who took the ERB, being in eighth grade at the time they took the test
- for participants who took the PSAT, being in 10th grade

Sampling and Sampling Procedures

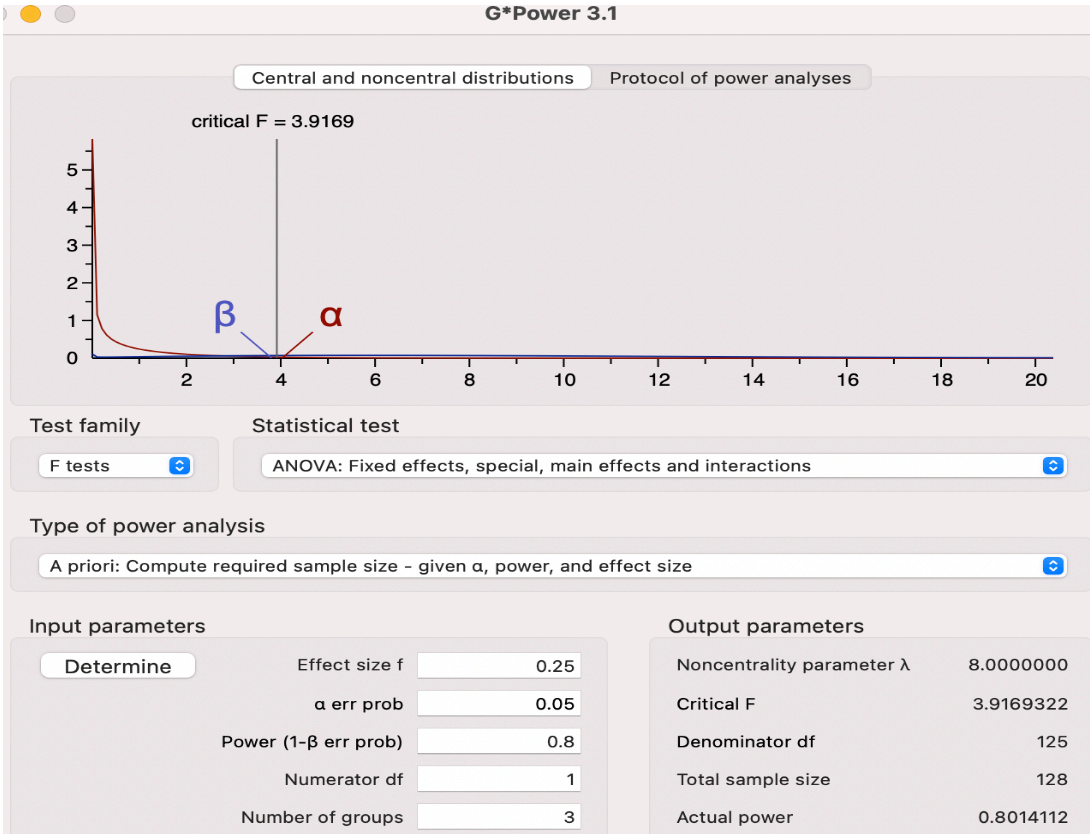
From the school's database, two groups of students were formed by the registrar's office, which houses all the information on the students. One of the groups consisted of eighth graders, who participated in either single-gender or coed classes. The given group was further divided into those students who took Algebra 1 or Geometry during their middle school experience. The second group consisted of 10th graders who took the PSAT and during their middle school years attended either single-gender or coed classes.

The groups were formed by the registrar's office, and a Microsoft Excel file was emailed to me after the names had been removed.

The groups were based on single-gender or coed, type of math class, ERB, and PSAT scores. The registrar's office provided the Microsoft Excel file with the above information. Results of an a priori G*Power (Version 3.1.9.6) analysis (see Figure 1) indicated that the required minimum sample size, using an effect size = 0.25, beta = .80, and alpha = .05, in an effort to control for Type I and Type II errors (Faul et al., 2007), was 128 participants. From the Microsoft Excel file received from the registrar's office, the following subsamples were randomly selected: (a) 50 eighth graders who went the single-gender route and 50 eighth graders who went the coed route; (b) 50 eighth graders who went the Algebra 1 route and 50 eighth graders who went the Geometry route; and (c) 50 tenth graders who went the single-gender route and 50 tenth graders who went the coed route.

Figure 1

*G*Power Analysis*



Procedures for Recruitment, Participation, and Data Collection

To answer the research questions, quantitative data from 2013–2014, 2014–2015, 2015–2016, 2016–2017, and 2021–2022 of archived standardized test scores in math from eighth graders who took the ERB and 10th graders who took the PSAT were used. Some of the female students had participated in single-gender classes since sixth grade, some had started single-gender classes in a later grade, and others had remained in coed classes throughout their middle school years. To gain access to the data, a meeting was held in the office of the associate head of school on December 14, 2022 at 7:45 a.m., during which the study was explained. A permission letter was signed by the associate head of school to use the archived data. Informed consent was not needed, as agreed upon in the permission letter, because no identifying information was provided. The data were provided in the form of a Microsoft Excel file.

Operationalization of Variables

The independent variables in this study were participation in single-gender classes (0 = no, 1 = yes) and participation in Algebra 1 or Geometry (0 = Algebra 1, 1 = Geometry). These data came from archived enrollment data of the students. The students either started participation in single-gender classes or did not.

The two dependent variables were the archived scores on the math sections of the ERB and PSAT. ERB scores were broken down into raw scores. Raw scores were obtained in the area of Math 1 and 2, which has one score. A fictional example is a student receiving in Math 1 and 2 a scale score of 546.

The PSAT math test taken by 10th graders is scored from 120 to 720. A student scoring 440 would be below the benchmark of 450 established by the College Board for college readiness.

Data Analysis Plan

The data were analyzed using SPSS software version 28 (IBM, 2021). A 2 (single-gender vs. coed classes) X 2 (Algebra 1 vs. Geometry)-way factorial ANOVA was run to answer the first and second research questions. Because the data were obtained in the form of a Microsoft Excel file, the data were first imported into SPSS, where they were subsequently cleaned and screened to make sure the information was complete for each participant in the study. Any data missing for a given participant resulted in the individual being dropped from the study. Prior to testing the research null hypotheses, the data were tested to see if they met the ANOVA assumptions.

Research Questions and Hypotheses

RQ1: Is there a significant mean difference in the math ERB scores due to having been in single-gender or coed classes?

H_{o1}: There is no significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

H_{a1}: There is a significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

RQ2: Is there a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o2}: There is no significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a2}: There is a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ3: Is there an interaction in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o3}: There is no interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a3}: There is an interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ4: Is there a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes?

H_{o4}: There is no significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

H_{a4}: There is a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

Data were input into SPSS for Windows software version. A 2 (single-gender vs. coed classes) X 2 (Geometry vs. Algebra 1)-way factorial ANOVA was run, along with an independent-samples *t* test. To test Hypotheses 1 and 2, in SPSS statistics two columns were set up and labeled class composition (single-gender = 0 or coed = 1) and course taken (Algebra 1 = 0 or Geometry = 1), respectively. The scores for the ERB test, the dependent variable, were entered in another column, under the variable name ERB score. To analyze the data, the general linear model univariate was selected. Class composition and course taken were listed as a fixed factors, and ERB score served as the dependent variable. There were two plots created. The horizontal axis was course taken, and class composition was a separate line. The second horizontal axis was class composition, and a separate line was course taken. No post hoc tests were run because only two groups were compared. To measure the effect size, eta-squared was run. The means and standard deviations for the interactions were analyzed and graphed. An interaction effect was represented by a set of nonparallel lines. A test of between-subjects effects table was used to show whether the two independent variables or the interaction were statistically significant.

To test Hypothesis 4, two new columns were created in SPSS. One column was the PSAT score, and the second column was the class composition (single-gender = 0 or coed = 1), respectively. To analyze the data, an independent-samples *t* test was run.

Threats to Validity

External

External validity helps determine if the results can be applied to real-world situations beyond the specific participants and setting used in the study (Warner, 2013). The ERB and PSAT assessments are used to assess students' comprehension of math concepts throughout the United States. However, because the class gender composition during sixth, seventh, or eighth grade might have varied, it would be worthwhile to determine how such class gender composition might have affected their achievement on the math section of their ERB test.

The most significant effect to external validity is that the study focused on students at a single private school; therefore, these research findings are generalized to one school and might not apply to other schools. Further, because this test was administered at a private school, some of the participants might have had access to outside tutors who could help with test preparation.

Internal

Threats to internal validity could have been caused by several factors such as the change in the test over time, the testing experience itself, and the participants becoming older and maturing (Shadish et al., 2002). Another threat to internal validity could have been differences in the teaching techniques of teachers in the classes.

Threats to internal validity for this study included, but were not limited to, the type of class the students participated in, single-gender or coed. Because the test was administered to every student on the same day in different rooms, the setting presented itself as an internal threat to validity.

Ethical Procedures

Permission from the Walden University Institutional Review Board (IRB) was obtained before research was conducted. There were no ethical concerns for recruitment of individuals because the data used were archived. The participants were anonymous middle school students; no names were used when the data were obtained, and parental consent was not needed. The associate head of school signed a data usage agreement on December 14, 2022. I worked in the environment; however, I did not have direct contact with the participants in the study. The information gathered for this research was only used by me and will be kept for a minimum of 5 years on a password-protected computer and backed up on a password-protected hard drive. After 5 years, the data will be destroyed.

Summary

In Chapter 3, I explained the research design and the rationale for the design of the study. An explanation of the methodology, which included population, sampling procedures, operationalization of variables, data analysis plan, validity, and ethical procedures, was also presented. Upon obtaining the Walden IRB’s approval, archival data, via a USB, was handed to me by the associate head of school, who had signed the data use agreement provided. The data on the USB drive was in the form of Excel spreadsheets. Data were then entered onto SPSS for data cleaning, assumptions testing, and analyses to commence. All analyses and their interpretations are done in Chapter 4. As there was no contact with subjects/participants, no consent form was needed.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to examine how class composition affected performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. The following four research questions and hypotheses guided the study:

RQ1: Is there a significant mean difference in the math ERB scores due to having been in single-gender or coed classes?

H_{o1}: There is no significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

H_{a1}: There is a significant mean difference in the math ERB scores due to having been in single-gender or coed classes.

RQ2: Is there a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o2}: There is no significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a2}: There is a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ3: Is there an interaction in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry?

H_{o3}: There is no interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

H_{a3}: There is an interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores due to having taken Algebra 1 or Geometry.

RQ4: Is there a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes?

H_{o4}: There is no significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

H_{a4}: There is a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

In this chapter, information is provided on the research questions and hypotheses that guided the research, data collection, procedures, and data analysis, concluding with a summary.

Data Collection

The data for this study were received from archival records at a private school in Georgia. Written authorization was obtained from the associate head of school to use the existing data on December 14, 2022. Walden IRB approval was received on December 19, 2022, and the approval number is 12-19-22-0017565. After obtaining the Walden IRB's approval for the study, I contacted the school registrar to request the data needed to conduct this research. The data were then transferred to me on a USB drive in the form of Excel spreadsheets. To ensure anonymity, only class composition (single-gender or coed), course taken (Algebra 1 or Geometry), and assessment scores (ERB and PSAT) were shared with me. The assessment scores, class composition, and course taken were transferred into SPSS software version 28 (IBM, 2021), where a general univariate analysis was conducted as well as testing for the six assumptions of factorial ANOVA. Finally, to test Hypotheses 1 and 2, a 2 (single-gender vs. coed classes) X 2 (geometry vs. algebra) factorial ANOVA was run in SPSS. To test Hypothesis 3, three columns were set up and labeled class composition (single-gender = 0 or coed = 1), course taken (Algebra 1 = 0 or Geometry = 1), and ERB score, respectively. To test Hypothesis 4, two new columns were created in SPSS. One column was the PSAT score, and the second column was the class composition (single-gender = 0 or coed = 1), respectively. To analyze the PSAT data, an independent-samples *t* test was run.

To determine the minimum sample size, a G*Power 3 (Faul et al., 2007) analysis was conducted, and the required minimum number was 128 participants. The Microsoft Excel file received from the registrar's office consisted of 266 students who took Algebra 1 and were single-gender, 68 who took Algebra 1 and were coed, 51 who took Geometry and were coed, and 70 who took Geometry and were single-gender, as indicated in Table 1. The following subsamples were randomly selected: (a) 50 eighth graders who went the single-gender route and 50 eighth graders who went the coed route; (b) 50 eighth graders who went the Algebra 1 route and 50 eighth graders who went the Geometry route; and

(c) 50 10th graders who went the single-gender route and 50 10th graders who went the coed route. Thus, the final sample size for this study was *n* = 200 students, to err on the side of caution.

Table 1

Class Composition

	Quantity	Participants	Valid participants	Cumulative participants
Algebra 1				
Single-gender	266	50	50	50
Coed	68	50	50	50
Geometry				
Single-gender	70	50	50	50
Coed	51	50	50	50
Total				
Single-gender	336	100	100	100
Coed	119	100	100	100

Results

Descriptive Statistics of Sample

The overall average Math 1 and 2 score on the ERB for students was 768.70 (*SD* = 95.99), while the average scores by class compositions were as follows: coed 791.36 (*SD* = 97.50) and single-gender 746.05 (*SD* = 89.31). The average overall Math 1 and 2 score for students in Algebra 1 was 716.46 (*SD* = 86.23), while the average scores by class composition were as follows: coed 730.92 (*SD* = 82.37) and single-gender 702.00 (*SD* = 88.39). The average overall Math 1 and 2 score for students in Geometry was 820.95 (*SD* = 74.63), while the average scores by class composition were as follows:

coed 851.80 (*SD* = 70.47) and single-gender 790.10 (*SD* = 65.90). More descriptive statistics are presented in Table 2.

Table 2

Descriptive Statistics of Educational Records Bureau Score Variables

	n	Mean	*SD*	Variance
ERB score	200	768.70	95.99	9213.13
Coed	100	791.36	97.50	9506.03
Single-gender	100	746.05	89.31	7976.43
Algebra 1score	100	716.46	86.23	7435.77
Coed	50	730.92		
Single-gender	50	702.00		
Geometry score	100	820.95	74.63	5569.34
Coed	50	851.80		
Single-gender	50	790.10		

Assumptions of Factorial Analysis of Variance Models

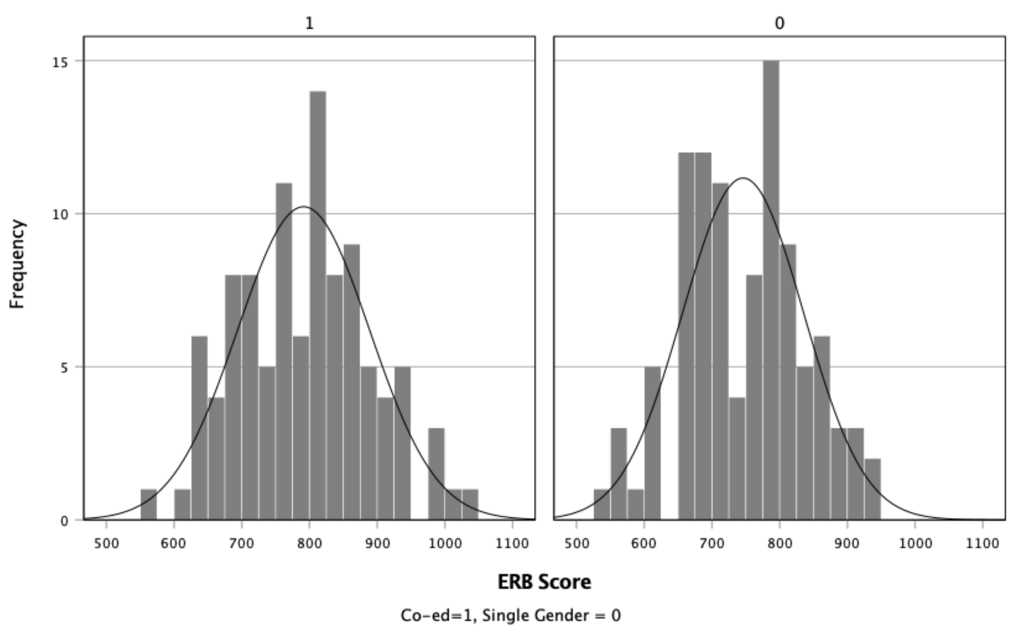
Assumptions for factorial ANOVA models were tested before performing analyses. There are six assumptions that should be tested. The assumptions are that the dependent variable should be continuous; two or more independent variables should consist of two or more categorical, independent groups; independence of observations; no significant outliers; dependent variables should be approximately normally distributed for each combination of the groups of the two independent variables; and homogeneity of variance for each combination of the groups of the two independent variables (Lund & Lund, 2020). The following are the explanations of the assumptions.

The dependent variables in the analysis were test scores, which are metric measurements. Therefore, the first assumption of the dependent variable data being continuous was established. The independent variables were class composition (single-gender or coed) and course taken (Algebra 1 or Geometry). This satisfies Assumption 2 because the groups are independent. The participants were put in groups based on their participation in middle school in single-gender or coed classes and then Algebra 1 or Geometry in eighth grade. Based on how the groups were designed, Assumption 3 of independence of observations was met. None of the observations were outside of the normal distribution; therefore, Assumption 4 was met. To test for normality, the data were entered into SPSS version 28; Kolmogorov-Smirnov and Shapiro Wilk's tests were calculated. For the Shapiro Wilk's test p-values greater than 0.05 indicate a normal distribution, p-values less than 0.05 suggests the data might not be normally distributed (Lund & Lund, 2020). The values indicated that the ERB score in Algebra 1 does not follow a normal distribution, $p < .01$ for the Kolmogorov-Smirnov's test and $p = .01$ for the Shapiro Wilk's test. According to Huck (2012), "violations of the normality assumption usually do not reduce the validity of the results of a two-way ANOVA when the sample sizes are large and equal" (p. 302). Additionally, "a two-way ANOVA with equal sizes is robust and the main effect and interaction *F* tests operate as intended even if the assumption is violated" (p. 304). The sample sizes of students are 100. The values indicated that the ERB score in Geometry might follow a normal distribution, $p = .02$ for the Kolmogorov-Smirnov's test and $p = .09$ for the Shapiro Wilk's test. In comparison of ERB scores for single-gender and coed, the values indicated that the data might follow a normal distribution, $p = .20$ for the Kolmogorov-Smirnov's test and $p = .58$ for the

Shapiro Wilk's test for single-gender. The values for coed were $p = .20$ for the Kolmogorov-Smirnov's test and $p = .76$ for the Shapiro Wilk's test. To further investigate the normal distribution, a histogram was created. Figure 2 reflects the histogram of the data, which formed a bell curve; thus, the data may be assumed to be normally distributed. Finally, to test Assumption 6, Levene's test was performed. Levene's test is used to test for equality of variances across groups (Warner, 2013). For Levene's test, a p-value less than .05 indicates a violation of this assumption (Warner, 2013). Levene's test resulted in $F(3,196) = 1.14$, $p = .312$. As the null hypothesis was not rejected, it may be assumed that the variances of the groups are equal. Table 3 reflects the results of this test.

Figure 2

Frequency Distribution of Educational Records Bureau Scores



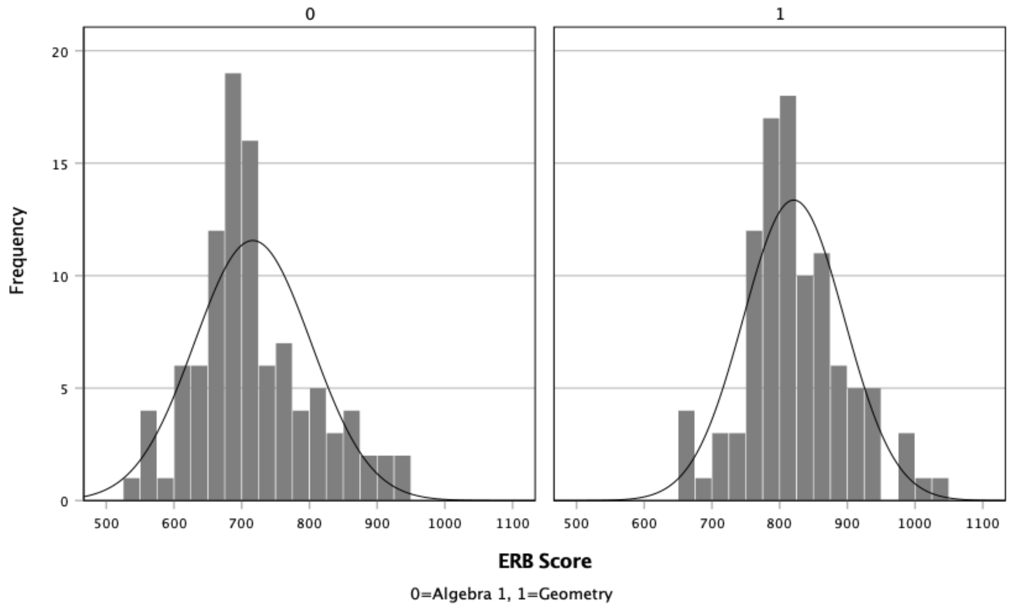


Table 3

Levene's Test of Equality of Error Variances

	Levene's statistic	*df*1	*df*2	Significance
ERB score				
Based on the mean	1.20	3	196.00	.31
Based on the median	0.98	3	196.00	.40
Based on the median with adjusted *df*	0.98	3	181.30	.40
Based on trimmed mean	1.14	3	196.00	.33

Assumptions of Independent-Sample *t* Test

Assumptions for independent-sample *t*-test models were tested before performing analyses. There are six assumptions that should be tested. The assumptions are as follows: The dependent variable should be continuous; the independent variable should consist of two categorical groups, independent groups; independence of observations; no significant outliers; dependent variables should be approximately normally distributed for each combination of the groups of the two independent variables; and homogeneity of variance for each combination of the groups of the two independent variables (Lund & Lund, 2020). The following are the explanations of the assumptions.

The dependent variables in the analysis were test scores, which are metric measurements. Therefore, the first assumption of the dependent variable data being continuous was established. The independent variable was class composition (single-gender or coed). This satisfied Assumption 2 because the groups were independent. The participants were put in groups based on their participation in middle school in single-gender or coed classes in eighth grade. Based on how the groups were designed, Assumption 3 of independence of observations was met. None of the observations were outside of the normal distribution; therefore, Assumption 4 was met. To test for normality, the data were entered into SPSS version 28 and Kolmogorov-Smirnov and Shapiro Wilk's tests were calculated. For the Shapiro Wilk's test, *p*-values greater than 0.05 indicate a normal distribution, and *p*-values less than 0.05 suggest that the data might not be normally distributed (Lund & Lund, 2020). In a comparison of PSAT scores for single-gender and coed, the values indicated that the data might follow a normal distribution, $p = .20$ for the Kolmogorov-Smirnov's test and $p = .871$ for the Shapiro Wilk's test for single-gender. The values for coed were $p = .20$ for the Kolmogorov-Smirnov test and $p = .400$ for the Shapiro Wilk test. To further assess for normality of the data, skewness and kurtosis were calculated and a histogram was created. The skewness values for the PSAT score and class composition (single-gender or coed) score were between -0.02 and -0.50, indicating a slight negative skewness. The kurtosis distribution is mesokurtic because it resembles a bell-shaped curve (Denis, 2015). Additionally, the kurtosis values for all the variables were close to 0, indicating a normal distribution (Martin, 2012). Figure 3 and Figure 4 reflect the histograms of the data, which resemble a bell curve. Finally, to test Assumption 6, Levene's test was performed. A *p*-value less than .05 indicates a violation of this assumption (Warner, 2013). Levene's test resulted in t(97.98 = 2.79 , p = .792) and satisfied Assumption 6 being met.

Figure 3

Preliminary SAT Scores Frequency Distribution for Class Composition (Single-gender)

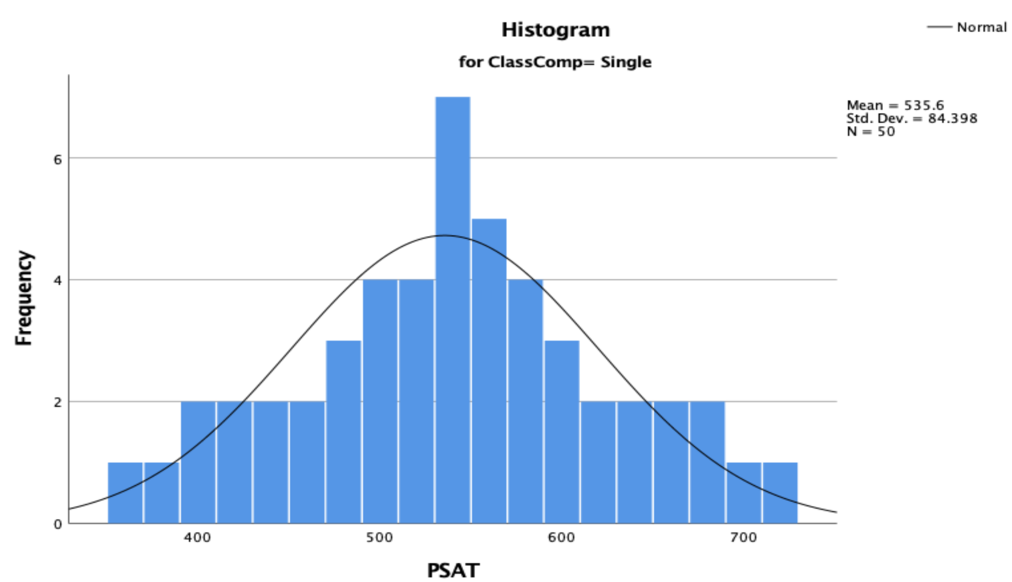
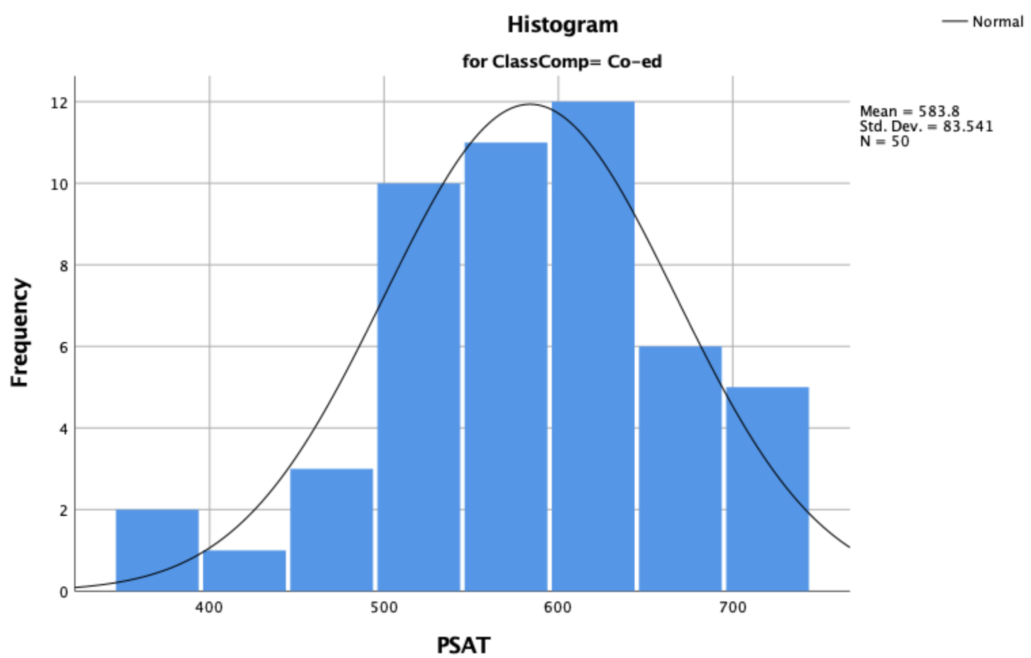


Figure 4

Preliminary SAT Scores Frequency Distribution for Class Composition (Coed)



Statistical Analyses

To answer the first three research questions and respective hypotheses, a 2 (single-gender vs coed classes) X 2 (Algebra 1 vs Geometry) factorial ANOVA was conducted. The factorial ANOVA analyzed the means, variances, and the interactions between subjects. To test Hypothesis 4, an independent sample *t*-test was run. All predictor variables were dummy coded. Course taken was coded Algebra 1= *0* and Geometry = *1*. Class composition was coded coed = *1* and single-gender = *0*. The results of the factorial ANOVA are shown in Table 4. Figure 5 shows there is not an interaction effect between single-gender and coed. The results for the independent samples *t*-test are presented in Table 5. All tests used a 95% confidence level to test each hypothesis.

Table 4

Tests of Interaction Between Course Name and Class Composition

Source	Type III sum of squares	*df*	Mean square	*F*	Sig.	Partial eta squared
Corrected model	661989.42 [a]	3	220663.14	36.92	< .001	.36
Intercept	118181475.41	1	118181475.41	19773.85	< .001	.99
Course name	545908.01	1	545908.01	91.34	< .001	.32
Class composition	102649.81	1	102649.81	17.18	< .001	.08
Course name [b] Class composition	13431.61	1	13431.61	2.25	.135	.01
Error	1171424.18	196	5976.65			
Total	120014889.00	200				
Corrected total	1833413.60	199				

[a] R squared = .36 (adjusted R squared = .35). [b] Dependent variable: ERB score.

Figure 5

Estimated Marginal Means of Educational Records Bureau Score

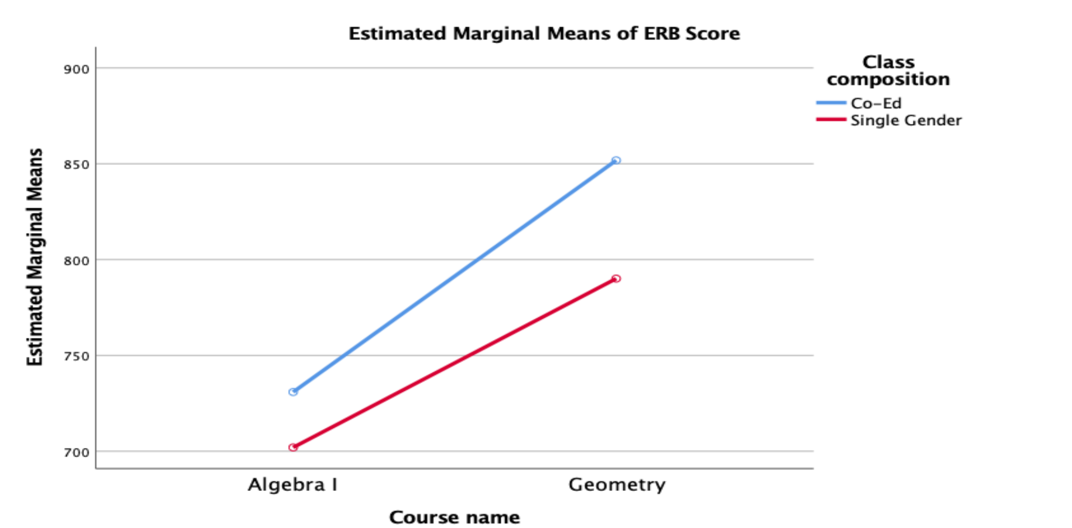


Table 5

Independent-Sample t-est

	Classcomp	*n*	Mean	*SD*	*t*	*p*
PSAT score	Coed	50	583.80	83.54	2.79	.006
	Single-gender	50	536.80	84.89		

Overall Results

A 2 X 2 factorial analysis of variance was used to examine the interaction of the independent variables course name and class composition effect on the dependent variable ERB scores. Kutner et al. (2005) suggested when analyzing factor effects in two-factor studies to examine how the factors interact, if no interaction, examine whether the main effects for the factors are important. The analysis of Table 4 (p = .135) indicates there is not a significant interaction. This finding is further supported by Figure 5 which shows the lines do not cross. Therefore, the main effects must be examined to understand the relationship between the independent variables and dependent variable because there was not a statistically significant interaction observed between the variables.

Results of the 2X2 factorial analysis of variance indicated that there is not a significant interaction between course name and class composition, $F(1, 199) = 2.25$, p = .135. Furthermore, examination of the main effects of course name and class composition indicated statistically significant findings. According to Table 4, statistically significant results were found in the examination of ERB scores when comparing students who were in single-gender classes to those in coed classes. Results were $F(1,199) = 17.18$, $p < .001$. Thus, null Hypothesis 1 was rejected and alternative hypothesis 1 was supported indicating there is a significant mean difference in the math ERB scores when comparing students who were in single-gender classes or coed classes. Also, statistically significant results were found in the examination of ERB scores when comparing students who were in Algebra 1 or Geometry. Therefore, null Hypothesis 2 was rejected and alternative hypothesis 2 was supported, indicating a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry. Results were $F(1,199) = 91.34$, $p < .001$, please see Table 4.

Statistically significant results were shown in the examination of PSAT scores when comparing students who had been in single-gender ($M = 536.80$, $SD = 84.89$) or coed ($M = 583.80$, $SD = 83.54$) classes, $t(98) = 2.79$, $p = .006$, please see Table 5. Null Hypothesis 4 was rejected and alternate Hypothesis 4 was supported; there is a significant mean difference in the math PSAT scores due to having been in single-gender or coed classes.

Summary

The purpose of this quantitative study was to examine how class composition affects performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. A 2 X 2 way factorial ANOVA was used to analyze the data. The results of 2 X 2 way factorial ANOVA showed a statistically significant main effect between course name and ERB score. Also, there was a statistically significant main effect between class composition and ERB score. The analysis of the interaction between course name and class composition was not statistically significant. Statistically significant results were shown in the examination of PSAT scores when comparing students who had been in single-gender or coed classes.

Chapter 5 will include an interpretation of the findings of the study as well as discussion of the limitations of the study and recommendations. Chapter 5 will conclude with a discussion of the implication of the study on social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Middle school is an important time in the development of girls in understanding math and building confidence (Wiest, 2008). Although single-gender schools may be found at the elementary, middle, and high school levels (Schachter, 2003), there is a lack of research on how the achievement of girls on standardized tests in single-gender math classes (i.e., single-gender throughout middle school or for at least one semester) compares to that of girls who remain in coed math classes. The research has shown that girls underperform boys on standardized tests even though girls may have higher grades in their math class (Ganley et al., 2013). Furthermore, there is little research that has addressed the performance of students in schools that offered coed classes for math and then switched the students to single-gender classes for math.

The purpose of this quantitative study was to examine how class composition affects performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. The results from the quantitative analyses indicated that there is a significant difference in math ERB scores for those having been in single-gender or coed classes and taking Algebra 1 or Geometry. However, there is no significant interaction between math ERB scores between single-gender and coed math classes due to having taken Algebra 1 or Geometry. Furthermore, there is a significant difference in math PSAT scores having been in single-gender or coed classes. In this chapter, the interpretations of the findings, limitations, recommendations, and implications will be discussed.

Interpretations of the Findings

Class Composition

RQ1: Is There a Significant Mean Difference in the Math ERB Scores Due to Having Been in Single-Gender or Coed Classes?

The data analysis for the study indicated a significant mean difference in the math ERB scores between those who went the single-gender route and those who went the coed route. Previous studies by Ibe (2017), Moyer et al. (1997), and Sikora and Pokropek (2012) addressed how the classroom environment allows students to experiment, discuss, and build on prior knowledge. Changing the environment could engage students who struggle and give girls confidence in subjects they might not normally excel in such as math. Researchers have concluded that single-gender classes provide an environment in which students are taught towards their interests and strengths. Being taught towards their strengths allow female students to overcome the inequality found in coed classes.

The results of the study were $F(1,199) = 17.18$, $p < .001$. Girls in coed classes on average ($M = 791.36$, $SD = 97.50$) scored higher than girls in single-gender classes ($M = 746.05$, $SD = 89.31$) on the math ERB. These results contradicted previous studies conducted by Wilson (2013) and Cherney and Campbell (2011), which found that teachers teach the girls in single-gender classes at a higher level, resulting in higher scores on math tests than those of girls in coed schools.

However, results of the current study support those found in a study by Good et al. (2003), which suggest that how students perceive themselves and their academic abilities can affect their performance on standardized tests.

RQ4: Is There a Significant Mean Difference in the Math PSAT Scores Due to Having Been in Single-Gender or Coed Classes?

Standardized tests are used annually to analyze student performance. Tests to measure the mathematics achievement of students can be norm referenced or curriculum based (Schwery et al., 2016). Norm-referenced tests measure broad areas and are not always taken from curriculum, while administration procedures are standardized and administered to multiple students from different educational backgrounds (Schwery et al., 2016). The PSAT is a standardized test administered to high school students prior to taking the SAT.

The data analysis for the study indicated a significant mean difference in the math PSAT scores between those who went the single-gender route and those who went the coed route. A previous study by Scafidi and Bui (2010) examined performance on standardized math tests and found gender similarities in performance. Fifty-one percent of the participants in the study were female. The students were tested on their ability to perform basic math skills such as operations using whole numbers, decimals, fractions, and word problems. This study showed that, in an environment in which girls feel confident in their mathematical abilities, they are able to perform at a similar level to boys.

Statistically significant results were shown in the examination of PSAT scores between those who went the single-gender route (*M* = 536.80, *SD* = 84.89) and those who went the coed route (*M* = 583.80, *SD* = 83.54) for classes; $t(98) = 2.79$, $p = .006$. This contradicts results from a study by McFarland et al. (2011) that found that girls in single-gender classes beginning in middle school improved their standardized test scores.

Course Taken

RQ2: Is There a Significant Mean Difference in the Math ERB Scores Due to Having Taken Algebra 1 or Geometry?

The study's data analysis indicated a significant mean difference in the math ERB scores for those who had taken Algebra 1 or Geometry. Results were $F(1,199) = 91.34$, $p < .001$. Girls in Geometry classes on average (*M* = 820.95*, SD* = 74.63) scored higher than girls in Algebra 1 classes (*M* = 716.46*, SD* = 86.23) on the math ERB. The results are supported by studies conducted by Spielhagen (2006), Cherney and Campbell (2011), and Tichenor et al. (2016).

In the literature review, Spielhagen (2006) studied how middle school students view single-gender and coeducational classes. It was concluded that girls benefited from the experience of single-gender classes. Researchers such as Cherney and Campbell (2011) have discovered that girls in single-gender schools score higher on tests than girls in coed schools and have higher self-esteem. Tichenor et al. (2016) examined elementary girls' attitudes towards mathematics in mixed-gender and single-gender classrooms, and their findings supported the study of Cherney and Campbell (2011). The overall results suggested that both sets of girls had positive attitudes towards math.

Interactions

RQ3: Is There an Interaction in Math ERB Scores Between Single-Gender and Coed Classes in the Math ERB Scores Due to Having Taken Algebra 1 or Geometry?

Data analysis indicated that the interaction between course name and class composition was not statistically significant $F(1, 199) = 2.25$, $p = .135$. Null Hypothesis 3 was not rejected; thus, there is no interaction effect in math ERB scores between single-gender and coed classes in the math ERB scores for those who had taken Algebra 1 or Geometry.

These findings contradict the arguments presented by Gurian et al. (2009), gender essentialists, and gender constructivists. Advocates of single-gender education contend that the environment should be different for boys and girls because of predispositions and hormones (Gurian et al., 2009). Gender essentialism proposes that males and females have different predispositions and behaviors; these differences are caused by genetics and hormones (Fine & Duke, n.d.). Gender constructivists propose that the environment causes differences.

Limitations of the Study

In this study, only girls attending and taking single-gender math classes or coed math classes at a single private school were included. Some of the girls began taking single-gender math classes in sixth grade, while others did not. Other limitations of the study were the use of archived data to be provided by the school (see Appendix); the private school student typically has more tools at home such as technology and private tutors and receives the material differently through instruction of the teacher. It was further assumed that the teachers were teaching the class offered based on the curricular guide provided for the course; however, the delivery method might have differed based on the teacher.

Recommendations

After review of the prior research and data from this current research study, it is recommended that this study be conducted again using a different population of students. The population was middle school girls currently attending a private school. Single-gender education has been used to fulfill the promise of No Child Left Behind by public schools (Mead, 2003). The number of single-gender public schools increased from six prior to 2000 to almost 600 in 2012 (Bowe et al., 2017). Conducting the study again using public and private school girls would increase the body of knowledge.

This study focused on eighth graders and 10th graders; a second recommendation would be to research other academic years. The ERB is given to sixth graders, seventh graders, and eighth graders. Because middle school starts in sixth grade, it would be beneficial to see if there is a difference in mean math scores over the years for students who took single-gender or coed math classes.

Else-Quest and Peterca (2015) studied students in single-gender schools and coed schools and determined that being in a single-gender school did not harm or help students overall. However, girls in single-gender schools did perform better than girls in coed schools. A third recommendation would be to conduct the study using students in a single-gender school and a coed school. Cherney and Campbell (2011) discovered that girls in single-gender schools score higher on tests than girls in coed schools. Girls in single-gender schools are motivated intrinsically more than girls in coed schools.

A fourth recommendation would be to focus the study on boys. The study was focused on girls attending a private middle school. Boys have been scoring higher on the mathematics portions of standardized tests for several years compared to girls (Schwery et al., 2016). This is despite the fact that girls tend to have higher grades than boys in class (Ryan & Ryan, 2005). The template for this study can be administered to examine the performance of boys.

Implications

Positive Social Change

The purpose of this quantitative study was to examine how class composition affects performance on the math section of the ERB and PSAT among girls who took single-gender classes and girls who remained in coed math classes. The findings of this quantitative study may create positive change for schools and districts as they continue to determine the best way to help girls with performance on standardized tests. Single-gender education has been used to fulfill the promise of No Child Left Behind by public schools (Mead, 2003). The data indicated that single-gender education and coed education could both be used as options to educate students.

Methodological Implications

The main findings of the study indicated that there is not a significant interaction between class composition and course taken when examining ERB scores. Future research could duplicate this design using a different population of students and possibly examining boys instead of girls. Additionally, future research on single-gender education should examine how the teachers are trained, how resources are used, students' perceptions, and school culture.

Theoretical Implications

The study contributes to the existing literature on single-gender education because evidence has been provided that suggests that there is not a significant interaction between class composition and course taken when examining ERB scores. Additionally, there are statistically significant results in the examination of PSAT scores due to having been in single-gender or coed. The findings support existing theories that there is no benefit for male or female students in language and STEM-related subjects. The findings contradict the belief that changing the environment will cause a change in overall performance. The study can inform future research by providing a foundation for more studies on the academic achievement of girls and the environment they are educated in.

Conclusion

Research has suggested that all students are not treated equally in the educational setting (Fryer & Levitt, n.d.; King & Gurian, n.d.; Sampson et al., 2014). No Child Left Behind caused public institutions to search for alternative methods to educate students and ensure academic success for all students by requiring institutions to come up with ways to ensure that students were receiving an education that was fair and equal. Public schools started investigating, and in some cases implementing, methods such as single-gender classes that had been used by private institutions for years (Sampson et al., 2014).

The implementation of single-gender classes allowed schools to address concerns such as behavior and the achievement gap between girls and boys in math (Sampson et al., 2014). This achievement gap in math starts in middle school and increases as girls get older (Fryer & Levitt, n.d.). Leahey and Guo (2001) supported other research conclusions and indicated that the difference between girls' and boys' math knowledge can be observed in their performance on the math portion of the SAT. Fryer and Levitt (n.d.) were not able to determine whether the gap was due to changes in standardized test design or the type of school setting (single-gender vs. coed classes).

The results of the study indicated a significant mean difference in the math ERB scores due to having taken Algebra 1 or Geometry. Girls in geometry classes, on average, scored higher than girls in Algebra 1 classes on the math ERB. Data analysis indicated a significant mean difference in the math PSAT scores due to placement in single-gender or coed classes. Statistically significant results were shown in the examination of PSAT scores due to participation in single-gender classes. Data analysis indicated that the interaction between course name and class composition was not statistically significant. Therefore, there is a need to examine how girls are being taught in school and the impact it has on achievement on standardized tests.

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Appendix: Data Use Agreement

DATA USE AGREEMENT

This Data Use Agreement ("Agreement"), effective as of (December 14, 2022.) ("Effective Date"), is entered into by and between (Joseph Moody.)("Data Recipient") and (.) ("Data Provider"). The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in research in accord with the HIPAA and FERPA Regulations.

1. Definitions. Unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the "HIPAA Regulations" codified at Title 45 parts 160 through 164 of the United States Code of Federal Regulations, as amended from time to time.

2. Preparation of the LDS. Data Provider shall prepare and furnish to Data Recipient a LDS in accord with any applicable HIPAA or FERPA Regulations.

3. Data to be included in the LDS. **No direct identifiers such as names may be included in the Limited Data Set (LDS).** The researcher will not name the Data Provider in the doctoral study that is published in Proquest unless the Data Provider makes a written request for the researcher to do so. In preparing the LDS, Data Provider or designee shall include the **data fields specified as follows**, which are the minimum necessary to accomplish the research: (Class composition (single-gender or coed), type of class (Algebra 1 or Geometry), scores on ERB test and PSAT test.).

4. Responsibilities of Data Recipient. Data Recipient agrees to:

a. Use or disclose the LDS only as permitted by this Agreement or as required by law;

b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;

c. Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;

d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and

e. Not use the information in the LDS to identify or contact the individuals who are data subjects.

5. Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS for its research activities only.

6. Term and Termination.

a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. Headings. The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.