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EFFECTS OF GENDER AND SCHOOL SIZE ON MATHEMATICS AND SCIENCE ACHIEVEMENT FOR STUDENTS IN WESTERN ARKANSAS

by

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EFFECTS OF GENDER AND SCHOOL SIZE ON MATHEMATICS AND SCIENCE ACHIEVEMENT FOR STUDENTS IN WESTERN ARKANSAS

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ABSTRACT

by
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Harding University
December 2015

Title: Effects of Gender and School Size on Mathematics and Science Achievement for Students in Western Arkansas (Under the direction of Dr. Raymond W. “Donny” Lee, Jr.)

The purpose of this dissertation was to research the effects of gender and school size on mathematics and science achievement for schools in western Arkansas. Related research revealed historical performance gaps in mathematics and science achievement between males and females, but also showed that those gaps have closed over the past few decades. However, the research also showed that there is still a large gap in the number of males and females working in Science, Technology, Engineering, and Mathematics (STEM) careers. This study also investigated this trend within western Arkansas to determine whether the gender gap in STEM is caused by differences in mathematics and science ability as evidenced by achievement, or may have another root cause. Other related research discussed the impact of school size on academic achievement with no definite conclusions and this study explored that impact specifically on mathematics and science achievement in western Arkansas.

Fourteen schools in western Arkansas were used for this causal comparative study. Within those 14 schools, 51.2% of the students were male and 48.8% of the students were female. The schools were categorized by their size and the categories were based on the Arkansas Activities Association’s classification system. Of the 14 schools, four were considered large schools, five were considered medium schools, and five were considered small schools.

In the four hypotheses, gender and size of school were the independent variables. The dependent variables were mathematics achievement as measured by the Augmented Benchmark Exam, science achievement as measured by the Augmented Benchmark Exam, mathematics achievement as measured by the End of Course Geometry Exam, and science achievement as measured by the End of Course Biology Exam. Seventh graders took the Augmented Benchmark Exams, and students taking the end of course Geometry and Biology exams were primarily 9th and 10th graders.

To analyze the data collected for each of the four hypotheses, a 3 x 2 factorial ANOVA was used. The results showed no significant interaction between school size and gender, but did show a significant difference in mathematics and science performance between small schools and medium and large schools. Therefore, according to this study, gender is not a factor affecting mathematics and science achievement, but size of school may be.

Due to the limitations of this study, generalizations about size of school should be made with caution. However, the impact of gender on mathematics and science achievement as determined by this study seems to line up with recent research. Males and females are performing at similar levels in western Arkansas, as they are across the nation. Consequently, the gender gap in STEM careers may have little to do with any genetic differences in mathematics and science ability.

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CHAPTER I

INTRODUCTION

In 1957, when the Soviet Union launched Sputnik, American education changed. The Space Race led to changes in American education, specifically with more emphasis on mathematics and science. To ensure that highly trained individuals would be able to help America compete with the Soviet Union in scientific and technical fields, Congress passed the National Defense Education Act, which included monies for the improvement of science, mathematics, and foreign language instruction (U.S. Department of Education, 2012). As technological advances progressed and the world became increasingly digital, the American education system continued to emphasize Science, Technology, Engineering, and Mathematics education, known as STEM. The government has recently purposed $180 million to implement initiatives to reorganize STEM education programs (U.S. Department of Education, 2012). However, gaps have been evident between male and female performance in these academic areas with males typically performing at higher levels in mathematics and science on national standardized tests (ACT, 2013; College Board, 2013). Researchers suggested numerous hypotheses to explain the gaps between male and female performance in STEM areas. These hypotheses can be categorized as genetic, social, and cultural.

Though the gaps between male and female test scores have lessened over the past few decades and scores are now more congruent, significant gaps in the number of males and females participating in STEM careers still persist (Beede et al., 2011). Because of these gaps, the U.S. government has again addressed the need for a focus on mathematics and science in public education and has provided funding for programs that promote these areas for both genders. President Obama's *Educate to Innovate* campaign, launched in 2009, includes three pillars. One of these is to expand STEM education and career opportunities for underrepresented groups including women (White House, 2009).

Because mathematics and science are considered important for the nation's success and minority groups (including women) should be targeted, state educational systems have re-written and implemented their standards for education and comprehensive testing systems to reflect these priorities. Of the 50 states, 45 have adopted the Common Core State Standards, which include frameworks in both mathematics and science with the goal of producing educated citizens with the needed skills to be successful in this technologically and scientifically driven world and the global economy (National Governor's Association and Council of Chief State School Officers, 2012).

Statement of the Problem

The purposes of this study were four fold. First, the purpose of this study was to determine the effects by size of school on male students versus female students on mathematics achievement measured by the Augmented Benchmark Exam for seventh grade students in schools in western Arkansas. Second, the purpose of this study was to determine the effects by size of school on male students versus female students on science achievement measured by the Augmented Benchmark Exam for seventh grade students in schools in western Arkansas. Third, the purpose of this study was to determine the effects by size of school on male students versus female students on mathematics achievement measured by the end of course exam for geometry students in schools in western Arkansas. Fourth, the purpose of this study was to determine the effects by size of school on male students versus female students on science achievement measured by the end of course exam for biology students in schools in western Arkansas.

Background

In 2012, the U.S. Department of Commerce determined that, in the years between 2012 and 2018, the number of jobs in STEM areas would grow 1.7 times faster than non-STEM careers. For that reason, the Obama administration set a goal to increase the number of students receiving undergraduate degrees in STEM careers by 1 million in the next decade (Feder, 2012). In order to meet this goal, more women must step into those careers. This need has renewed interest and focus on the gender gaps that have historically existed between boys and girls in mathematics and science education and specifically on pinpointing the culprit responsible for the gap. Government, education, and business are all concerned with finding a way to fix the problem in order to produce more STEM workers and keep America competitive in the global economy.

The Gender Gap in Mathematics and Science

The National Science Foundation (2002) reported that on the National Assessment for Educational Progress (NAEP) exams in mathematics and science, boys tend to score higher than girls do, historically. However, the gap has narrowed in the past three decades. The Foundation noted the gap favoring 17-year-old males in mathematics declined from an 8-point difference in 1973 to a statistically insignificant difference in 1999. The gap declined by six points in science.

Because of these historical gaps in achievement, much research has been conducted and several hypotheses have been suggested as the cause for the gaps. Some researchers pointed to genetic differences between males and females as the reason for the gap; others claimed the gap was caused by social and cultural factors. Gurian and Stevens (2004) reported that boys' brains are better suited to spatial-mechanical functioning, which makes them superior in mathematics and science. Baren-Cohen (2003) expanded this notion and claimed that the core cognitive development systems in humans cause learning pre-dispositions. His research suggested that males are more likely to learn about objects and mechanical relationships and females about people, emotions, and personal relationships from an early age. Due to this difference, males are more likely to be successful in mathematics and science. Other research claimed that the attention and perception ability in information processing might differ between the sexes as well. Variations in the development of the sensory system might cause males to develop more dynamic visual acuity, and females have better developed senses of taste, touch, and smell. The visual acuity and spatial skills that come with these systems might give males the edge in mathematical and scientific fields (Halpern, 2000).

However, most of these studies have been disputed, and there is not solid evidence that genetic factors cause differences in performance. For example, Spelke (2005) cited behavioral and neuroimaging studies of human cognition and cognitive development and agreed that there is a genetic basis in a set of core cognitive development systems for learning to represent objects, space, and numbers. Children access these systems when they learn mathematical and scientific principles. However, she also reported evidence that these systems are equally available to males and females and therefore not to blame for any gender differences in performance. At the same time, most recent data supported the gender similarities hypothesis, which holds that males and females are similar on most but not all psychological variables. This hypothesis claimed that males and females are more alike than different (Hyde, 2005).

The bulk of the research blames social and cultural factors as the offenders causing the gap. Niederle and Vesturlund (2010) identified several social reasons why boys and girls perform differently. These included the idea that boys tend to engage in more movement-oriented play that exposes them to a more spatially complex environment, resulting in superior spatial skills. Their research also claimed that males are more competition driven. They argued that careers using mathematics and science are typically more competitive, and the competitive pressure influences males to select those fields. Charette (2013) agreed that STEM fields are especially competitive today because science and technology jobs today are often linked to funded projects rather than a company. These jobs can often be temporary rather than permanent, and STEM workers are often searching for jobs, further driving competition. Studies cited by Niederle and Vesturlund (2010) showed men performed better compared to women in competitive situations, and women shied away from competition when given the choice. Therefore, women might shy away from careers in a competitive field.

Attitudes toward the subjects could also include a social cause. A study conducted by Else-Quest, Shibley Hyde, and Linn (2010) found that, on average, males and females differ very little in mathematics achievement, but boys tend to have more positive attitudes toward mathematics. However, this global study did find variability across nations, directly related to the status and welfare of women in particular nations.

Many other studies, however, place the cause of the gender gap on cultural circumstances. The University of Michigan (2011) summed up some of the possible reasons for a gender gap, all of which included cultural explanations instead of physiological. Traditional gender roles have caused there to be certain jobs in which there are more males than females and vice versa. In 1996, women made up 98.6% of secretaries and receptionists, but only 9.2% of engineers and architects (Valentin, 1997). A cultural stereotype of women working as assistants, teachers, or even nurses has existed for decades. The level of encouragement or discouragement toward a specific area by parents and teachers, societal expectations about family roles, different learning opportunities from elementary school on, and the values placed on the subjects by a family and community might also play a role in career decisions (University of Michigan, 2011). All of these factors come from parents, peers, or society and are not attributed to the genetic differences between males and females.

No matter where the blame is placed, there is no denying the gender gap has existed historically. If genetic factors are truly causing the difference, then it makes it very difficult to address the problem. However, by investigating social and cultural factors, educators could attempt to address these elements and close the gap.

Davis (2008) identified the symptoms of the gender gap that need to be treated in order to close the gap. These included the belief in stereotypes, a lack of self-confidence in science by girls, and girls' dissatisfaction with the way science is presented. According to Buck (2000), surveys of adolescent girls found that girls want connections to science but often have a hard time relating science lessons to the world around them. Girls have also been found to have very specific interests within science, namely natural and biological sciences. These are the least tested areas overall nationwide, therefore, the least targeted by instruction (Kahle, 2004). To effectively teach mathematics and science to females, the family and school could address these external factors.

Although the cited research is based on the idea that a gender gap exists and it is a significant problem, there is evidence showing the gender gap currently does not exist on a worldwide scale (Else-Quest et al., 2010). At the same time, some data do reveal gaps in this country. The U.S. is seeing STEM achievement disparities at the K-12 level based on results from Advanced Placement and NAEP exams. Other countries are not seeing this trend. These data directly contradict the idea that innate differences between males and females are the reason for the gaps in the U.S. (Robelen, 2012).

Employment data supports the gender gap in mathematics and science performance that is still the American trend. Women fill half of the jobs in the American work force but make up less than a quarter of STEM jobs (Beede et al., 2011). Women also hold a disproportionately low share of STEM degrees, particularly in engineering. Research conducted by the U.S. Department of Commerce tied this to a lack of female role models in these careers, gender stereotyping, and less family-friendly flexibility in STEM fields. STEM jobs tend to be less accommodating to those cycling in and out of the workforce to raise a family (Beede et al., 2011). In fact, the data do not attribute this to ability level differences between males and females but again to cultural and societal pressures placed on women.

On a state level, Arkansas also reflects this employment trend. Interestingly, the state does not show significant discrepancies in mathematics and science achievement on the NAEP assessments. In Grades 4 and 8, test scores are showing no significant difference between male and female performance in mathematics and science (NAEP, 2011). Overall, research supports the idea that the gender gap is closing concerning performance in mathematics and science. Although this is happening, the gap persists in the American workforce. For this reason, although the focus is still on quality instruction and curriculum in these academic areas, schools have also been charged with guiding females toward careers in STEM areas (Feder, 2012).

The federal government is leading this charge and various federal agencies are administering grants to schools who are finding innovative and effective ways to increase female interest in STEM fields. In 2009, the White House and the U.S. Department of Education launched their Race to the Top initiative, budgeting $4.35 billion to encourage states to develop comprehensive strategies to broaden the participation of women and girls in STEM areas. Money is given to those who demonstrate efforts to address the barriers to STEM careers for women, girls, and other underrepresented groups (U.S. Department of Education, 2009).

Non-profit organizations concerned with science and mathematics achievement are also joining the movement. For example, the Alfred P. Sloan Foundation collaborates with universities who have proven track records of recruiting and graduating minorities, including women, in STEM fields. In 2012, the foundation gave over $5.5 million in grant money (Alfred P. Sloan Foundation, 2014). According to the American Association of University Women (2011), their organization gave $3.2 million in 2010 in support of scholars, research projects, and programs promoting education and equity in STEM fields for women and other minorities.

Government, business, and other organizations are recognizing the gender gap in STEM careers as a problem for American society and the American economy. The blame is placed on many different factors, and there are differing viewpoints about what needs to be done to fix it. Whether the issue is genetic, cultural, or social, fixing the problem begins with providing males and females both the educational opportunities to be successful in science and mathematics, and the first line of defense is public schools.

School Size and the Gender Gap

The first logical step to increasing the number of women in STEM careers is to ensure they are successful in mathematics and science in elementary and middle schools (Baine, 2013). Great debate has occurred among educators about whether the size of a school affects its ability to ensure quality instruction that will ensure this success. Various studies have been conducted to determine the relationship between school size and academic achievement. The results vary, with some studies showing larger schools with higher achievement, and others report smaller schools are superior. Still other studies have shown no significant relationship between school size and student achievement (Slate & Jones, 2005).

Larger schools are typically able to offer more course offerings and with that more science and mathematics offerings. Studies specific to mathematics and science course offerings found a positive relationship between the number of mathematics and science courses a student takes and gains in achievement in secondary schools (National Science Foundation, 2004). Smaller schools, on the other hand, are able to offer smaller teacher to student ratios. As a result, relationships built between teachers and students are often closer, engagement is increased, and closer academic monitoring occurs. This can outweigh the benefits of more course offerings and activities and lead to higher achievement (Abdulkhdirogulu, Hu, & Pathak, 2013).

Hypotheses

The researcher generated the following hypothesis.

1. No significant difference will exist by size of school between seventh grade male students versus seventh grade female students in western Arkansas school districts on mathematics achievement measured by the Augmented Benchmark Exam.
2. No significant difference will exist by size of school between seventh grade male students versus seventh grade female students in western Arkansas school districts on science achievement measured by the Augmented Benchmark Exam.
3. No significant difference will exist by size of school between male geometry students versus female geometry students in western Arkansas school districts on mathematics achievement measured by the End of Course Geometry Exam.
4. No significant difference will exist by size of school between male biology students versus female biology students in western Arkansas school districts on science achievement measured by the End of Course Biology Exam.

Description of Terms

Augmented Benchmark Exam. The Arkansas Department of Education (2013a) defined the exam as the test given to third through eighth grade students that combine the criterion-referenced and norm-referenced components of the Arkansas testing program.

End of Course examination. The Arkansas Department of Education (2013b) defined End of Course examinations as assessments given at the end of Algebra I, Geometry, and Biology courses. The examinations consist of multiple-choice and open-response questions that directly assess student knowledge in various topics in each discipline. The Arkansas Algebra I, Geometry, and Biology frameworks are the basis of the corresponding tests.

Gender gap. Random House Dictionary defined gender gap as the discrepancy in opportunities, status, attitudes, etc. between men and women (Dictionary.com, n.d.). Concerning education, the gender gap refers to the discrepancies in academic performance in various academic areas.

STEM education. STEM is an acronym for Science, Technology, Engineering, and Mathematics. Tsupros, Kohler, and Hallinen (2009) defined STEM education as an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons. Students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and global enterprise. These connections enable the development of STEM literacy, and with it, the ability to compete in a new economy.

Significance

Research Gaps

The American economy and the global workforce require students to have strong mathematics and science skills. The federal government has made it a goal within the next decade and has increased funding toward STEM careers (U.S. Department of Education, 2012). Studies have looked at this need on a global and national level and have identified a gender gap. There is no clear research, however, on why this gap exists. This study focused on how the gender gap is or is not present in science and mathematics achievement in the western part of Arkansas. It also addressed how the size of the school and the availability of courses affected science and mathematics achievement. The study needed to be done in order to determine how the schools in the researched area are performing in mathematics and science and whether instruction is providing all students with the skills needed to be successful in careers that require mathematics and science. Because of this study, recommendations were made about how schools could better prepare their students for STEM careers and help meet the goals set forth by the government for the U.S.

Possible Implications for Practice

The results of the study provided districts in western Arkansas with specific data on the effects of possible gender gaps within their schools. The school district staff and business community could use these results to determine how to tailor their curriculum and instructional strategies to promote consistent and more equitable achievement and encourage both males and females to pursue careers in mathematics and science in their community. This study identified whether there was a need for increased STEM programs within the western part of Arkansas and encouraged districts to apply for STEM education grants that could provide funding for mathematics and science programs in their schools.

Process to Accomplish

Design

A quantitative, causal-comparative research strategy was used in this study. The first hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was seventh grade mathematics achievement measured by the Augmented Benchmark Exam. The second hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was seventh grade science achievement measured by the Augmented Benchmark Exam. The third hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was mathematics achievement for geometry measured by the End of Course Geometry Exam. The fourth hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable for hypothesis four was science achievement for biology measured by the End of Course Biology Exam.

Sample

The study used seventh grade students who tested in the areas of mathematics and science along with students who tested in the areas of geometry and biology. Students were selected from 14 different school districts in western Arkansas, which were chosen because of their geographic location. All school districts in three counties participated and ranged in size from Class 1A to Class 7A. Of the participants in every district, approximately 48.8% were female and 51.2% were male.

The school districts were classified by their size and placed into three different categories; large, medium or small based on the classification system of the Arkansas Activities Association (2013). The large group consisted of districts within the 5A, 6A, and 7A classifications. The schools in this group had district populations between 3,398 and 13,896 students. The medium group consisted of schools in the 3A and 4A classifications that had between 853 and 1,887 students. The small group consisted of schools in the 1A and 2A classifications. These schools had between 399 and 697 students. There were four districts in the large group, five districts in the medium group, and five districts in the small group. All four schools in the large group were used in the study. To narrow the field of five to four in the medium and small groups, simple random sampling was used. After the groups were classified, stratified random sampling was used within each classification to select nine male and nine female students from each school district.

Instrumentation

During the 2011-2012 school year, seventh grade students took the Augmented Benchmark Examination. This test was composed of both criterion-referenced and norm-referenced test components in literacy, mathematics, and science. The test was given over a period of five days. Within the mathematics section, students were asked 30 multiple-choice questions and 6 open response questions for the criterion-referenced portion of the test. In the norm-referenced mathematics portion, 33 multiple-choice items were included. Scores were reported in five areas: Numbers and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability. The science segment of the test included 38 multiple-choice questions within the criterion-referenced portion and 41 multiple-choice questions in the norm-referenced portion. Scores were reported in four areas: Nature of Science, Life Science, Physical Science, and Earth and Space Science (Arkansas Department of Education, 2012a).

Each student enrolled in a geometry course took the End of Course Geometry Exam. This criterion-referenced test was given over a period of 2 days and included 90 multiple-choice questions and 7 open responses. Scores were reported in five areas: Language of Geometry, Triangles, Measurement, Relationships between Two and Three Dimensions, and Coordinate Geometry and Transformation (Arkansas Department of Education, 2012b).

Each student enrolled in a biology course took the End of Course Biology Exam, which is also a criterion-referenced test. The exam was given over 2 days and included 90 multiple-choice questions and 7 open response. Scores were reported in five areas: Molecules and Cells, Heredity and Evolution, Classification and Diversity of Life, Ecology and Behavioral Relationships, and Nature of Science (Arkansas Department of Education, 2012b).

A Cronbach alpha reliability coefficient was unable to be obtained for any of the four examinations. However, in order to comply with the rules governing the Arkansas testing system, the Arkansas Department of Education (2013c) must provide examinations that are reliable and valid tests for educational purposes.

Data Analysis4

To address Hypothesis 1, a 3 x 2 factorial analysis of variance (ANOVA) was conducted using size of school and gender as the independent variables and seventh grade mathematics achievement as the dependent variable. To address Hypothesis 2, a 3 x 2 factorial ANOVA was conducted using size of school and gender as the independent variables and seventh grade science achievement as the dependent variable. To address Hypothesis 3, a 3 x 2 factorial ANOVA was conducted using size of school and gender as the independent variables and mathematics achievement for geometry as the dependent variable. To address Hypothesis 4, a 3 x 2 factorial ANOVA was conducted using size of school and gender as the independent variables and science achievement for biology as the dependent variable.

CHAPTER II

INTRODUCTION

In recent decades, education has been charged with improving the nation's STEM skills. The National Academies (2007) asserted that, in order for the U.S. to maintain a competitive advantage in the world economy, the U.S. must optimize its knowledge-based resources, particularly in these STEM areas. Through research efforts, a gender gap has been identified between male and female professionals in STEM fields. Hence, schools are trying to find ways to close that gap and to help prepare both males and females for successful careers in STEM areas. There are varying hypotheses on why the gender gap exists and as a result, varying methods for addressing the gap. However, closing this gap is not solely the responsibility of the education system. There are parts for government and business to play as well. Finding ways to work together to address the issues causing the gap is now the task at hand.

The Existence of Gender Gaps

Gaps in Performance on Standardized Testing

Historically, boys have outperformed girls in mathematics and science on standardized tests. This is evidenced by test scores on the ACT, SAT, and the NAEP. Data collected by the National Center for Education Statistics (2001) revealed that, in 1975, males scored 3.1 points higher on average than females on the ACT mathematics portion. Males also scored higher in science by 2.4 points. Ten years later, the gap still existed with the males having a 2.8-point advantage in mathematics and 2.6 points in science.

SAT data also supports that trend. In 1975, there was a 35-point average SAT mathematics score gender gap favoring boys (College Board, 2013). Even in 2012, males still scored 33 points higher in mathematics, on average, compared to females (College Board, 2012). Data collected by the NAEP also reveals a gap. In 1973, males performed at higher levels than females at age 9, 13, and 17. The same was true in 1999 (National Center for Educational Statistics, 2009). The gap has been identified and has become a targeted issue by American education for many years.

Closing the Gaps

Though these data support the existence of a gender gap in mathematics and science performance, some of the same data reveal that the gap has closed in the past few decades. In 2010, the gap in average ACT scores still existed, although it was significantly smaller with males averaging 1.1 points higher in mathematics and 0.9 points higher in science than females compared to 3.1 points in mathematics and 2.4 points in science 35 years earlier (National Center for Educational Statistics, 2011). The 2012 SAT score data revealed a similar gap as the 1975 data, only a 2-point average difference. However, in 2012, over 100,000 more females than males took the SAT, providing a larger sampling of students (College Board, 2013). On the NAEP test, the gap in mathematics declined from an 8-point average difference in 1973 to an insignificant difference in 1999 and declined by six points in science (National Science Foundation, 2002).

It is also important to note that, although there might be gender gaps in performance on standardized testing, College Board (2013) contended that females are excelling in science and mathematics in high school. Of students in the top 10% of their class, 55% are female. In addition, more females are taking advanced mathematics and science classes; 54% of girls take advanced mathematics classes compared to 46% of boys. The same trend is true for science, with 53% of girls taking advanced classes and only 47% of boys. Therefore, trends in testing as well as performance in science and mathematics classes in high school show that a gender gap in performance that might have historically existed has narrowed and may be closing. At the same time, the similar levels of achievement by both genders have not transferred over into the work world, specifically in STEM fields.

Science, Technology, Engineering, and Mathematics in America

Importance of STEM Areas in the Global Economy

The U.S. has historically been at the top of the global economy, mostly because of dominance in technology and scientific innovation. Of all occupations, 97% or approximately 6% of U.S. employment make up the STEM career areas. STEM jobs play an instrumental role in expanding scientific frontiers, developing new products and generating technological progress (Cover, Jones, & Watson, 2011). These careers are essential for the nation to develop technological innovation and global competitiveness. They have a large impact on the nation’s economic growth and overall standard of living (Beede et al., 2011). The number of STEM occupations has grown in the past few decades. Beede et al. (2011) claimed that they are projected to grow by another 17% from 2008-2018, and non-STEM occupations are only projected to grow by 9.8%.

The problem lies in the need for STEM workers. Rothwell (2012) revealed that in 2010, 30% of job openings were in STEM fields, and only 11% of the population had STEM degrees. There were seven openings in computer occupations for every graduate from a relevant major. Comparably, there were six job openings in healthcare to every graduate and four in engineering.

This shortage in STEM workers has possibly diminished America’s global economic competitiveness, as U.S. advantages in science and technology are lessening. The U.S. today is a net importer of high-technology products because the trade balance in high-tech products lessened from a $33 billion surplus to a $24 billion deficit from 1990 to 2004 (National Academies, 2007).

These statistics and projections have caused government to address the issue of the need for STEM workers in the coming decades. The Obama Administration created a goal to increase the number of students receiving undergraduate degrees in STEM areas by 1 million by the year 2020 (The White House, 2012). Other government agencies have made recommendations as well. The National Academies (2007) recommended four actions for increasing U.S. competitiveness. These included increasing the number of students in advanced mathematics and science courses, increasing the funding for research in these areas, providing scholarships for students to pursue higher education in STEM areas, and addressing economic policy to provide incentives for innovation. The National Academies contended that, without a renewed effort to bolster the foundations of competitiveness, the U.S. could lose its privileged position in the world economy.

Description of STEM Areas and Needed Skills

There is not just a need for workers in the STEM fields; these need to be qualified workers who are able to maintain high levels of performance and innovation. Schools are being charged with helping develop specific skills in students that will make them successful in STEM areas. Therefore, it is necessary to identify each particular field included in the STEM acronym and pinpoint the skills students need to be successful in a career in each field.

Vilorio (2014) described each of these fields and the skills necessary for workers to be successful. Science professionals can be in the subfields of life science, physical science, or geoscience. They study the physical and natural world through observation and experimentation. Scientists are often charged with writing research proposals, conducting research, and presenting the findings of said research. Workers in the technology field create and troubleshoot computer and information systems. They design, test, maintain, and improve computer software and hardware as well as systems and networks. Engineers develop systems, structures, products, or materials. Their industry that includes mechanical, chemical, electrical, etc. often subcategorizes these professionals. Mathematicians use numerical, spatial, and logical relationships to study and solve problems. Their work often involves finding patterns and using abstract logic.

There are various skills needed to be effective as a worker in any of these fields. Both critical and creative thinking are used daily. Professionals use these thinking skills to problem solve, gather information, and understand relationships. However, it is just as crucial that STEM workers are able to communicate well. They must work well with others and convey information clearly. Technical writing, public speaking, interpersonal skills, and the ability to explain difficult concepts simply are crucial (Vilorio, 2014).In order to increase the number of skilled workers in STEM fields, schools at all levels must prepare students with these skills. Not only will they allow students to be successful in STEM areas, Gonzalez and Kuenzi (2012) asserted that the economic and social benefits of scientific thinking and STEM education have broad application for workers in both STEM and non-STEM occupations. Therefore, widespread STEM literacy may include critical human capital competencies for a 21st century economy.

The Gender Gap in STEM Careers

Gender Gap Statistics

Many historians agree that World War II was the instigator that drove women into the workforce, as women stepped in to fill jobs that men left to go to war. From 1940 to 1945, the female labor force grew by 50%, and female employment in the defense industries grew by 462% (Bureau of Labor and Statistics, 2002). After the war ended, many women remained in the workforce. According to the Bureau of Labor and Statistics (2002), the number of women in the workforce grew 256% between 1950 and 2000. Once women entered the workforce, they also began to enter higher education in larger numbers in order to prepare themselves for the jobs they sought. In 1870, less than 1% of college enrollees were women. By 1900, it was near 3%. Twenty years later, it had increased to almost 8% (American Association of University Women, 2011). Twelve years after World War II ended, 19% of women ages 18 to 24 were in college. By 1988, the number had increased to 30%. In 2005, women made up 54% of college students (U.S. Census Bureau, 2007).

The increase of women in higher education had several possible causes. These include higher achievement in secondary schools, changes in societal values, and a shift in women's expectations for future employment (Jacob, 2002). Government intervention may have also played a role in the increase of women receiving post-secondary training. Title IX was passed in 1975 and prohibited programs and activities that received federal funding from discriminating based on gender. For government-funded higher education institutions, this included admissions, recruitment, financial aid, academic programs, class assignments, grading policies, athletics, and housing (U.S. Department of Education, 2014). Valentin (1997) asserted that Title IX combined with the Women's Educational Equity Act of 1984 opened the doors for women in higher education. The 1984 act began funding programs of national, statewide, or general significance to overcome sex stereotyping and promote achievement of educational equity for girls and women.

Even with the numbers of women in higher education being equal to or greater than the number of males, the numbers in STEM careers have disparities. In 2011, women held half of the jobs in the American economy, but less than a quarter of STEM jobs. In the same year, women earned only 31% of STEM degrees and certificates (Beede et al., 2011). Therefore, even though women are getting higher education, they are not choosing STEM fields.

Causes of the Gender Gap

Research has suggested various causes for the existence of the gender gap in STEM, some of these genetic and others social and cultural. The majority of the research supports the social and cultural approach, but it is important to note the research that supports a genetic cause as well.

Genetic Causes

Gurian and Stevens (2004) simply contended that boys’ brains are better suited to spatial-mechanical functioning, and this makes them better in mathematics and science. This conclusion is based on the analysis of brain scans and magnetic resonance images that found structural and functional differences that affect learning. They claimed that females have a larger corpus callosum, stronger neural connectors, and a more active prefrontal cortex. This enables more cross-talk between hemispheres of the brain, more sensually detailed memory storage, and causes their most satisfying stimulation to be through verbal and emotive cues. Males, on the other hand, use more of the cortical areas dedicated to spatial-mechanical functioning and tend to have more lateralized brain activity. The most satisfying stimulation for males is through symbols, abstractions, diagrams, pictures, objects, and space. Due to these genetic differences, they concluded that girls are less drawn to mathematics and science fields.

Genetic research also suggests that there are core cognitive development systems in humans that cause learning pre-dispositions and women to be better at empathizing and communicating, and men are better at understanding and building abstract systems (Baren-Cohen, 2003). The evidence is drawn from clinical case studies and scientific research and uses the Empathy Quotient and Systemizing Quotient scale to measure the levels of each characteristic in males and females. Baren-Cohen (2003) found that even fetal testosterone levels support the idea, as higher fetal testosterone levels are positively correlated with scores on the Systemizing Quotient scale and negatively correlated with scores on the Empathy Quotient scale. In the end, he alleged that males are more likely to learn about objects and mechanical relationships, and females are more likely to learn about personal relationships. This could be the cause of males being superior in mathematics and science.

Competitive nature might also play a role in women shying away from STEM careers. In competitive situations, men performed better compared to women, and women avoided the competition when given the choice (Niederle & Vesturlund, 2010). This conclusion is based on research in which men and women were both asked to solve mazes on the Internet for 15 minutes. When completion of the mazes paid the same no matter how many mazes were solved, there was a 1.5 maze difference between male and female performance. When competition was introduced, the difference grew to 4.2 mazes. The researchers concluded that men outperform women in competitive situations and asserted that STEM fields tend to be more competitive than other jobs. This is especially true today because science and technology jobs are often linked to funded projects rather than a company. In addition, these jobs can be temporary rather than permanent, causing workers to search for jobs more often, further driving competition (Charette, 2013).

Halpern (2000) studied the development of the sensory system in males and females. He found variations that cause women to score higher on tests of memory, production, comprehension of complex prose, fine motor tasks, and speech articulation. Males scored higher on tests of fluid reasoning, tests involving objects that are moving or that require transformations of objects, and tasks that require aiming. Therefore, males develop more dynamic visual acuity and spatial skills, which may give males the edge in mathematics and science fields. It is important to note that Halpern, though convinced there are some biological cognitive differences between males and females, is an advocate of considering both biological differences and social consequences when determining why males and females may differ in mathematics and science performance.

While these aforementioned studies link biological gender differences to science and mathematics achievement, there are numerous research reports that contradict that idea. Spelke (2005) conducted behavioral and neuroimaging studies of human cognition and cognitive development. She found a genetic basis in the core cognitive development systems for representing objects, space, and numbers. These systems are accessed when learning mathematics and science principles. Her research showed that these systems are equally available to males and females.

Hyde (2005) agreed and championed the gender similarities hypothesis, which contends that males and females are similar on most but not all psychological variables. Through review of major meta-analyses conducted on psychological gender differences, she grouped these differences into six variables: cognitive, verbal and non-verbal communication, social and personality variables, psychological well-being, motor behaviors, and miscellaneous constructs. Her research supported the idea that males and females are alike on most variables and should perform comparably in mathematics and science. However, although some studies do support the idea that biological differences between males and females may cause a difference in academic performance, more of the research leans toward social and cultural causes as the culprit.

Social and Cultural Causes

Randall (2013) stateed that inadequate academic skill or even preparation is not the reason women are not in STEM careers. Instead, social structures that are pervasive and lifelong are the cause. Some of these social structures include gender stereotypes and bias, a lack of female role models in STEM fields, and less family-friendly flexibility in STEM jobs (Beede et al., 2011).

Gender stereotypes and biases may be a key reason for women not entering stem fields. Correll's (2010) research investigated the effects of stereotypes on performance. Her research found that, when a person is exposed to a negative stereotype about a group to which they belong, they perform worse on tasks related to the stereotype. When subjects were told men were better at a skill, women rated their aptitude lower, held the performance up to higher standards, and reported lower interest in entering fields requiring that skill. When they were told they had the same ability, the disparities disappeared. This tendency can be problematic for women in the STEM fields: societal beliefs falsely indicate that women have weaker mathematics ability than men and that men make better engineers and scientists.

Research by Spencer (1999) had a similar result. Girls who were primed to feel inadequate did significantly worse than their male peers on challenging mathematics tests, and girls in the control group who did not face a stereotype threat condition scored similarly to the boys. Along those same lines, Kahne and Mertz (2012) compared the scores of 300,000 eighth graders in 34 countries on standardized mathematics and science tests. There was a strong link between the gender stereotype of the country and the gender difference in test performance. As a result, they contended that implicit stereotypes and sex differences in mathematics science participation and performance are mutually reinforcing.

The National Coalition for Women and Girls in Education (2012) also spoke out about the damaging nature of gender biases on women in STEM careers. They noted that these biases affect students by preventing them from pursuing science and mathematics from the beginning, play a role in academic performance, and can influence whether parents and teachers encourage them to pursue science and engineering careers. They added that the stereotypes might also influence whether women are hired and might hinder the promotion rate and career advancement of female employees.

Because stereotypes may be a major factor in keeping women out of STEM fields, there are also few female role models in STEM fields. Goodman and Damour (2011) contended that a lack of STEM role models harms females in two related ways. First, as they begin to consider majors and careers, respected role models do not reinforce the choice of a STEM career. Second, the lack of female role models reinforces some of the negative stereotypes held by young women about STEM fields. The work of Panechelli (2011) supported this idea. His research showed that girls who interacted with female STEM professionals had an incredibly strong positive outlook regarding STEM and their ability to succeed, and those who had no previous interaction with a female STEM professional had sour feelings about their ability to succeed in the field. He asserted that just the interaction with the female STEM professional allows girls to connect with and accept the projection of their own abilities in STEM and also protects girls from being overwhelmed with the inhibiting effects of the subtle negative stereotypes they have previously experienced.

Research by DeWelde, Laursen, and Thiry (2012) indicated that the presence of female role models dramatically influences female students’ persistence in completing their STEM education. These female role models are often not only successful in their careers but also successful at balancing career and family, providing an example for women who want to both work and raise children. The idea of work-family balance may be a consideration for many women, and STEM careers also tend to be less family-friendly. As a result of stereotypes as well as historical gender roles, women often consider a work-family balance more important than men do (Steele, 2013). Beede et al. (2011) asserted that STEM jobs are less accommodating to those cycling in and out of the workforce to raise a family.

Wang, Eccles, and Kenney (2013) contended that there might be another reason women are not in the STEM fields in equal numbers to men. They suggested that women have broader intellectual talents that provide them with more occupational options. This is based on SAT verbal and mathematics scores. Of those with the highest scores on these tests in 2012, 63% of them were female. This research concluded that, if a female is highly skilled in two areas but one is more in line with social stereotypes and support, she is more likely to choose that one. Therefore, female *ability* was not a factor in a female’s decision to pursue non-STEM careers. Instead, it was likely that females with high mathematics ability also had a high verbal ability and considered a wider range of occupations.

The reason for the gender gap in STEM fields may be a combination of many factors, which is what makes it difficult for schools in preparing students to enter STEM fields. Schools must address the possible causes and seek to promote gender equity and equal access to STEM subject areas for both genders.

Emphasis on Females in STEM

Government

No matter the reason for the gender gap in STEM workers, it is important the gap closes. In order for the U.S. to meet the demands of the job market in upcoming decades, females must enter STEM careers in larger numbers. Therefore, the government has taken the lead in encouraging this trend. In 2009, the White House and the U.S. Department of Education jointly launched Race to the Top, a $4.35 billion campaign to encourage states to develop comprehensive strategies to broaden the participation of women and girls in STEM areas (U.S. Department of Education, 2009). The Educate to Innovate campaign was also launched in 2009, and the first pillar of that campaign was to expand STEM education and career opportunities for underrepresented groups, including women (White House, 2009). President Obama addressed this topic in various appearances, including his remarks at the 2012 White House Science Fair. He suggested that it is critical that gender equality be advanced in order to maintain the competitive advantage with other countries in an increasingly globalized world (White House, 2012).

Since the implementation of these mandates, analysts have identified 252 STEM programs and activities conducted by 13 to 15 different agencies. Between $2.8 billion and $3.4 billion are appropriated annually to fund these activities. The U.S. Department of Education, National Science Foundation, and Department of Health and Human Services are the key agencies in administering these programs (Gonzalez & Kuenzi, 2012). Other agencies also have programs geared toward increasing the number of women in STEM. For example, the U.S. Department of Agriculture (2014) offers grants for organizations conducting projects that encourage women in STEM. In 2014, they gave $400,000 to various projects in amounts varying from $75,000 to $150,000.

Some government agencies have also collaborated with outside organizations to start programs for women in STEM. The U.S. Department of Energy and the Massachusetts Institute of Technology began the Clean Energy and Empowerment Program with the goal of advancing women's leadership and participation in clean energy research and development (Sheeler, 2012). The National Aeronautic and Space Administration partners with the Girl Scouts of America. In 2009, they issued a memorandum of understanding to describe their intent to work together to motivate and encourage girls to do their best in school. NASA attends the Girl Scouts' National Convention and conducts fun hand-on, STEM-based activities to inspire girls to pursue degrees in that field (White House, 2009).

Large amounts of money have been pumped into STEM education by the U.S. government. Program funding, research, and educational tools are available to those who want to promote minorities in STEM. The money for these programs does not just come from government, but may also come from business or non-profit sources as well.

Business and Non-Profit Organizations

Various companies in the U.S. business sector have identified the importance of STEM in the American economy. STEM Connector (2013) published statements from 100 CEO Leaders in STEM including the leaders of Microsoft, Wal-Mart, AT&T, and 3M among others. STEM Connector quoted Steve Ballmer, the CEO of Microsoft, "If we do not improve access and attainment in STEM, the U.S. will continue to fall behind other nations" (p. 13). In addition, Michael Duke, CEO of Wal-Mart, is quoted in support of that idea, "If we do not encourage young people to major in STEM fields, we simply will not have the talent pool to meet the demand" (p. 13). Randall Stephenson, CEO of AT&T, stated, "Developing STEM skills in young people will be increasingly important to this country's ability to innovate and compete. In a world where every job is being transformed by technology, the nations with the best STEM training will have the advantage" (p. 14). In addition, the CEO of 3M, Inge Thulin, said, "We recognize the importance of STEM disciplines in solving the world's most pressing problems" (p. 17).

Because these and other business leaders and their organizations recognize the importance of STEM, they have invested time and money into programs that encourage young people to enter into STEM careers. Bayer Corporation (2014) has a program entitled Making Science Make Sense, which is a companywide initiative to improve science education and insure all individuals are scientifically literate. Bayer Corporation collaborates with the U.S. Department of Education, the National Science Foundation, and the National Science Teachers Association to provide materials and resources to promote science education. The Boys and Girls Club of America partners with CA Technologies for the Tech Girls Rock program, which provides unique workshops for girls that include career exploration panels, technology-focused challenges, and hands-on technology experiences (Boys and Girls Club of America, 2014). Microsoft has created the Youth Spark program that works to create opportunities for young people to find their passion, get training to pursue their chosen field, and help them learn skills. This program has several different aspects including seminars, mentoring, and summer camps. Much of this program has a technology focus. Cognizant (2011) runs the Making the Future

Program, which seeks to inspire young learners to pursue STEM fields through fun, hands-on learning opportunities that include after school and summer programs.

Outside of government and business, there are organizations who have addressed the gender disparity of women in STEM. For example, the Alfred P. Sloan Foundation (2014) gave $5.5 million in grant money in 2012 to universities who recruit and graduate minorities, including women, in STEM fields. The American Association of University Women (2011) provided $3.2 million in support of scholars, research projects, and programs promoting education and equity in STEM fields for women and minorities.

No matter where the funding comes from, government, business, and non-profit organizations have charged the elementary and secondary school systems with making changes that will promote STEM careers for students, especially minorities. Since a student’s educational foundation is laid there, even the early levels of schooling can and should be involved.

The Role of Public Education in Closing the Gender Gap in STEM

Addressing the Causes

Fortunately, genetic causes are not supported by the majority of the research on the gender gap in STEM careers, nor is there significant evidence that there is a gap in the performance of males and females on standardized tests. Hence, addressing cognitive or physical differences between males and females is not something on which schools should waste their time. Nevertheless, schools can address the possible social and cultural causes for girls not entering STEM careers after graduation and can ensure their instructional strategies are teaching students the skills they need to be successful in those careers should they choose to pursue them.

Gender stereotyping in classrooms may be a barrier to females choosing STEM careers. Student achievement can be affected not only by teaching quality, but also by classroom management behaviors such as the frequency of being called on, being affirmed or corrected, being praised, getting individual help, attentive listening, and courtesy and respect (WEEA Equity Resource Center, 2001). According to a study by Sadker and Sadker (1994), in which they observed several teachers and documented their interactions with students, they found that males were overall more likely to be praised, corrected, helped, and criticized. Females were more likely to get superficial reactions from teachers.

In order to avoid gender stereotyping, it is important that teachers practice self-awareness. They should examine their classroom for signs of gender bias. It may be present in their activities, questions, examples, behavioral expectations, and punishments and rewards. The teacher’s classroom behaviors should support student inquiry, boost the self-image of boys and girls, and accept independence in both genders. Teachers can also structure activities that will expose males and females to various vocational options (WEEA Equity Resource Center, 2001).

Schools should recognize that having female role models in STEM could be extremely beneficial to young women who are considering those fields (Goodman & Damour, 2011). Role models can help show female students the real-world applications of STEM fields and help challenge the stereotypes. They can also show how all STEM fields have socially important applications. This is important to many young girls. In order to challenge the stereotypes and encourage young women toward STEM, they should be exposed to role models and mentors for extended periods. This can happen through intra-school opportunities, local partners from higher education, and curricular partners from the community. Schools can seek out and promote programs that allow this access for young women.

However, it is important that these female STEM role models do not necessarily project the stereotypes of the STEM field. A study on the effect of role models on stereotype beliefs found that when recruiting women to STEM, the role model gender might make less of a difference than whether role models fit stereotypes incompatible with the female gender role (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). For that reason, when schools are identifying and working with female role models in STEM, those role models should be similar in characteristics to the young women they are trying to reach.

The University of Massachusetts (2011) contended that, to increase the number of individuals entering STEM majors in college for eventual employment in STEM fields, students must be both proficient and interested in STEM. Baine (2013) agreed that the two are intertwined and stated that, in order for females to be interested in STEM careers, it is essential that they are successful in mathematics and science in elementary and middle schools. This success is ensured both through the climate of the school as well as the instructional practices in the STEM areas.

Policy Issues for K-12 Schools and STEM

Several considerations should be made by schools when determining how to provide quality STEM education to students. Gonzalez and Kuenzi (2012) identified three main issues that must be addressed: teacher quality, accountability and standards, and how to use resources to promote STEM education programs. Within these three issues, several matters must be taken into account.

Teacher quality is an important consideration. Overall, the American public education system’s stock of fully credentialed mathematics and science teachers is in short supply as there are several classrooms at the secondary level in which teachers have not been trained to teach those subjects (Gonzalez & Kuenzi, 2012). The Southern Regional Education Board (2002) found that teachers who are qualified in their subject area tend to see higher achievement because they ask higher-level questions, engage students in more challenging learning, and use more student-centered activities. This raises the question of whether the focus of schools should be on recruiting more qualified teachers or on improving teacher effectiveness for those already employed.

Accountability and standards are another major factor for schools to consider. Many states have now adopted the Common Core State Standards in mathematics and science, though not all states have high-stakes accountability attached to the performance. Gonzalez and Kuenzi (2012) asserted that quality standards and a system of accountability are necessary for schools to be successful in STEM education.

Schools must also determine how to allocate their resources for STEM education. Many states have pushed a “STEM for all” philosophy through which they are working to prepare all students to pursue and be successful in STEM fields. Critics of this encourage schools to instead focus their resources on high-achieving students with an interest in STEM in order to help those students reach higher levels of learning in STEM fields. This includes expanding AP and IB course offerings (Gonzalez & Kuenzi, 2012). No matter the courses a student takes, daily quality instruction is a very important piece of high levels of achievement.

Instruction in STEM Education

Throughout a student's educational journey, it is important that he or she continue to take courses in mathematics and science. Studies specific to mathematics and science courses found a positive relationship between the number of mathematics and science courses a student takes and gains in academic achievement (National Science Foundation, 2004). Research by the University of Massachusetts (2011) determined that the number of mathematics and science courses taken in high school has the greatest direct influence on the field of study chosen by girls, even more than mathematics and science test scores. Consequently, it is essential that students become interested in STEM before they enter high school so they can take courses to prepare them for those STEM majors and careers.

To promote participation in those courses, schools must find ways to engage males and females alike in mathematics and science instruction. According to the U.S. Department of Education (2014), several strategies that Blue Ribbon Schools use in order to improve student performance in these disciplines exist. These include the alignment of standards to classroom instruction and activities, using frequent benchmarks to monitor mastery, sufficient time in the school day for mathematics and science instruction, giving formative assessments and immediate intervention, using manipulatives and making real-world connections with the content, and promoting parent involvement and coherent progression. By using effective teaching techniques, public schools can help students grasp mathematics and science concepts early in their education and encourage males and females alike to continue to challenge themselves in those areas and to become college ready.

Data from the ACT (2014) showed that only 44% of 2013 high school graduates in the U.S. are ready for college level mathematics, and only 36% are ready for college-level science. Therefore, ACT has established a list of practices of higher performing school systems. These include clearly documenting curriculum and academic goals and prioritizing these appropriately, providing strong leadership and faculty who practice collaboration to improve instruction, providing evidence and standards-based instructional tools to support academic rigor, using student assessments to drive instruction, and using targeted interventions and adjustments to address learning needs.

Large Schools versus Small Schools

Another factor that has been considered when seeking to create optimal learning conditions is the size of the school. There is varying research on the size of the school and the level of student achievement (Slate & Jones, 2005). Larger schools are able to offer more courses, specifically advanced mathematics and science courses. These schools also have more resources available for programs to encourage girls in STEM. In the 1960s, Conant (1959) pioneered the movement for large “comprehensive” schools in the wake of the Cold War and the Space Race. He pointed out the benefits of these schools, specifically their ability to sufficiently prepare students because of their numerous course offerings and adequate resources, specifically in science and mathematics. Many schools subscribed to his assertion and high schools were built to hold many students with large class sizes. The past few decades have seen a shift away from large schools.

On the other side, Blatchford, Bassett, and Brown (2011) argued that small class size may facilitate a more individualized and more effective instruction, more complete curriculum coverage, and greater student involvement in classroom activities. The Bill and Melinda Gates Foundation has been a catalyst in this movement as they have pushed for “redesigned high schools” and the downsizing of large high schools into smaller schools housed in the same building. This creates small learning communities that ideally will create a better culture for learning (American Institutes for Research and SRI International, 2005).

Proponents of smaller schools believe that the culture of the school is the key factor in achievement and smaller schools can more easily create that culture. Smaller learning communities allow closer relationships to be developed. Closer relationships often mean increased engagement and closer academic monitoring. In some cases, this may outweigh the benefits of more course offerings and lead to higher achievement (Abdulkhdirogulu et al., 2013).

The National Center for Education Statistics (2001) compiled a national survey of NAEP achievement data that reveals a positive relationship between small classes and achievement. This relationship is stronger for secondary schools than elementary ones. Another study by the California Public School Panel Data supported the idea that small schools do have a positive effect on achievement, though it is very modest. This research suggested that the relationship between school size and achievement may be non-linear and that the school climate, no matter the size of enrollment, may play a larger role (Bullard, 2011). Research by Kahne, Sporte, de la Torre, and Easton (2008) discovered that, in Chicago, schools converted from large to small resulted in more collegial and committed teachers, more academically and personally supportive student context, and increased graduation rates. However, there was not necessarily improved achievement.

The key may not be in the size of the class but rather in the classroom instruction. In order for achievement to improve in smaller classes and smaller schools, teachers must take advantage of the possibilities of increased individualization. This means more adventurous and flexible teaching and more effective collaborative learning among pupils. It is essential that schools provide professional development to help teachers harness the opportunities provided by small class sizes (Blatchford et al., 2011).

Smith and Lee (1997) contend that mid-sized schools are ideal. Their research showed that schools with enrollment between 600-900 students had the highest gains in achievement. Students learn more in smaller high schools and learning is more equitable in small places; however, small high schools could be too small to offer adequate programs to their students. Therefore, a compromise between the two may be the best solution for helping students achieve at high levels.

Graduates from all schools, no matter their size, must then move on to higher education in order to be qualified to work in STEM careers. Once students have completed high school, colleges and universities then have a role to play in closing the gender gap.

The Role of Higher Education in Closing the Gender Gap in STEM

Research conducted by Carnevale, Smith, and Melton (2011) found that many students who intend to pursue a STEM career out of high school drop out of the STEM pipeline between high school and college. They either do not enroll in college or do not complete a degree. In fact, 30% of their subjects who scored in the top quartile on a mathematics skills test in high school did not have a degree eight years after graduating high school. Almost 50% who scored in the second quartile did not have a degree. This evidences the possibility that higher education plays a crucial role in promoting STEM graduates and in doing so, closing the gender gap.

In 2010, Forbes Magazine published a list of the best colleges for females in STEM fields (Doss, 2010). In order to rank the universities, Forbes began by assuming that women studying STEM subjects wanted to attend a school that is good at teaching those subjects. They took the 400 schools in their ranking of America’s Best Colleges and eliminated those where overall STEM populations were small. Then, they ranked the remaining schools based on how closely they approached an ideal where the distribution of males and females in STEM classrooms look like the gender distribution overall. They found that schools shared some common practices in recruitment and retention. First, these schools ensured that they have several faculty members in the STEM areas who are females, therefore providing role models for women entering STEM degree fields. The majority of these universities were also targeting women with their recruitment, thus showing their recognition and commitment to increasing the numbers of women graduating from their institution with STEM degrees. Once women make it to campus, support systems are in place to assist them academically, socially, and emotionally. This is often overseen by the Office of Diversity. Within the schools offering STEM degrees, there were typically mentoring programs that pair up undergraduate students with graduate students or female STEM professionals. There were also many student organizations for women, usually in their major fields, that offered support, resources, and networking. These organizations also offered women the opportunity to participate in outreach programs, further connecting them to the college and the community.

Providing Female Role Models

Having women faculty members in the STEM departments is an important first step for universities to take. When asked about reasons for leaving the fields of physics, chemistry, electrical engineering, and computer sciences, women cited a lack of role models as a significant reason (Etzkowitz, Kemelgor, Neuschatz, & Uzzi, 1994). These faculty members can serve as role models and help connect female students to other professionals in the field. In addition, Robst, Keil, and Russo (1998) found that the presence of female faculty members increases female retention. It is helpful for female undergraduate students in the STEM fields to have women faculty members to make connections with, and the school can advertise this in their recruitment materials targeting women.

Recruitment Strategies

Another essential part of increasing women's participation in STEM is effective recruitment strategies. Recruitment efforts should be well thought-out and purposeful. McGrath Cohoon (2013) stated that women choose occupations based on interest, confidence, belonging, and identity. Therefore, universities and STEM departments should consider those when actively recruiting women. There are stereotypes in each of those areas that threaten to inhibit women from choosing those careers, so dismissing those stereotypes is important. Effective recruitment programs will demonstrate how women can use those careers in the real world, typically demonstrating how STEM careers have value in society. Recruitment materials will also show the university's confidence in the ability of females to be successful in STEM areas, often by highlighting the achievements of women in their institution. There will also be information distributed about the different mentoring programs and student organizations that women can join for support and a sense of belonging. By addressing the issues that women typically see as important, the university will be more successful in recruiting them into the institution and then into the STEM degree programs (McGrath Cohoon, 2013).

Retention Efforts

Once female STEM students reach campus, it is important for universities to have a support system in place. The most common program found in these successful schools is a mentoring program. By pairing up a first-year student with a graduate student or a female STEM professional, the new student is given a role model who has walked the road they are about to travel. According to Blackwell (2010), a mentor gives the mentee perspective that is both encouraging and practical. The STEM student can learn what life as a scientist is about, see what a professional looks like, and have someone with whom to discuss his or her struggles and successes. If they face gender stereotypes or feel overwhelmed as one of the few females in their courses, they have a guide to help them navigate. In some cases, this makes the difference between continuing in the degree program or not. Mentoring can be beneficial to all college students, but has been especially helpful for female students in male-dominated career fields.

Other Factors for Higher Education to Consider

Another characteristic of these successful institutions is the presence of active student organizations, typically those for women in STEM fields. Though these organizations often have programs to assist with academics, the social support that they provide makes a greater difference. Students who master course content but fail to develop social support and involvement are at greater risk of dropping out (Lotkowski, Robbins, & Noeth, 2004). To develop a strong affiliation with the academic environment, interaction with faculty and peers and involvement in student organizations is often necessary. Mangold, Bean, Adams, Schwab, and Lynch (2003) found that activities or programs that bring students together facilitate the development of community and in turn promote persistence. Universities should promote these organizations and encourage the involvement of women in STEM degree fields especially. This participation can help create that sense of belonging that may help women persevere and complete the degree program.

In the successful universities, these organizations were not only present; they also had effective outreach programs in which the college students went in to elementary and secondary schools to promote the cause of increasing the numbers of women in STEM. These programs are effectively service learning, which research shows can help strengthen engagement of students. Astin, Vogelgesang, Ikeda, and Yee (2000) concluded that service learning could increase students’ sense of personal effectiveness and awareness of the outside world and their personal values. It can also increase the students’ level of engagement in a course or program. The personal connections and the commitment to the cause allow these female STEM students to strengthen their engagement, making them less likely to withdraw from their degree program.

Some of the universities discussed actually made changes in their curriculum in order to tailor to the research-based preferences of women. Others ensured that women had access to resources, either through a specific office assigned to oversee women’s affairs or through hosting seminars and forums with topics important to female students. No matter the specific activities, they all were making cognizant efforts based on research and targeted toward women in particular. Even when higher education institutions are successful in recruiting, retaining, and graduating females with STEM degrees, there is still a level of attrition in the workforce. The employers who are hiring these STEM graduates must address this.

The Role of STEM Employers in Closing the Gender Gap

In 2011, only 26% of women who held STEM degrees were working in STEM jobs (Beede et al., 2011). There are varying factors causing this discrepancy. These include inequity in hiring practices as well as barriers to women both working and raising families. In 1997, the Report Card on Gender Equality gave the U.S. a *C*, stating that sameness of opportunity exists for men and women, but this has not resulted in equity for women. Employers can help create equity by developing policies, practices, and materials to combat stereotyping, socialization, and other systemic factors that deny equitable outcomes (Valentin, 1997).

In order to combat stereotypes and bias within the organization, Correll (2010) suggested that management is careful to control the messages being sent about equality in the workplace. They should also make all performance standards unambiguous and communicate them clearly to all employees. Gatekeepers in senior management should be accountable for reporting on gender disparities in hiring, retention, and promotion. By doing those things, the organization will be aware of their tendencies and be able to adjust their practices to promote equity.

To make STEM careers more family-friendly, the National Science Foundation (2013) promoted the Career Life Balance Initiative. This initiative elevates successful programmatic policies aimed at creating flexible environments for the recipients of their grants. The goal is to address existing barriers that force women to choose between caring for their families and continuing their research.

Addressing the gender gap is also about making careers in STEM areas more welcoming, accessible, and financially attractive. Research has found that in countries where there is government required paid family leave and free or cheap access to quality childcare, no gender gap exists in mathematics and science (Wang et al., 2013). If government and employers can find ways to offer these types of benefits to women, they are likely to recruit qualified female professionals into STEM fields at higher rates.

Conclusion

The issue of gender gaps in mathematics and science performance has implications far beyond the elementary and secondary schools. The American economy is dependent upon qualified workers who are skilled in those areas in order to fill jobs that are crucial to the success of the system. Currently, there is a shortage in these workers, and especially in women filling these jobs. The possible causes of that shortage are many, and some are fixable while others are not. Either way, in order to provide those workers, many different players must work together.

Elementary and secondary schools must lay the foundation for helping students be successful in science and mathematics but also expose them to careers in those fields and encourage them toward those careers. Higher education must recruit those students who have interests in STEM fields, then retain and graduate them with STEM degrees.

Business and industry must find ways to address the social and cultural factors that may be driving some of these qualified workers, namely women, away from careers in those fields. Government also has a role to play. This may be in helping fund the education of these workers, or in providing incentives for the workers themselves to enter these STEM fields. It may also be in providing incentives for businesses who are seeking to help create a work environment that may be more inviting to women.

No matter the steps that government or businesses take, education systems have a responsibility to prepare students for any career they choose. Strong mathematics and science skills will serve students well for their entire work life. Therefore, schools should make it a priority to assess student achievement in mathematics and science and use best practices to address student weaknesses and provide them with a strong foundation in those areas.

CHAPTER III

METHODOLOGY

A large body of research exists on the effects of gender on mathematics and science performance that shows a historically existent gap. The gap is closing in regard to standardized test performance, but a gap still exists in the number of males and females working in STEM careers. There is no conclusive research explaining the reason for the gaps as some research pointed to a genetic cause though most considered the cause to be cultural. Since genetic causes are harder to address in the classroom, the majority of the efforts recommended by the research are targeted at the cultural causes. Schools can evaluate their curriculum and climate to determine whether they are creating an environment of equality and encouraging both males and females to be successful in mathematics and science and, as a result, pursue careers in those areas.

The review of literature also examined research on the effects of school size on mathematics and science performance. Proponents of larger schools claimed that they had more resources to encourage and aid students interested in STEM careers, while those who favored small schools maintained that they created a closer environment for more effective individualized instruction. However, the majority of research in this area concluded that school size had less of an effect on student achievement than did quality of instruction. Therefore, the research recommended that instructional design and strategies be the focus of schools.

This particular study examined these researched factors in several school districts in western Arkansas. The major components to be discussed in this chapter are research design, sample, instrumentation, data collection procedures, analytical methods, and limitations.

Research Design

A quantitative, causal-comparative research strategy was used in this study. The first hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was seventh grade mathematics achievement measured by the Augmented Benchmark Exam. The second hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was seventh grade science achievement measured by the Augmented Benchmark Exam. The third hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable was mathematics achievement for geometry measured by the End of Course Geometry Exam. The fourth hypothesis was a 3 x 2 between-groups factorial design. The independent variables were size of school (large versus medium versus small) and gender (male versus female). The dependent variable for hypothesis four was science achievement for biology measured by the End of Course Biology Exam.

Sample

The study used seventh grade students who tested in the areas of mathematics and science along with students who tested in the areas of geometry and biology. Students were selected from 14 different school districts in western Arkansas, which were chosen because of their geographic location. All school districts in three counties participated and ranged in size from Class 1A to Class 7A. Of the participants in every district, approximately 48.8% were female and 51.2% were male.

The school districts were classified by their size and placed into three different categories (large, medium or small) based on the classification system of the Arkansas Activities Association (Arkansas Activities Association, 2013). The large group consisted of districts within the 5A, 6A, and 7A classifications. The schools in this group had district populations between 3,278 and 14,313 students. The medium group consisted of schools in the 3A and 4A classifications that had between 849 and 1,847 students. The small group consisted of schools in the 1A and 2A classifications. These schools had between 325 and 686 students. Any students enrolled after October 1 were removed from the sample. There were four districts in the large group, five districts in the medium group, and five districts in the small group. All four schools in the large group were used in the study. To narrow the field of five to four in the medium and small groups, simple random sampling was used. After the groups were classified, stratified random sampling was used within each classification to select nine male and nine female students from each school district.

Instrumentation

During the 2011-2012 school year, seventh grade students took the Augmented Benchmark Examination. This test was composed of both criterion-referenced and norm-referenced test components in literacy, mathematics, and science. The test was given over a period of five days. Within the mathematics section, students were asked 30 multiple-choice questions and 6 open response questions for the criterion-referenced portion of the test. In the norm-referenced mathematics portion, 33 multiple-choice items were included. Scores were reported in five areas: Numbers and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability. The science segment of the test included 38 multiple-choice questions within the criterion-referenced portion and 41 multiple-choice questions in the norm-referenced portion. Scores were reported in four areas: Nature of Science, Life Science, Physical Science, and Earth and Space Science (Arkansas Department of Education, 2012a).

Each student enrolled in a geometry course took the End of Course Geometry Exam. This criterion-referenced test was given over a period of 2 days and included 90 multiple-choice questions and 7 open responses. Scores were reported in five areas: Language of Geometry, Triangles, Measurement, Relationships between Two and Three Dimensions, and Coordinate Geometry and Transformation (Arkansas Department of Education, 2012b).

Each student enrolled in a biology course took the End of Course Biology Exam, which is also a criterion-referenced test. The exam was given over 2 days and included 90 multiple-choice questions and seven open response. Scores were reported in five areas: Molecules and Cells, Heredity and Evolution, Classification and Diversity of Life, Ecology and Behavioral Relationships, and Nature of Science (Arkansas Department of Education, 2012b).

A Cronbach alpha reliability coefficient was unable to be obtained for any of the four examinations. However, in order to comply with the rules governing the Arkansas testing system, the Arkansas Department of Education must provide examinations that are reliable and valid tests for educational purposes (Arkansas Department of Education, 2013c).

Data Collection Procedures

The researcher contacted all school districts that were used in this study to obtain consent for data usage. Once this consent was obtained, the researcher applied to the Harding University Institutional Review Board for approval to acquire the needed data to be used in the study from the Arkansas Department of Education Data Center. The data requested included Grade or EOC Test, District LEA, User Identification, Student Supplied Gender, Enrolled after October 1 status, Mathematics Scaled Score, and Science Scaled Score. A representative from the state pulled and coded the data to protect the confidentiality of the students. The representative then sent an email with a secure data transfer link to the researcher. The researcher was then able to download the data to a Microsoft Excel file, which was later converted to an SPSS file to be analyzed. No personal identifying information was collected or reported.

Analytical Methods

IBM Statistical Packages for the Social Sciences (SPSS) Version 21 was used for data analysis. Data collected for the four hypotheses were coded according to size of school and gender. The following codes were used for each group: size of school (1 = large, 2 = medium, 3 = small) and gender (0 = male, 1 = female).

Next, the four hypotheses were analyzed using the following statistical analysis. To address the first hypothesis, a 3 x 2 factorial ANOVA was conducted using county (large versus medium versus small) by gender (male versus female) as the independent variables and mathematics achievement as measured by the 2012 Arkansas Augmented

Benchmark Examination as the dependent variable. To address the second hypothesis, a 3 x 2 factorial ANOVA was conducted using county (large versus medium versus small) by gender (male versus female) as the independent variables and science achievement as measured by the 2012 Arkansas Augmented Benchmark Examination as the dependent variable. To address the third hypothesis, a 3 x 2 factorial ANOVA was conducted using county (large versus medium versus small) by gender (male versus female) as the independent variables and mathematics achievement as measured by the 2012 Arkansas End of Course Geometry Exam as the dependent variable. To address the fourth hypothesis, a 3 x 2 factorial ANOVA was conducted using county (large versus medium versus small) by gender (male versus female) as the independent variables and science achievement as measured by the 2012 Arkansas End of Course Biology Exam as the dependent variable. To test the four null hypotheses, the researcher used a two-tailed test with a .05 level of significance.

Limitations

In all studies, limitations need to be noted to help the reader determine how to interpret the results of the studies. Some limitations adversely affect a study‘s generalizability, and some limitations do not. The following limitations were associated with this study.

This study was conducted on a small scale in a specific area of the state of Arkansas. This makes it difficult to generalize the results on a statewide or nationwide scale. In addition, all but one of the schools used had similar characteristics concerning socioeconomic status and racial makeup. The results may not be reflective of schools that are not predominately low-income and Caucasian.

Another limitation of this study is that it was conducted on only 1 year’s data. These results may not be the same over a period of 3 to 5 years. These results may simply give a snapshot instead of indicate trends.

This study also did not take into account any instructional strategies used by the schools, though research suggested the strategies are the most important factors affecting performance. Lastly, the research design for this study was causal comparative, which constitutes a limitation in itself. The researcher was unable to manipulate the independent variables or randomly assign participants, which produced less conclusive evidence. However, this and the other limitations did not seem to exceed the typical circumstances that are encountered in using schools for research purposes.

CHAPTER IV

RESULTS

The purposes of this quantitative research study were four fold. First, the purpose of this study was to determine the effects by size of school on male students versus female students on mathematics achievement for seventh grade students in schools in western Arkansas. Second, the purpose of this study was to determine the effects by size of school on male students versus female students on science achievement for seventh grade students in schools in western Arkansas. Third, the purpose of this study was to determine the effects by size of school on male students versus female students on mathematics achievement for geometry students in schools in western Arkansas. Fourth, the purpose of this study was to determine the effects by size of school on male students versus female students on science achievement for biology students in schools in western Arkansas. Prior to running the statistical analysis, assumptions of normality and homogeneity of variances were checked. The results of this analysis are found in this chapter.

Demographics

The study used seventh grade students who tested in the areas of mathematics and science along with students who tested in the areas of geometry and biology. Students were selected from 14 different school districts in western Arkansas, which were chosen because of their geographic location. All school districts in three counties participated and ranged in size from Class 1A to Class 7A. Of the participants in every district, approximately 48.8% were female and 51.2% were male. The student free and reduced lunch status ranged from 32.23% to 100%, while the racial makeup of each school was predominantly Caucasian with 12 of the 14 schools being over 88% Caucasian and the other two coming in at 71.47% and 45.96%.

The school districts were classified by their size and placed into three different categories; large, medium or small based on the classification system of the Arkansas Activities Association (Arkansas Activities Association, 2013). The large group consisted of districts within the 5A, 6A, and 7A classifications. The schools in this group had district populations between 3,398 and 13,896 students. The medium group consisted of schools in the 3A and 4A classifications that had between 853 and 1,887 students. The small group consisted of schools in the 1A and 2A classifications. These schools had between 399 and 697 students.

There were four districts in the large group, five districts in the medium group, and five districts in the small group. All four schools in the large group were used in the study. To narrow the field of five to four in the medium and small groups, simple random sampling was used. After the groups were classified, stratified random sampling was used within each classification to select nine male and nine female students from each school district.

Hypothesis 1

Hypothesis 1 stated that no significant difference would exist by size of school between seventh grade male students versus seventh grade female students in western Arkansas school districts on mathematics achievement. The assumptions of independent observations, homogeneity of variances, outliers, and normal distributions of the dependent variable for each group were checked (Leech, Barrett, & Morgan, 2011). Because of the way the study was designed, the assumption of independent observations was met; no subject contributed scores in more than one group. The Levene's test, $F(5, 210) = 0.10$, $p = .993$, indicates that homogeneity of variances has not been violated. There were no outliers. Shapiro Wilk test was used to test for normality with $p > .05$ for each group, indicating that the data was normally distributed across all groups. Table 1 displays the group means and standard deviations.

Table 1

Means, Standard Deviations, and Number of Participants for Mathematics Achievement as a Function of Size of School and Gender

	Male			Female			Total	
School Size	*n*	*M*	*SD*	*n*	*M*	*SD*	*M*	*SD*
Large	36	753.03	84.55	36	750.50	90.64	751.76	87.04
Medium	36	738.28	90.30	36	749.33	87.47	743.81	88.44
Small	36	692.86	85.19	36	696.17	81.92	694.51	82.99
Total	108	728.06	89.67	108	732.00	89.63	730.03	89.46

Figure 1 shows the means for mathematics achievement as a function of size of school and gender.

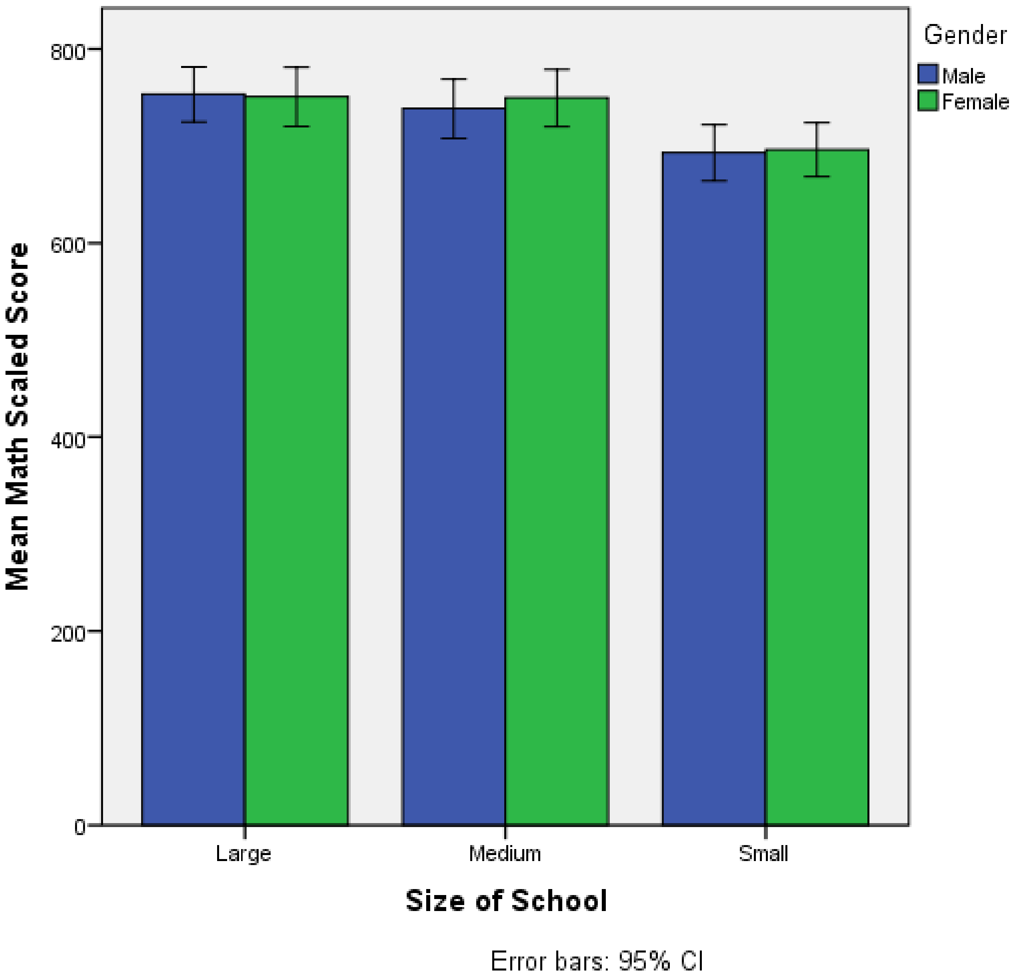

Figure 1. Means for mathematics achievement as a function of size of school and gender.

To test this hypothesis, a 3 x 2 Factorial ANOVA was conducted to evaluate the effects of size of school by gender on mathematics achievement as measured by the 2012 Arkansas Augmented Benchmark Examination. The results are displayed in Table 2.

Table 2

Two-Way Analysis of Variance for Mathematics Achievement as a Function of Size of School and Gender

Variable and Source	*df*	*MS*	*F*	*P*	η^2
Size of School	2	69246.79	9.21	.000	.081
Gender	1	840.17	0.11	.739	.001
Size of School*Gender	2	835.79	0.11	.895	.001
Error	210	7522.63			

Insufficient evidence existed based on the interaction of the variables to reject the null hypothesis, $F(2, 210) = 0.11$, $p = .895$, partial eta^2 = .001. Given there was no significant interaction between the variables of size of school and gender, the main effect of each variable was examined separately. The main effect for size of school was significant, $F(2, 210) = 9.21$, $p = .000$, partial eta^2 = .081. As shown above in Table 1, Large schools ($M = 751.76$, $SD = 87.04$) and Medium schools ($M = 743.81$, $SD = 88.44$) means were higher than Small schools ($M = 694.51$, $SD = 82.99$). A post hoc Tukey test was run to determine if that difference was significant and it revealed that Large schools ($p = .000$, $d = 0.67$) and Medium schools ($p = .002$, $d = 0.57$) did differ significantly from Small schools.

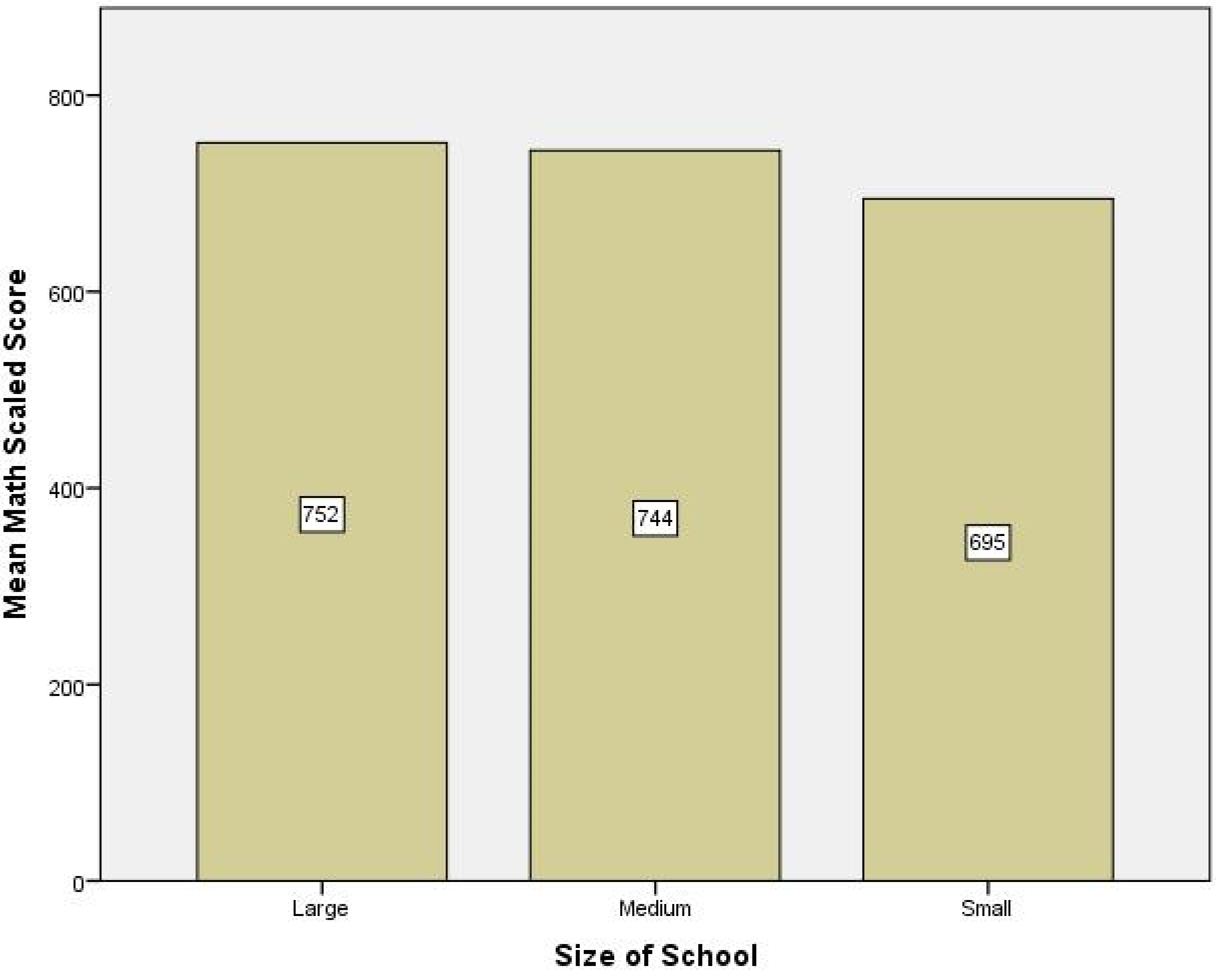

Figure 2. Means for mathematics achievement as a function of size of school.

Figure 2 displays the means of the Large, Medium, and Small schools and shows the difference. The main effect for gender was not significant, *F*(1, 210) = 0.11, *p* = .739, partial eta^2 = .001.

Hypothesis 2

Hypothesis 2 stated that no significant difference will exist by size of school between seventh grade male students versus seventh grade female students in western Arkansas school districts on science achievement. The assumptions of independent observations, homogeneity of variances, outliers and normal distributions of the dependent variable for each group were checked (Leech et al., 2011). Because of the way the study was designed, the assumption of independent observations was met; no subject contributed scores in more than one group. The Levene's test, *F*(5, 210) = 1.09, *p* = .368, indicates that homogeneity of variances has not been violated. There were no outliers. Shapiro Wilk test was used to test for normality with *p* > .05 for each group, indicating that the data was normally distributed across all groups. Table 3 displays the group means and standard deviations.

Table 3

Means, Standard Deviations, and Number of Participants for Science Achievement as a Function of Size of School and Gender

	Male			Female			Total	
School Size	*N*	*M*	*SD*	*N*	*M*	*SD*	*M*	*SD*
Large	36	187.89	35.33	36	191.81	43.75	189.85	39.53
Medium	36	191.94	40.01	36	194.42	33.56	193.18	36.68
Small	36	167.08	30.99	36	173.50	32.77	170.29	31.84
Total	108	182.31	36.96	108	186.57	37.85	184.44	37.38

Figure 3 show the means for science achievement as a function of size of school and gender.

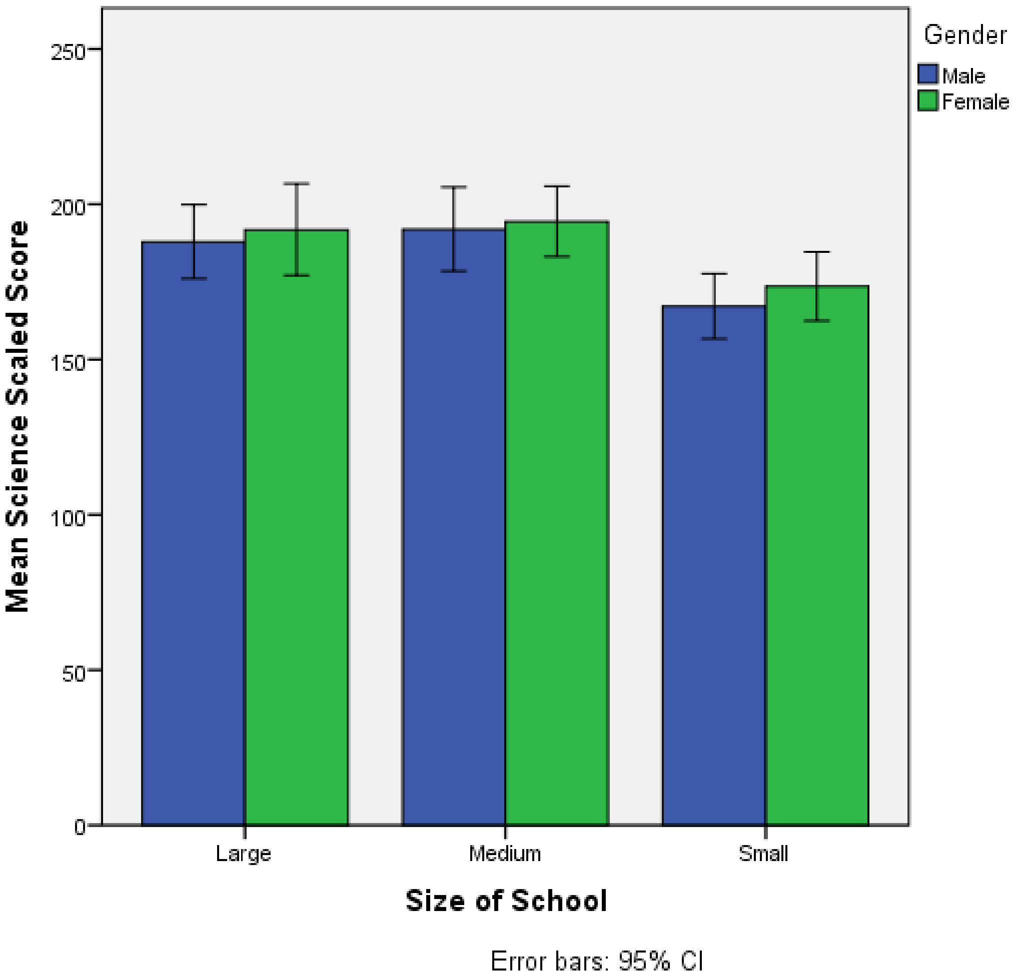

Figure 3. Means for science achievement as a function of size of school and gender.

To test this hypothesis, a 3 x 2 Factorial ANOVA was conducted to evaluate the effects of size of school by gender on science achievement as measured by the 2012 Arkansas Augmented Benchmark Examination. The results are displayed in Table 4.

Table 4

Two-Way Analysis of Variance for Science Achievement as a Function of Size of School and Gender

Variable and Source	*df*	*MS*	*F*	*p*	η^2
Size of School	2	11009.19	8.34	.000	.074
Gender	1	983.89	0.75	.389	.004
Size of School*Gender	2	71.69	0.05	.947	.001
Error	210	1320.54			

Insufficient evidence existed based on the interaction of the variables to reject the null hypothesis, *F*(2, 210) = 0.05, *p* = .947, partial eta^2 = .001. Given there was no significant interaction between the variables of size of school and gender, the main effect of each variable was examined separately. The main effect for size of school was significant, *F*(2, 210) = 8.34, *p* = .000 partial eta^2 = .074. As shown above in Table 3, Large schools (*M* = 189.85, *SD* = 39.53) and Medium schools (*M* = 193.18, *SD* = 36.68) means were higher than Small schools (*M* = 170.29, *SD* = 31.84). A post hoc Tukey test was run to determine if that difference was significant, and it revealed that Large schools (*p* = .004, *d* = 0.55) and Medium schools (*p* = .001, *d* = 0.67) did differ significantly from Small schools.

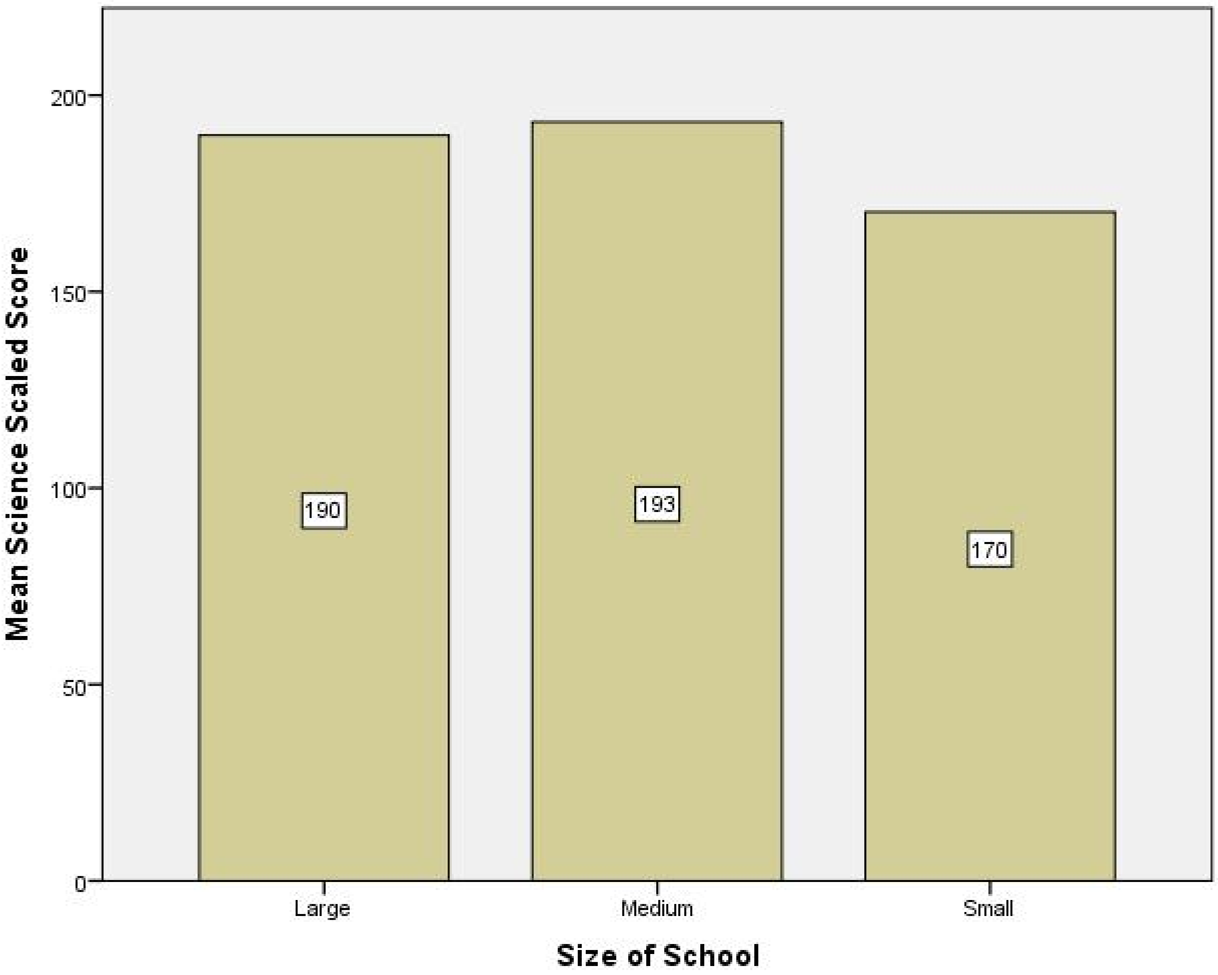

Figure 4. Means for science achievement as a function of size of school.

Figure 4 displays the means of the Large, Medium, and Small schools and shows the difference. The main effect for gender was not significant, *F*(1, 210) = 0.75, *p* = .389, partial eta^2 = .004.

Hypothesis 3

Hypothesis 3 stated that no significant difference will exist by size of school between male geometry students versus female geometry students in western Arkansas school districts on mathematics achievement. The assumptions of independent observations, homogeneity of variances, outliers and normal distributions of the dependent variable for each group were checked (Leech et al., 2011). Because of the way the study was designed, the assumption of independent observations was met; no subject contributed scores in more than one group. The Levene's test, *F*(5, 210) = 1.73, *p* = .130, indicates that homogeneity of variances has not been violated. There were no outliers. Shapiro Wilk test was used to test for normality with *p* > .05 for each group, indicating that the data was normally distributed across all groups. Table 5 displays the group means and standard deviations.

Table 5

Means, Standard Deviations, and Number of Participants for Mathematics Achievement as a Function of Size of School and Gender

	Male			Female			Total	
School Size	*n*	*M*	*SD*	*n*	*M*	*SD*	*M*	*SD*
Large	36	236.39	37.09	36	234.86	30.99	235.63	33.94
Medium	36	224.67	33.68	36	233.50	46.99	229.08	40.84
Small	36	208.53	39.50	36	212.64	45.81	210.58	42.52
Total	108	223.19	38.25	108	227.00	42.75	225.10	40.51

Figure 5 shows the means for mathematics achievement as a function of size of school and gender.

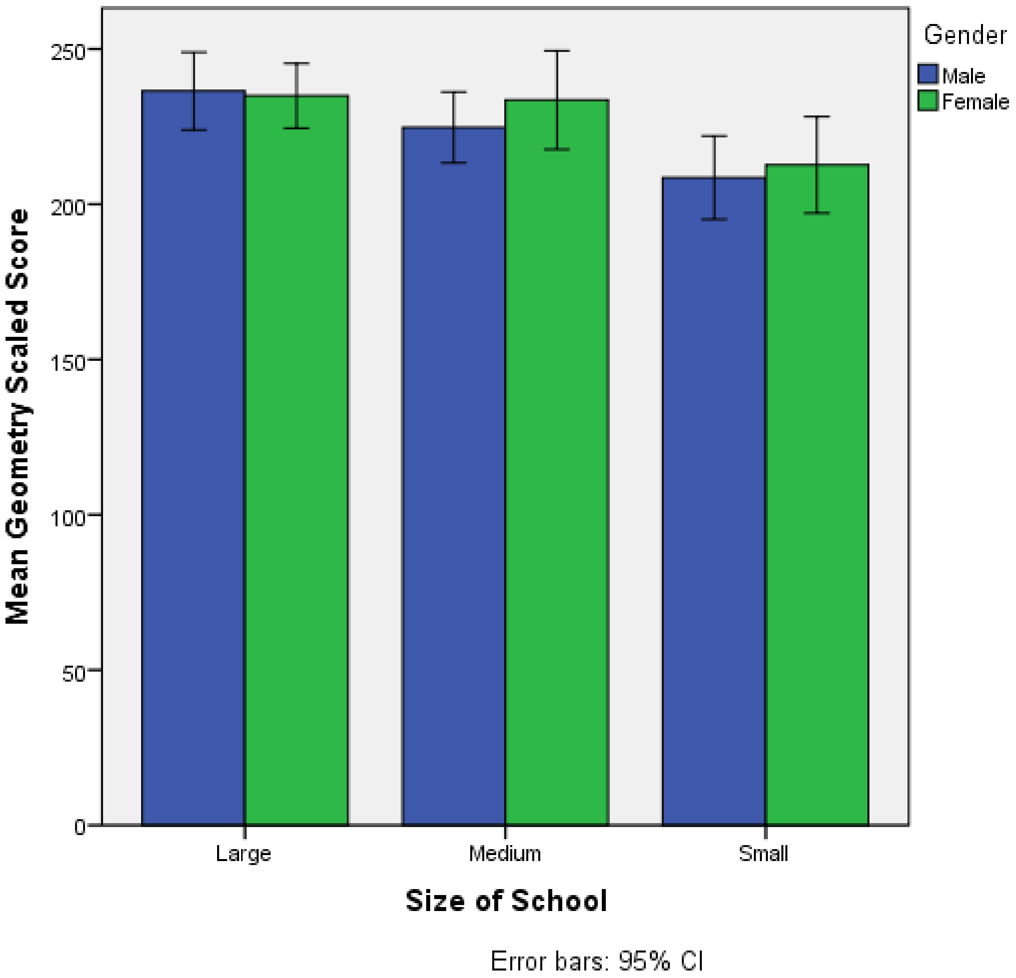

Figure 5. Means for mathematics achievement as a function of size of school and gender.

To test this hypothesis, a 3 x 2 Factorial ANOVA was conducted to evaluate the effects of size of school by gender on mathematics achievement as measured by the 2012 Arkansas End of Course Geometry Exam. The results are displayed in Table 6.

Table 6

Two-Way Analysis of Variance for Mathematics Achievement as a Function of Size of School and Gender

Variable and Source	*df*	*MS*	*F*	*p*	η^2
Size of School	2	12145.54	7.80	.001	.069
Gender	1	782.04	0.50	.479	.002
Size of School*Gender	2	484.34	0.31	.733	.003
Error	210	1556.29			

Insufficient evidence existed based on the interaction of the variables to reject the null hypothesis, $F(2, 210) = 484.35$, $p = .733$, partial eta^2 = .003. Given there was no significant interaction between the variables of size of school and gender, the main effect of each variable was examined separately. The main effect for size of school was significant, $F(2, 210) = 7.80$, $p = .001$ partial eta^2 = .069. As shown above in Table 3, Large schools ($M = 235.63$, $SD = 33.94$) and Medium schools ($M = 229.08$, $SD = 40.84$) means were higher than Small schools ($M = 210.58$, $SD = 42.52$). A post hoc Tukey test was run to determine if that difference was significant and it revealed that Large schools ($p = .001$, $d = 0.65$) and Medium schools ($p = .015$, $d = 0.44$) did differ significantly from Small schools.

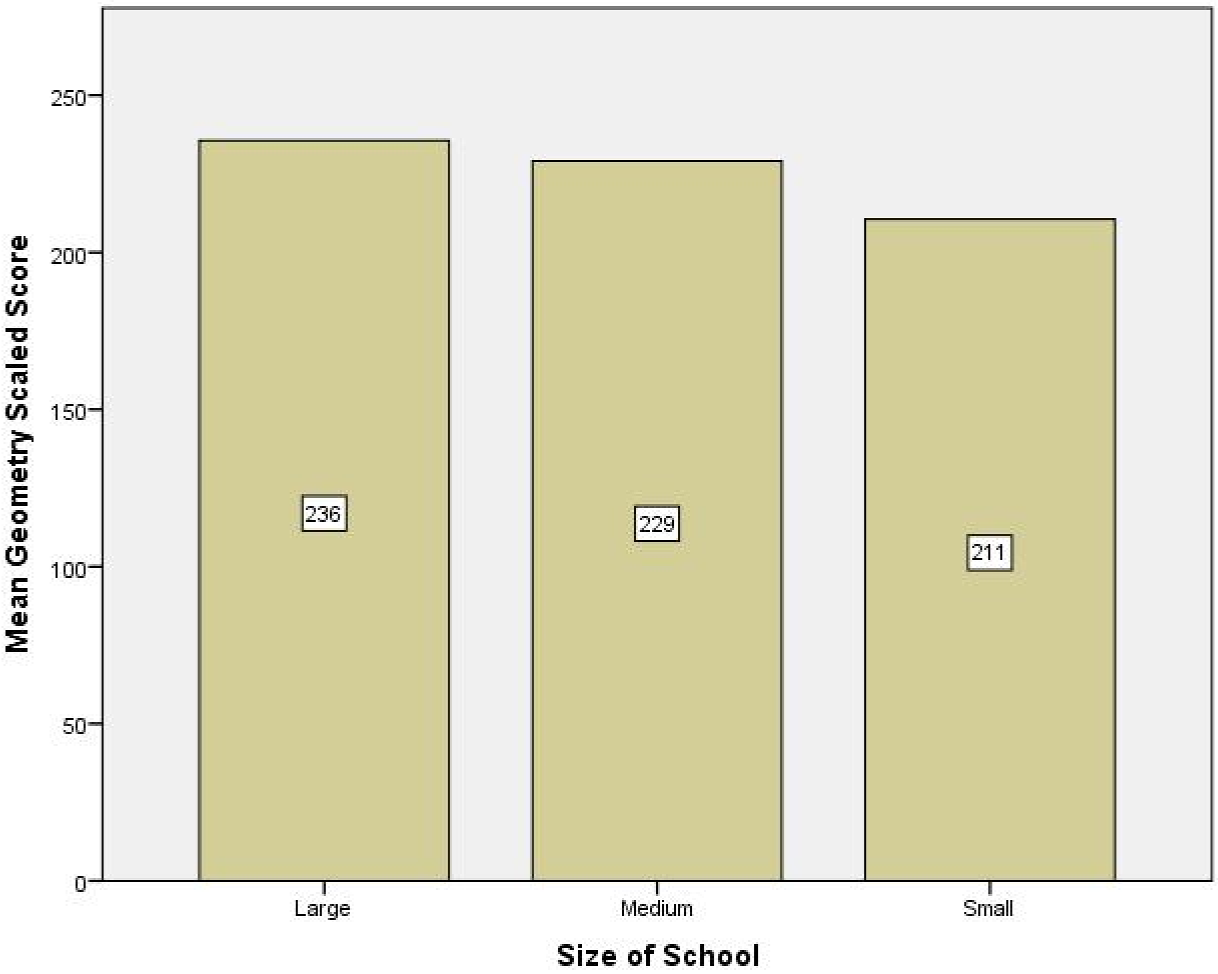

Figure 6. Means for mathematics achievement as a function of size of school.

Figure 6 displays the means of the Large, Medium, and Small schools and shows the difference. The main effect for gender was not significant, $F(1, 210) = 0.50$, $p = .479$, partial eta^2 = .002.

Hypothesis 4

Hypothesis 4 stated that no significant difference will exist by size of school between male biology students versus female biology students in Western Arkansas school districts on science achievement. The assumptions of independent observations, homogeneity of variances, outliers and normal distributions of the dependent variable for each group were checked (Leech et al., 2011). Because of the way the study was designed, the assumption of independent observations was met; no subject contributed scores in more than one group. The Levene's test, *F*(5, 210) = 0.73, *p* = .601, indicates that homogeneity of variances has not been violated. There were no outliers. Shapiro Wilk test was used to test for normality with *p* > .05 for each group, indicating that the data was normally distributed across all groups. Table 7 displays the group means and standard deviations.

Table 7

Means, Standard Deviations, and Number of Participants for Science Achievement as a Function of Size of School and Gender

	Male			Female			Total	
School Size	*n*	*M*	*SD*	*n*	*M*	*SD*	*M*	*SD*
Large	36	202.33	35.56	36	197.31	39.57	199.82	37.44
Medium	36	177.78	45.93	36	185.64	41.39	181.71	43.59
Small	36	167.42	44.39	36	175.06	45.67	171.24	44.88
Total	108	182.51	44.32	108	186.00	42.87	184.25	43.54

Figure 7 shows the means for science achievement as a function of size of school and gender.

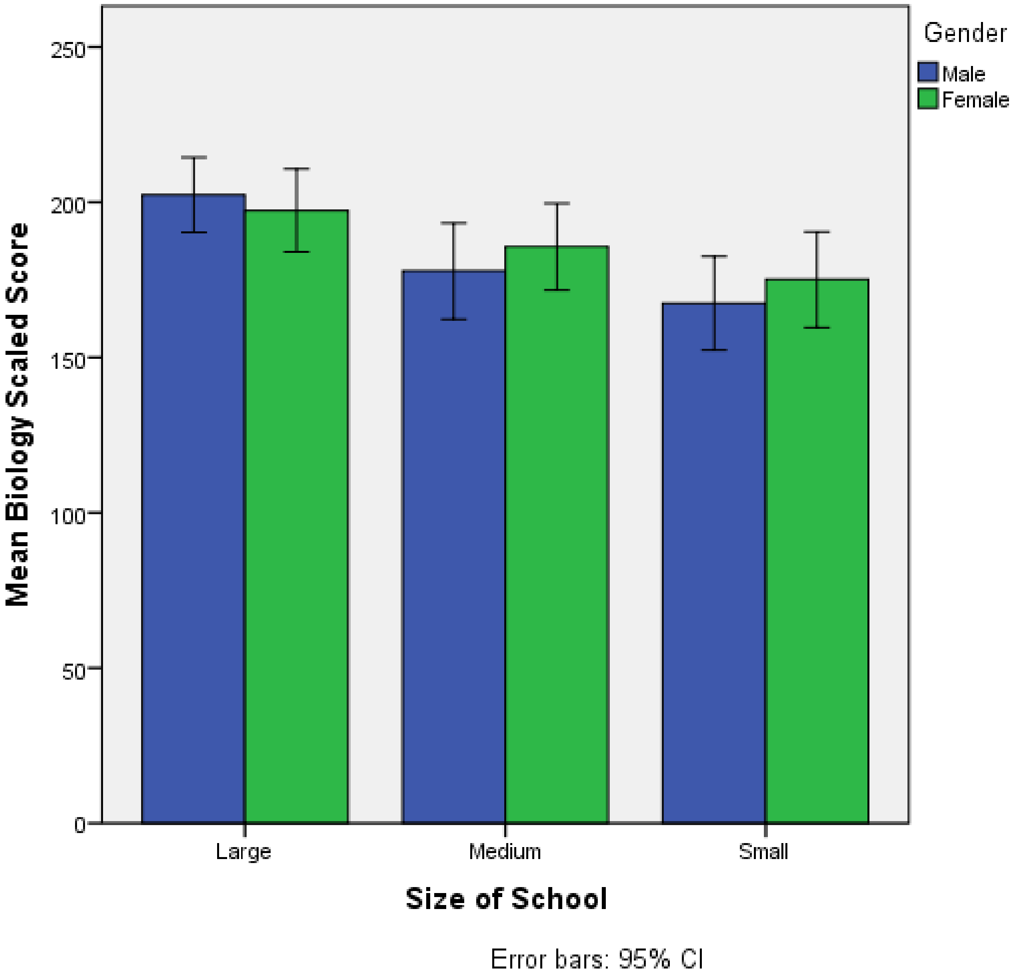

Figure 7. Means for science achievement as a function of size of school and gender.

To test this hypothesis, a 3 x 2 Factorial ANOVA was conducted to evaluate the effects of size of school by gender on science achievement as measured by the 2012 Arkansas End of Course Biology Exam. The results are displayed in Table 8.

Table 8

Two-Way Analysis of Variance for Science Achievement as a Function of Size of School and Gender

Variable and Source	*df*	*MS*	*F*	*p*	η^2
Size of School	2	15056.24	8.44	.000	.074
Gender	1	658.01	0.37	.544	.002
Size of School*Gender	2	979.85	0.55	.578	.005
Error	210	1784.86			

Insufficient evidence existed based on the interaction of the variables to reject the null hypothesis, $F(2, 210) = 0.55$, $p = .578$, partial eta^2 = .005. Given there was no significant interaction between the variables of size of school and gender, the main effect of each variable was examined separately. The main effect for size of school was significant, $F(2, 210) = 8.44$, $p = .000$ partial eta^2 = .074. As shown above in Table 7, Medium schools (*M* = 181.71, *SD* = 43.59) and Small schools (*M* = 171.24, *SD* = 44.88) means were lower than Large schools (*M* = 199.82, *SD* = 37.44). A post hoc Tukey test was run to determine if that difference was significant and it revealed that Medium schools (*p* = .029, *d* = 0.45) and Small schools (*p* = .000, *d* = 0.69) did differ significantly from Large schools.

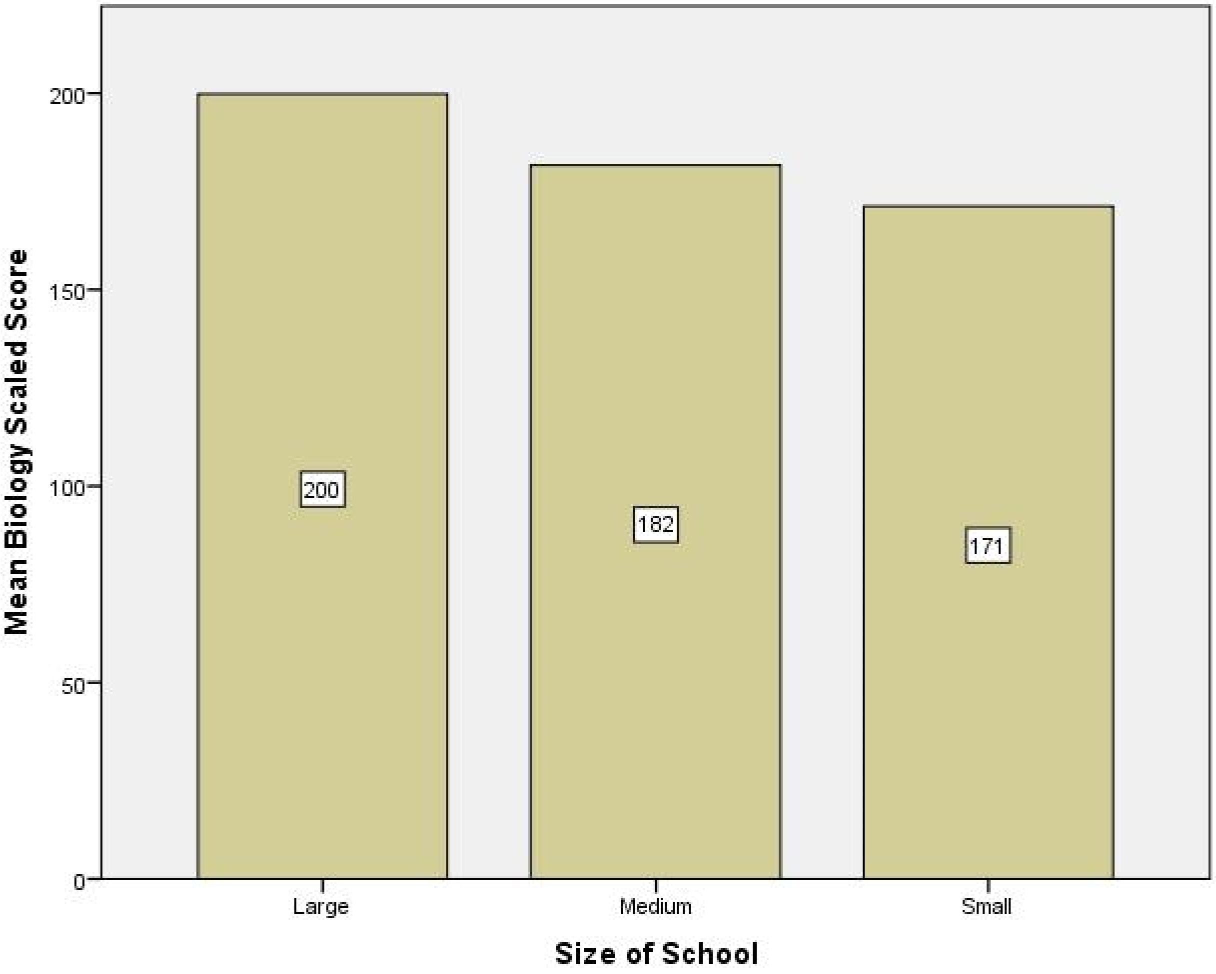

Figure 8. Means for science achievement as a function of size of school.

Figure 8 displays the means of the Large, Medium, and Small schools and shows the differences. The main effect for gender was not significant, *F*(1, 210) = 0.37, *p* = .544, partial eta^2 = .002.

Summary

When determining whether size of school had a significant interaction with gender on mathematics and science achievement, the data showed no significant interaction on seventh grade mathematics achievement, seventh grade science achievement, geometry mathematics achievement, or biology science achievement. The main effect of gender also showed no significant effects on seventh grade mathematics achievement, seventh grade science achievement, geometry mathematics achievement, or biology science achievement. The main effect of size of school did show significant effects on seventh grade mathematics achievement, seventh grade science achievement and geometry mathematics achievement with Small schools scoring significantly lower compared to Large schools and Medium schools. The main effect of size of school also showed significant effects on biology science achievement with Large schools scoring significantly higher than Medium schools and Small schools.

CHAPTER V

DISCUSSION

Throughout the past few decades, much discussion has taken place and much research has been conducted over mathematics and science performance in relation to gender. Trends of the past few decades indicate a small to non-existent gender gap (National Center for Education Statistics, 2011). As that gap in performance has closed, the gender gap in STEM employment remains large. Therefore, government and industry are seeking to determine why that is. Some research suggests a genetic cause, and most other research claims cultural and social causes. Either way, education has been charged with helping close that gap. The first step is for schools to determine whether a gap in performance exists in their school and then to move forward from there.

Another hot topic in education is school size. There are impassioned proponents of both small and large schools, though there is no definitive research on which is most conducive to higher levels of learning and strong academic performance. Larger schools may have more resources and be able to offer more courses, but smaller schools may have a greater chance for individualized learning and strong relationships (Smith & Lee, 1997).

The purpose of this study is to determine whether gender and size of school affects mathematics and science performance in western Arkansas. The previous chapter discussed the results of the research, and this chapter will provide a discussion and explanation of those results. The conclusions of the study will be stated and clarified, implications of the findings will be discussed within the context of broader research on the topic, and recommendations for policy and practice as well as future research will be given.

Conclusions

This study addressed four hypotheses. To address the first hypothesis, a 3 x 2 factorial ANOVA was conducted using county (large versus medium versus small) by gender (male versus female) as the independent variables and mathematics achievement as measured by the 2012 Arkansas Augmented Benchmark Examination as the dependent variable. Hypothesis 2 was analyzed in the same manner as the first with science achievement as measured by the same benchmark as the dependent variable. Hypothesis 3 also used the same statistical analysis with mathematics achievement as measured by the 2012 Arkansas End of Course Geometry examination as the dependent variable. In Hypothesis 4, the same analysis was used with science achievement as measured by the 2012 Arkansas End of Course Biology examination as the dependent variable. To test the null hypotheses, the researcher used a two-tailed test with a .05 level of significance. Interaction between the two independent variables and main effects of each of the two independent variables were examined in each of the hypotheses. The following hypotheses were tested and used to determine conclusions.

Hypothesis 1

Hypothesis one stated that no significant differences will exist in mathematics performance between males and females on the seventh grade mathematics benchmark in large, medium, and small schools in western Arkansas. After the research, no significant interaction was found. Neither male students nor female students performed better in large schools, medium schools, or small schools. The size of school did not favor either gender as males and females had equal performance across the board. However, both genders performed better in large and medium schools than they did in small schools. Large schools had an average scaled score of 751.76, medium schools had an average scaled score of 743.81, and small schools had an average scaled score of 694.51. This is a difference of close to 50 points between medium and small schools, with the large schools performing at the highest level.

Hypothesis 2

Hypothesis 2 stated that no significant differences will exist in science performance between males and females on the seventh grade science benchmark in large, medium, and small schools in western Arkansas. No significant interaction was found. Large schools, medium schools, or small schools did not have male students or female students performing better than the other did. Large, medium, and small schools all saw equal performance from both males and females. However, the large and medium schools did see better performance from both genders than the small schools. The large schools had an average scaled score of 189.85, the medium schools had an average scaled score of 193.18, and the small schools had an average scaled score of 170.29. This is a difference of almost 20 points between the large schools and the small schools, with the medium schools performing at the highest level.

Hypothesis 3

Hypothesis 3 stated that no significant difference will exist in mathematics performance between males and females on the End of Course Geometry Test in large, medium, and small schools in western Arkansas. No interaction was found. Neither males nor females had an advantage in large, medium, or small schools. Males and females scored approximately the same across the board. The medium and large schools had better performance from both genders than the small schools. The large schools had an average scaled score of 235.63, the medium schools had an average scaled score of 229.08, and the small schools had an average scaled score of 210.58. This is a difference of almost 20 points between medium and small schools, with large schools performing at the highest level.

Hypothesis 4

Hypothesis 4 stated that no significant difference will exist in science performance between males and females on the End of Course Biology Exam in large, medium, and small schools in western Arkansas. No interaction was found. Neither males nor females performed better at one school size than they did at another. The size of school did not favor either gender as males and females performed fairly equally across the board. Both genders in large schools did perform better than medium and small schools for both genders. Large schools had an average scaled score of 199.82. Medium schools had an average scaled score of 181.71, and small schools had an average scaled score of 171.24. That is a difference of almost 20 points between large and medium schools, with small schools performing at an even lower level.

To summarize, no significant interaction existed for any of the four hypotheses between size of school and gender. On mathematics and science standardized tests, males and females performed at an equal level. There appears to be no difference in mathematics and science ability based on gender in schools of all sizes in western

Arkansas. In regard to school size, there was a significant difference in performance. For Hypotheses 1, 2, and 3, large and medium schools saw better performance from both genders than did small schools. For Hypothesis 4, both genders at large schools performed better than small and medium schools. According to this study, size of school did make a statistically significant difference.

Implications

The review of related literature created a context for interpreting the results of this study. Research conducted on gender difference in mathematics performance as well as the effects of school size on performance can help explain what the results of this study mean. The most recent research on gender performance in mathematics and science supported the idea that a gender gap no longer exists. Average scores on the ACT, SAT, and NAEP tests in the past few decades showed very little difference in performance (National Center for Educational Statistics, 2011). Males and females are participating in higher-level mathematics and science classes equally, with females actually having an advantage (College Board, 2013). The results of this study aligned with that data. In these schools in western Arkansas, males and females performed equally, and these results seemed to align with the nationwide data and could possibly be generalized on a larger scale.

The results of this study supported the idea that the existing gender gap in STEM employees is not because of genetic differences between males and females that cause males to be better at mathematics and science. The claim of Gurian and Stevens (2004) that boys’ brains are better suited to excel in mathematics and science as well as the assertion by Baren-Cohen (2003) that the difference in core cognitive systems makes males better at mathematics and science than females were both contradicted. At least in the western Arkansas area at this time, females are just as prepared educationally as males for success in careers involving mathematics and science. Therefore, the causes might lie in the cultural and social practices of American society.

Many schools have addressed the cultural and social issues that may give an advantage to males over females in mathematics and science performance. Sadker and Sadker (1994) suggested that avoiding damaging gender stereotyping could make a difference. Purposeful actions by teachers to encourage both genders to be successful in mathematics and science have been recommended as well (WEEA Equity Resource Center, 2001). The results of this study suggested that these schools in western Arkansas are not creating an advantage for males over females through their instruction or teacher behavior. Again, because this study aligned with the recent research that a gender gap in performance no longer exists, this contention could possibly be applied to educational practices across the U.S.

Concerning school size, the results of this study supported the idea proposed by Conant (1959) that large schools create opportunity for superior performance. This might be because of their larger number of course offerings in mathematics and science electives, as well as their access to resources for teaching effectively. In three of the four hypotheses, the large and medium schools performed better than the small schools with the large schools outperforming both medium and small schools in the fourth. Again, this might not be due to courses or resources, but could be a result of school culture (Bullard, 2011). Bullard’s assertion is contradicted by this study, however, because he contended that small schools typically have a better school culture because it is easier to create.

Smith and Lee’s (1997) asserted that medium sized schools are the most ideal because they have varied course offerings and access to resources, as well as the ability to create strong culture. This notion was somewhat supported by this study because medium schools did perform at the same level as large schools and better than small schools in three of the four hypotheses.

Performance in mathematics and science based on school size is not something that should be widely generalized to other groups or larger populations. There is not conclusive research that school size affects performance as a whole. In this area of western Arkansas, there must be reasons why larger schools are performing better for both genders, but those same reasons may not apply to large schools across the U.S.

The fact that this study was conducted only in western Arkansas was a limitation of the research. This was because this region might have varying characteristics from other regions of the state or the nation that were not taken into consideration. The results that align with the national data can possibly be generalized, but the results that do not should be considered within the context of this limitation. Another limitation of this study was that only one year’s data was investigated. These results may not be the same over a period of 3 to 5 years. Therefore, even these schools may show some different trends. The fact that it is a snapshot of a single year should be considered as well when applying the results to educational practice.

Recommendations

Potential for Practice/Policy

This study was conducted at large, medium, and small schools in western Arkansas and considered the scores of both males and females on the seventh grade mathematics benchmark, the seventh grade science benchmark, the End of Course Geometry Exam and the End of Course Biology Exam. The results may have implications for these schools in western Arkansas, for the state of Arkansas as a whole, and schools with similar demographic characteristics.

First, schools should examine their mathematics and science instruction. The findings suggest that there are things they are doing well in providing equal instruction for both genders. They should identify the practices they are using to provide quality instruction that is free of gender-bias and encourages both males and females in these areas. These practices should be focused on and purposefully continued. Schools should also try to identify any practices that may promote gender inequality and work to eliminate those.

Second, these research results support the idea that both genders are being equally prepared for success in STEM careers; yet, the gender gap in STEM employment is very real. Therefore, schools should go further than just examining their instruction and preparation of students for these standardized tests and look at what they do to prepare students for higher education and careers in STEM areas, specifically females. Schools should determine steps they can take to encourage students toward these careers and to expose them to how the mathematics and science curriculum will be applied to real-world job situations. Rigorous instruction is important, but the relevance of this instruction should also be made clear to students as part of the curriculum.

Third, professional development practices are something else that schools can examine. Training in gender-equal practices in the classroom as well as how to encourage students toward careers in STEM can help teachers integrate both of these ideas into their everyday instruction. Teachers who are new to the district should especially be exposed to the importance that the district places on gender-equal mathematics and science instruction as well as the encouragement of students toward STEM careers.

School size is not something that is often under the district's control. Nevertheless, schools of every size can analyze the implications that come with the number of students they have. Large schools can determine what advantages they have in regard to class offerings and resources and can use those advantages to provide better instruction to their students. They can also identify ways to create relationships and build a school culture that is often easier for small schools to attain. This could possibly be achieved through the structure of the school and efforts to create small schools within schools that may more easily allow for the positive culture to be cultivated. No matter the steps taken, this culture for effectiveness should be a focus of the schools and all employees should be aware of its importance.

The results of this study support the idea that small schools have more challenges than the large schools do. The research suggests that these may be in regard to the ability to provide higher-level electives in mathematics and science or in the availability of resources for instruction. This may not necessarily be the case, but that is what small schools need to determine. Pinpointing the disadvantages they have should be the first step to overcoming them. Logistically, they may not be able to add higher-level mathematics and science electives, but they might be able to integrate them into their regular curriculum through differentiated instruction. They may not have the funds to access instructional resources for their students, but various companies or non-profit institutions may offer grants or free materials. Small schools can also use the resources available from their local educational cooperative. Small districts should access those resources in order to provide all they can for their students. At the same time, small schools should also recognize the advantages of small class sizes and use them to help their students. Individualization and targeted remediation for students who are not performing at high levels is easier in a small school.

The researcher considered other possible disadvantages, though they are speculative and not based on research or data. These include teacher quality, as smaller schools offer smaller salaries and may not be able to retain good teachers who apply for and accept jobs in larger districts. Larger schools may also offer more support, not just in resources, but also in collaboration with colleagues. These schools often have more than one teacher teaching the same subject and collaborative planning and problem solving may take place more often in larger schools than in small ones. Teachers in large schools are often able to focus more on specific subjects as well. At the secondary levels, they may have only one or two different courses to prepare for, whereas teachers at small schools may teach five or six different courses. All of these suppositions may be considered as a part of further research to determine the reasons behind the stronger performance by large and medium schools.

Finally, the state legislature and state Department of Education might want to consider these results. With further research and a data-based identification of higher performance in larger schools, funding may need to be considered. In addition, the notion that males and females are both equally adept at mathematics and science but not filling STEM jobs at the same rates may require action by the state government. A focus by education and industry on encouraging females toward STEM majors and ultimately STEM careers may need to be undertaken.

Future Research Considerations

The researcher’s findings do not support the idea that a gender gap in performance exists in regards to mathematics and science performance, however, a gap does still exist in STEM employment. Though the results do not conclusively show that any school size is superior to others, they do suggest that large and medium schools may provide opportunities for better performance, at least in mathematics and science. To further evaluate these findings and identify the reasons behind the results, the researcher recommends that the following studies be considered:

1. A similar longitudinal study over 3 to 5 years to determine whether the findings of this study represent a trend or simply a single-year snapshot
2. A study of the instructional practices of these schools in mathematics and science to determine the level of gender neutrality
3. An examination of the number of males and females in STEM careers in western Arkansas and an identification of the extent of the gap
4. A study of the effect of constant and purposeful encouragement of females to STEM careers at the public school level
5. A study of the relationship between higher-level mathematics and science course offerings and student performance in mathematics and science
6. A study of the effect school size has on school culture
7. A study of school size with other important factors such as teacher quality, collaborative practice, and subject-specific focus by teachers

It will be important to know whether these findings are in fact a trend and not just evidence of a single year’s performance. This will help schools determine the actions they need to take to improve performance in mathematics and science and to overcome the challenges they face. With evidence of a trend, a stronger and more focused effort can be constructed and implemented toward improved performance.

The findings of this study suggested that these schools are doing well in gender-equal instruction. However, this can be researched to determine whether this is in fact the case. This research may be mostly qualitative and based on observations and surveys, but it would help these schools to identify what they are doing well, in addition to areas for improvement. Data and research showed that a gender gap in STEM employment exists across the U.S., but there is no available data for that gap in regard to western Arkansas. Further study could be conducted to determine the existence of the gap and the extent of it in this area. This would help educators know how much of a priority to place on encouraging females to pursue STEM careers. Many efforts have been implemented across the nation and in Arkansas to encourage females toward STEM careers. A study of their effectiveness could help identify which ones are being successful and help schools create a plan of action toward this end. There may also be some specific programs emerge that can be implemented across America.

One of the arguments by proponents of large schools is that they are able to offer more courses and higher-level mathematics and science electives, which are leading to improved mathematics and science performance. A study of the relationship between number of electives and performance on standardized tests could help determine whether the offering of these electives are important enough for small schools to make them available. This may lead to action by districts themselves or by the state legislature. School culture was another factor that was identified by researchers as a possible factor for success (Bullard, 2011). Further, study on the effects of school size on creating a positive school culture may determine actions that schools need to take in improving performance.

There may be other reasons besides greater course offerings and access to resources that caused small schools to underperform compared to medium and large schools in this study. An identification of these possible reasons and research based on them may help pinpoint the challenges that small schools need to overcome to perform at equal levels. All of this further research could help clarify the results of this study and provide guidance to schools that are using these findings to drive their instruction. Further investigation into the reasons behind the results will allow schools to individualize their efforts to meet their own needs.

The historical gender gap in performance and subsequent stereotype that males are superior to females in mathematics and science has been widely considered and researched. A lot of this has been brought on by the existing gender gap in STEM careers that currently plagues the nation. The U.S. has much at stake because of the need of STEM workers to keep high-tech industry afloat; therefore, government and industry have cause for concern. The recent research and this study suggest that the cause for this existing gap is not due to ability in mathematics and science, but instead is due to something else. Many different institutions in government, business, and education have poured millions of dollars into closing this gender gap. Many efforts have been made in the last decade to try to encourage females toward STEM careers at young ages.

Education is making it a priority, but time and further research will tell whether the efforts are effective.

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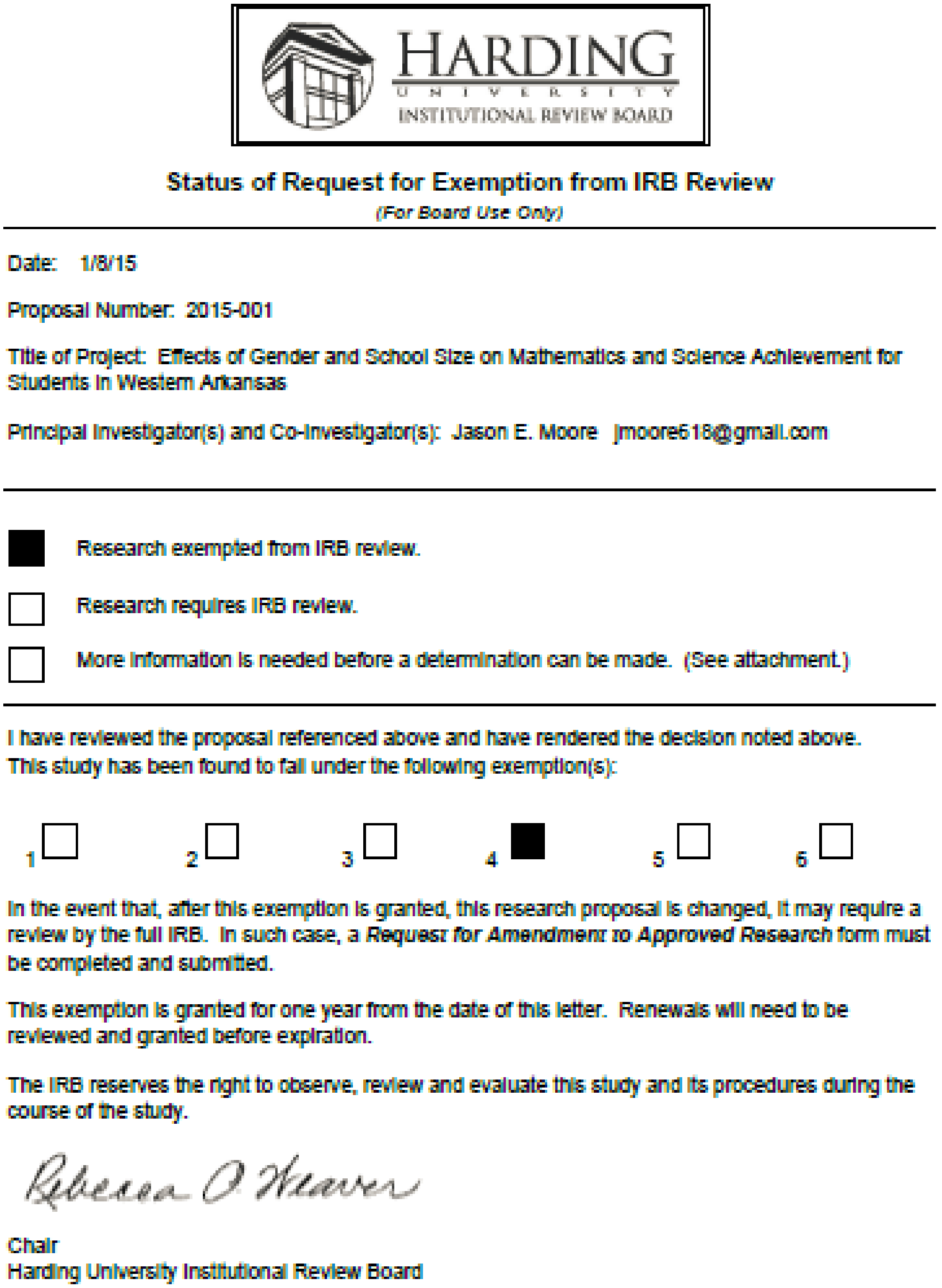
APPENDIX



HARDING UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Status of Request for Exemption from IRB Review

(For Board Use Only)

Date: 1/8/15

Proposal Number: 2015-001

Title of Project: Effects of Gender and School Size on Mathematics and Science Achievement for Students in Western Arkansas

Principal Investigator(s) and Co-Investigator(s): Jason E. Moore jmoore618@gmail.com

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☒ Research exempted from IRB review.

☐ Research requires IRB review.

☐ More information is needed before a determination can be made. (See attachment.)

I have reviewed the proposal referenced above and have rendered the decision noted above.
This study has been found to fall under the following exemption(s):

1 ☐ 2 ☐ 3 ☐ 4 ☒ 5 ☐ 6 ☐

In the event that, after this exemption is granted, this research proposal is changed, it may require a review by the full IRB. In such case, a ***Request for Amendment to Approved Research*** form must be completed and submitted.

This exemption is granted for one year from the date of this letter. Renewals will need to be reviewed and granted before expiration.

The IRB reserves the right to observe, review and evaluate this study and its procedures during the course of the study.

Rebecca O. Weaver

Chair
Harding University Institutional Review Board