GENDER AND STEM RELATED ADVANCED PLACEMENT EXAMS: A REVIEW OF THE LITERATURE

JILL B. MORRIS
Bryan Independent School District, John R. Slate and George W. Moore
Sam Houston State University

Abstract
In this analysis of the literature, we reviewed the research and theory related to gender differences in the STEM field and then in STEM related Advanced Placement exams. In particular, we focused on (a) the gender gap in math and science education, (b) the history of STEM education, (c) the history of AP, (d) gender and AP performance, and (e) the economy and AP. Given the importance of increasing involvement in the STEM field and of gender equity, we documented in our analysis the continued presence of strong gender differences. Implications of our critical analysis of the literature are provided.
Keywords: Gender differences, STEM, Advanced Placement

Introduction

According to the U.S. Department of Labor predictions, by 2018 nine of the 10 fastest growing careers will require mathematical, technological, or scientific training (National Science Board, 2010). In recent years, growth of STEM careers has been approximately three times faster than the growth of non-STEM careers (Langdon, McKittrick, Beede, Khan, & Dome, 2011). Langdon and colleagues (2011) contended that STEM "workers drive our nation's innovation and competitiveness by generating new ideas, new companies and new industries" (p. 1). However, as the nation's need for STEM workers is growing, the STEM workforce is aging (American Association of University Women, 2010; Langdon et al., 2011; National Science Board, 2010). In his 2011 State of the Union address to Congress, President Obama (2011) remarked:

Maintaining our leadership in research and technology is crucial to America's success. But if we want to win the future -- if we want innovation to produce jobs in America and not overseas -- then we also have to win the race to educate our kids. (para 33)

To maintain the nation's economic stability, it is imperative that the STEM workforce grows in number and becomes more diverse (American Management Association, 1998; Congressional Commission on the Advancement of Women and Minorities in Science Engineering and Technology Development, 2000; Langdon et al., 2011).

Gender Gap in Math and Science Education

The stereotype that boys are superior to girls in science and math has been a long-held belief. However, girls tend to earn better grades in school than boys in all subjects, have a higher grade point average in math and science courses than boys, and earn more high school math and science credits than boys (Dwyer & Johnson, 1997; Kimball, 1989; National Center for Education Statistics, 2010; Shettle et al., 2007). Yet, boys tend to outperform girls on tests, especially when the tests are timed or given under stressful conditions (Gonzales et al., 2009; National Center for Education Statistics, 2007, 2010). Gender differences in math and science achievement and class selection are still present but have decreased since 1980 (Clewell & Campbell, 2002; Kimmel, Miller, & Eccles, 2012).

"Mathematics is a major key necessary in unlocking a majority of important career opportunities available for our most intelligent and academically able students" (Rekdal, 1984, p. 11). In 1973, Sells stated that math courses prevent many women from pursuing higher paying careers in science and technology related areas. Ma and Johnson (2008) argued that Algebra II was the most important course in determining if students would pursue a career in engineering or physical sciences. Science courses also serve as gatekeepers for future study, and the gender gap in science achievement may partially explain why fewer women pursue STEM related degrees and careers (Amelink, 2009b; Hazari, Tai, & Sadler, 2007; Madigan, 1997). Successfully completing high school science and math courses may be an important factor in students' decisions to enter into a STEM related major in college (Eccles, 2007; Ma & Johnson, 2008; Sells, 1980; Shaw & Barbuti, 2010; Trusty, 2002). Trusty (2002) argued that for girls, math achievement was a stronger predictor of entrance into a STEM major than it was for boys. Conversely, success in science was the better predictor for boys' decisions to pursue a STEM career (Trusty, 2002). In addition to high school success in math and science, doing well on STEM related AP exams, and a desire for an advanced degree were all positively correlated with students successfully completing a degree in a STEM related field (Shaw & Barbuti, 2010).

Historical Overview of the Gender Gap

In 1974, Maccoby and Jacklin argued that boys were inherently better at mathematics than girls starting at about age 12. Similarly, Fennema (1974) noted that although a noticeable difference between boys and girls was not present in mathematical performance during elementary school, a difference emerged during high school. Boys tended to do better than girls at higher level tasks and girls generally surpassed boys on tasks that required lower level thinking, simple computation, and repetition (Fennema & Carpenter, 1981). In their study of mathematically precocious youth, Benbow and Stanley (1982) stated that boys earned higher scores than girls on the math portion of the Scholastic Aptitude Test.

In an analysis of investigations through 1985, Stage, Kreinberg, Eccles, and Becker (1985) determined:

The following results are fairly consistent across studies using a variety of achievement tests: 1) high school boys perform a little better than high school girls on tests of mathematical reasoning (primarily solving word problems); 2) boys and girls perform similarly on tests of algebra and basic mathematical knowledge; and 3) girls occasionally outperform boys on tests of computational skills...Among normal populations, achievement differences favoring boys do not emerge with any consistency prior to the 10th grade, are typically not very large, and are not universally found, even in advanced high school populations. (p. 240)

Hyde, Fennema, and Lamon (1990) mentioned the presence of a small, statistically significant difference between the performance of boys and girls on mathematical tests, but concluded that the difference did not provide evidence that boys were always better at math than girls or that boys were more capable of understanding math than girls. However, boys did tend to outperform girls on higher-level tasks and problem solving questions that are often present in high school level math courses. Hyde and colleagues (1990) asserted that these differences were important because higher level thinking and problem solving are two important skills required for many math-related careers and the difference may account for some of the disparity in women pursuing jobs requiring the extensive use of mathematics.

Another reason posited for the performance difference on math tests between boys and girls is that girls take fewer upper level math classes than boys (Kerr, 1991; Laing, Engen, & Maxey, 1987; Pallas & Alexander, 1983; Reis, 1987). However, the number of boys and girls taking advanced math classes has increased in recent years. As can be seen in Figure 1, the percentage of both boys and girls taking upper level math courses has increased. In 2004, a higher percentage of girls (53%) took Pre-Calculus or Calculus than the percentage of boys (50%). The percentage of boys and girls not taking math has decreased from about 25% in 1982 to less than 10% in 2004.

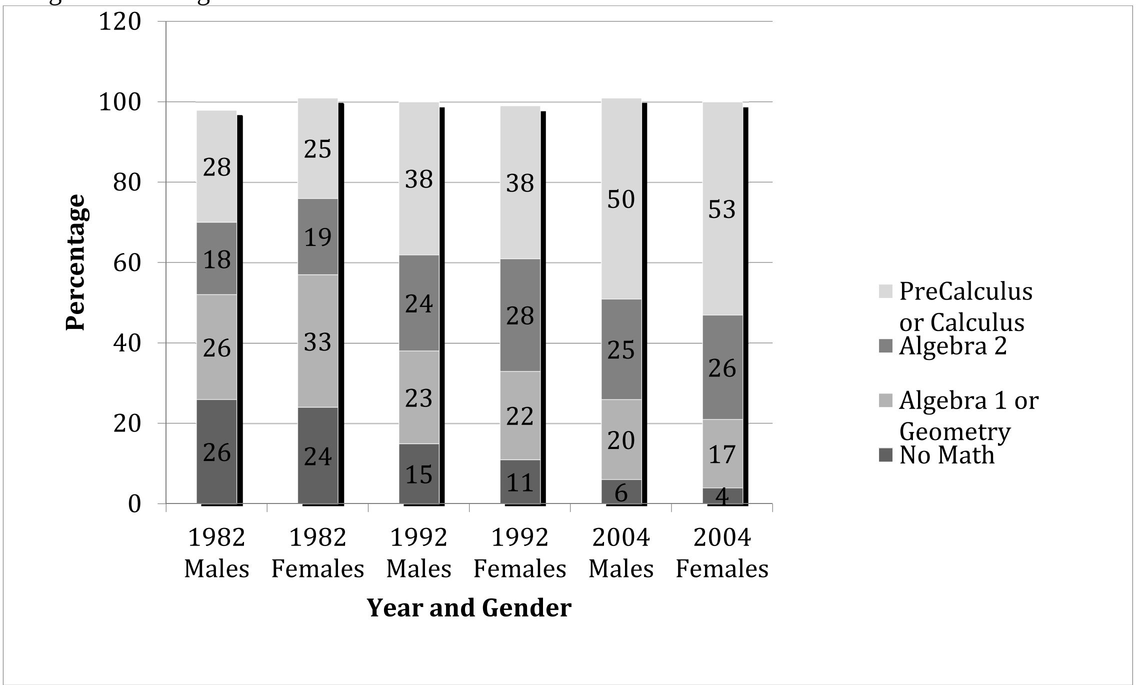

Figure 1. Percentage of high school graduates taking math classes from 1982 - 2004. Data were synthesized from the National Center for Education Statistics (2004).

In the 1980s and 1990s, the authors of several studies (e.g., Brophy, 1985; Friedman, 1989; Hayes & Slate, 1993; Marsh, 1989) indicated that gender differences in math performance persisted but were becoming smaller. However, boys still outperformed girls when completing tasks that involved higher cognitive thinking and problem solving skills, and girls tended to score higher than boys on tests involving computational or lower level thinking skills (Feingold, 1988). Another important difference noted by researchers (e.g., Gallagher & DeLisi, 1994; Low & Over, 1993; Mills, Ablard, & Stumpf, 1993) was the methods that boys and girls selected when solving mathematical problems. Boys were more likely to utilize shortcuts and new strategies to solve problems, whereas girls had a propensity to rely on techniques learned in their math classes. Strategies chosen by girls often require more time than the strategies utilized by boys, and therefore girls were at a disadvantage on timed tests (Gallagher & DeLisi, 1994; Low & Over, 1993; Mills et al., 1993).

The authors of two more recent studies (e.g., Else-Quest, Hyde, & Linn, 2010; Hyde, Lindberg, Linn, Ellis, &

Williams, 2008) stated that even though gender differences on math tests still existed, they have decreased in size. Hyde et al. (2008) determined that the average effect size (i.e., Cohen's *d*) of d = 0.15 for all samples in the meta-analysis was small, with the largest effect size (d = 0.32) being present for problem solving at the high school level. However, boys expressed higher confidence and less anxiety when performing mathematically (Else-Quest et al., 2010). Else-Quest and colleagues (2010) postulated that girls should perform comparable to boys if they are "encouraged to succeed, are given the necessary educational tools, and have visible female role models excelling in mathematics" (p. 125).

Ingels and Dalton (2008) posited that differences in science performance between boys and girls begin in elementary school and persist through high school. Boys tend to outperform girls on tests that assess how well specific content is mastered even though girls often complete the same coursework as boys (Amelink, 2009b). Although the gender gaps in science have narrowed between boys and girls, differences in performance on assessments persist (Amelink, 2009b). O'Reilly and McNamara (2007) concluded that boys scored higher on both reading comprehension and science knowledge and girls scored higher on science strategy. Males also tended to have higher scores on both free-response questions and multiple-choice questions than girls, especially when the tests were given under timed or stressful conditions (O'Reilly & McNamara, 2007; Penner, 2003). In their analysis of performance on multiple choice and free-response questions, O'Reilly and McNamara (2007) documented a medium effect size (i.e., Cohen's *d* ranging from 0.51 to 0.58). However, girls were more likely to outperform boys on science tests that involved life sciences (Ingels & Dalton, 2008; National Assessment of Educational Progress, 2005).

Madigan (1997) examined national science achievement data from the National Education Longitudinal Study (NELS) and student transcripts and determined that overall 54% of students increased in science proficiency between grades eight and 12. However, girls were less likely than boys to increase their science proficiency between grades eight and 12. Madigan (1997) suggested that the taking eight or more science courses was positively associated with science proficiency. As displayed in Figure 2, the percentage of boys and girls taking advanced science classes (e.g., Chemistry II, Physics II, or Advanced Biology) has increased slightly since 1982. Over the same time, the percentage of both boys and girls not taking a science class or only taking a basic science class has decreased from about 30% to less around 7% for boys and 5% for girls.

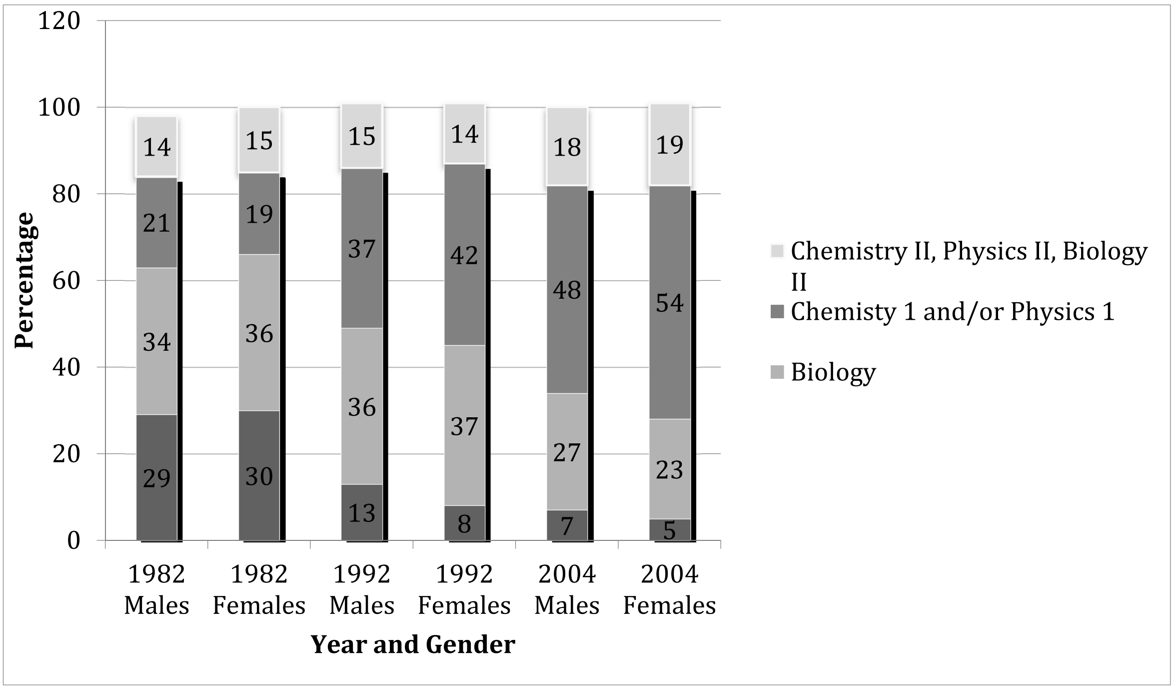

Figure 2. Percentage of high school graduates taking science classes from 1982 - 2004. Data were synthesized from the National Center for Education Statistics (2004).

Lee and Burkam (1996) concluded eighth grade girls scored better in life science courses and had a better grade point average, but boys tended to score better on physical science assessments. The gender difference for the physical science courses became larger as the difficulty level of the course increased (Lee & Burkam, 1996). In a 2003 investigation, Bacharach, Baumeister, and Furr argued a statistically significant difference was present for science achievement between boys and girls by Grade 8, and the difference increased with age, with boys outperforming girls. One factor that may influence the ability of boys and girls to master science topics is how the material is taught in class (Schroeder, Scott, Tolson, Huang, & Lee, 2007). Girls benefited more from laboratory experiences in physical science courses, and boys performed better in courses that required extensive memorization (Lee & Burkam, 1996). For physics courses, girls noted a higher level of understanding when the instructor was able to connect the material being taught to their real-life experiences and did not rely on the typical examples provided in a physics class (Hazari et al., 2007). Present in Table 1 is a summary of research into gender differences in math and science performance.

Table 1*Summary of Research into Gender Differences in Math and Science*

Study	Significant Findings	Gender Favored	Effect Size
Maccoby & Jacklin (1974)	Yes	Boys	Not reported
Benbow & Stanley (1982)	Yes	Boys	Not reported
Stage et al. (1985)	Yes	Boys	Not reported
Hyde et al. (1990)	Yes	Boys	Small
Bacharach et al. (2003)	Yes	Boys	Not reported
Hyde et al. (2008)	Yes	Boys	Small
O'Reilly & McNamara (2007)	Yes	Boys	Medium
Ingels & Dalton (2008)	Yes	Boys	Not reported

The reasons for the persistent differences in math and science performance are not clear (Gibbs, 2010). But, whatever the reasons, gender has been identified as an important factor in several studies regarding STEM careers (Betz, 1997; Cross, 2001; Eccles, 1994, 2009; Hanson, 1996; Kimmel et al., 2012; Rosser, 2004; Watt, 2008). In an attempt to explain the math and science gender gap, two hypotheses have been proposed: (a) innate gender differences exist in the mathematical or scientific ability of boys and girls; and (b) social, cultural, or environmental factors may explain the different choices boys and girls make regarding pursuit of science and math (Legewie & DiPrete, 2012). Some researchers (e.g., Ellison & Swanson, 2010; Kimura, 2002; Lohman & Lakin, 2009) claimed that innate differences exist between boys and girls, and these differences can explain why boys outperform girls in math and science. Conversely, other researchers (e.g., Ceci, Williams, & Barnett, 2009; Hoffmann, Gneezy, & List, 2011; Penner, 2008) argued that environmental and social factors explain the math and science differences between boys and girls. Stereotyping and culturally accepted norms may negatively influence the decision made by girls as to whether or not to pursue STEM-related study (Charles & Bradley, 2002; Ridgeway, 2001). Girls expressed a greater interest in jobs that center around people and helping others, whereas boys expressed a greater interest in careers involving physical objects and rewards (Eccles, 2007; Johnson, 2001).

History of Science, Technology, Engineering, and Math Education

Politicians, business leaders, and researchers have argued that for the United States to maintain a global leadership role, the education of young people must be a priority, and students with the interest and ability to pursue STEM-related careers must be encouraged to do so (American Management Association, 1998; Congressional Commission on the Advancement of Women and Minorities in Science Engineering and Technology Development, 2000; Hilton & Lee, 1988; Langdon et al., 2011; Obama, 2011; Subotnik, Tai, Rickoff, & Almarode, 2010). Hilton and Lee (1988) established that in 1972 four times as many high school boys indicated an interest in math, science, and engineering (MSE) majors as did high school girls. By 1982, more girls were expressing interest in MSE careers. Even so, in 1982 twice as many boys expressed an interest in MSE careers as girls (Hilton & Lee, 1988). Although girls enter MSE majors at a lower rate than boys, the persistence level for girls was higher than for boys, with 29% of boys changing majors compared to 14% of the girls changing majors (Hilton & Lee, 1988). In 2008, members of the National Mathematics Advisory Panel (NMAP) conducted an examination of the nation's STEM education in general but specifically focused on mathematics education. The authors of the report concluded:

> During most of the 20th century, the United States possessed peerless mathematical prowess—not just as measured by the depth and number of the mathematical specialists who practiced here but also by the scale and quality of its engineering, science, and financial leadership, and even by the extent of mathematical education in its broad population. But without substantial and sustained changes to its educational system, the United States will relinquish its leadership in the 21st century. (NMAP, 2008, p. xi)

When students are challenged with rigorous curriculum, strong instruction, and peer interaction, they are more likely to pursue STEM-related majors in college (Pyryt, 2000; Subotnik, Duschl, & Selmon, 1993; Tai, Liu, Maltese, & Fan, 2006). A variety of options exist for creating the environment described above, but one approach that has been used since the early 1900s is specialized math and science schools (Subotnik et al., 2010). Talented and interested students apply to and are accepted into schools specializing in STEM education. The schools might be residential schools, schools within schools, or magnet schools (Subotnik et al., 2010). The idea of high schools providing focused instruction in math and science originated at the beginning of the 19th century (Means, Confrey, House, & Bhanot, 2008). Schools originally established as trade schools began to refocus instruction on science and math. Gradually these schools became more exclusive, with students having to complete applications and take exams prior to admittance (Hanford, 1997). The governmental push for specialized math and science schools continued into the 1950s because of the space race and the Cold War as well as the desire of America's leaders to gain technological supremacy over the Soviet Union (Hanford, 1997). Another reason for the creation of specialized math and science schools was school desegregation. Larger school district used these specialized schools to attract or to retain White students by offering special programs with restrictive enrollment (Metz, 2003). The number of STEM schools continued to increase during the latter part of the 20th century but continued to focus mainly on gifted students (Means et al., 2008).

Specialized STEM high schools were one feature of the 2007 America COMPETES Act signed into law by President Bush. The American COMPETES Act (2007) was intended to increase the nation's global competitiveness by providing funding for states to start schools specializing in STEM related fields. However, access to STEM schools is not readily available to all students because not all states have STEM schools and many states have fewer than five specialized schools. Thus, most students continue to be educated in traditional schools (Subotnik, Edmistron, & Rayhack, 2007).

Since the beginning of the 21st century, an understanding has developed among leaders and educators that if the United States is to maintain its position as a world leader more STEM educated citizens are needed, and these students cannot come from a same pool of gifted students (Means et al., 2008). As a result, in 2004, more than 200 STEM education programs received almost three billion dollars from the federal government (Kuenzi, 2008). Among the programs supported with federal money are college scholarships for students majoring in STEM related careers and programs to improve K-12 math and science education (Atkinson, Hugo, Lundgren, Shapiro, & Thomas, 2007; Means et al., 2008). As can be seen in Figure 3, the federal government supported over 250 STEM programs with $3.4 billion in 2011 (Federal Inventory of STEM Education Fast-Track Action Committee, 2011).

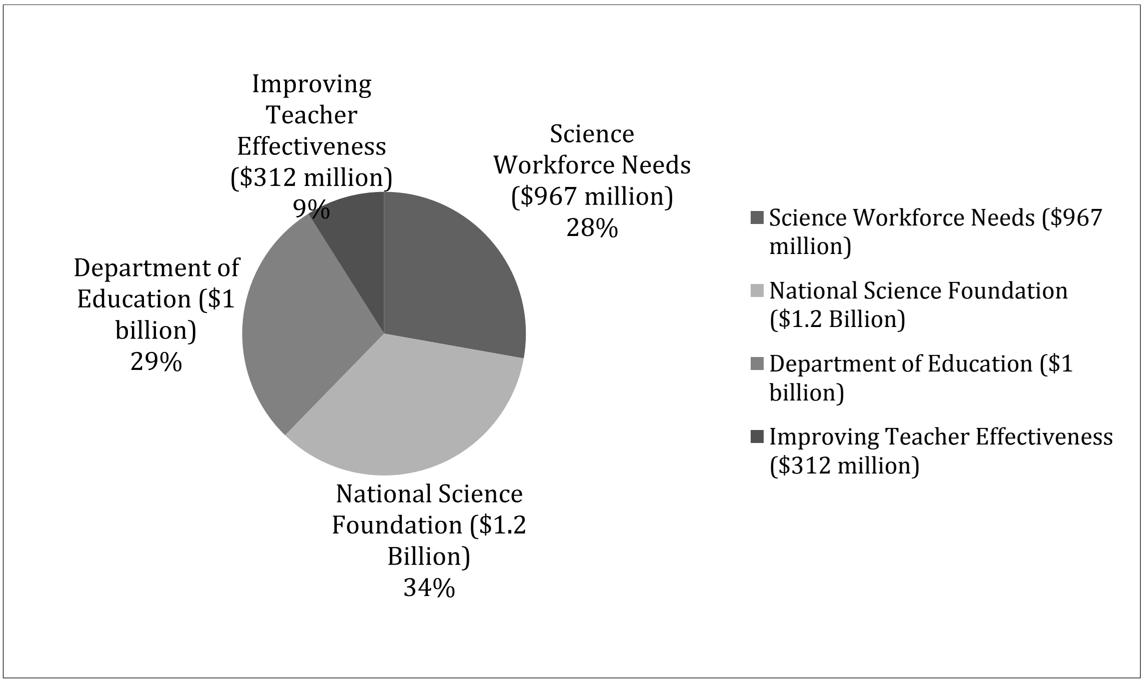

Figure 3. Expenditures of the Federal Government on STEM education programs, 2011. Data were synthesized from the Federal Inventory of STEM Education Fast-Track Action Committee (2011).

Specialized STEM schools alone cannot meet the need for preparing students for further study in STEM related fields and so all high schools must improve their math and science curriculum (Means et al., 2008). Several federal initiatives have been proposed to improve the STEM education for all students (Federal Inventory of STEM Education Fast-Track Action Committee, 2011; Means et al., 2008). The recommendations included in the *American's Competitiveness Initiative* of 2006 are as follows: (a) expand AP and International Baccalaureate (IB) programs, (b) retain mathematicians and scientists to teach in high schools, improve math and science instruction in elementary schools, and develop more rigorous science assessments. Suggested in a second 2006 initiative, *Innovation America*, were to develop and support Best Practices STEM Centers to improve teaching and to solicit proposal requests to develop best practices for STEM education. In 2007, the authors of *Rising Above the Gathering Storm*, recommended the recruitment of 10,000 math and science teachers, additional training in STEM education for current teachers, increase the number of students passing AP and IB tests, and increase the number of students majoring in STEM areas. Conducting a survey of all STEM related federal programs, developing a 5-year strategic plan for STEM education, and creating a Committee on STEM Education were ideas put forth in the *America COMPETES Reauthorization Act* of

2010. (Committee on Prospering in the Global Economy of the 21st Century, 2007; Federal Inventory of STEM Education Fast-Track Action Committee, 2011; Means et al., 2008).

Focused on in the federal initiatives were improving STEM education for all students in secondary high schools. Both the *America's Competitiveness Initiative* and *Rising Above the Gathering Storm* focused on expanding the AP program through increased recruitment of traditionally underrepresented students, teacher training, and improved test scores as a means of improving STEM education in the United States (Means et al., 2008). The College Board (2012) also seeks to increase the number of traditionally underrepresented students participating in the AP program.

History of Advanced Placement

According to the College Board (2003), the AP program is the "premier program advancing educational excellence in secondary schools across the United States" (para. 1). In the 1950s, educators began to search for methods to provide capable students with the opportunity to earn college credit while still in high school following the realization that the gap between high school completion and higher education was widening (College Board, 2003; Dounay, 2006; Nugent & Karnes, 2002). The Ford Foundation established the Fund for the Advancement of Education in an attempt to determine what educational reforms were needed to reduce the duplication of course work between high school and college and to encourage able students to perform up to their capabilities (College Board, 2003). One of the studies funded by the Ford Foundation was led by Chalmers, the president of Kenyon College. The plan, entitled the Kenyon Plan, was designed to improve secondary education by providing students with the opportunity to enroll in challenging coursework while in high school and then to enter college with advanced standing (Kenyon College, 2011). Santoli (2002) stated that in 1952 leading educators from a variety of fields were recruited to design the curriculum and assessments for 11 courses (i.e., English composition, English literature, biology, physics, chemistry, French, Latin, German, Spanish, and history). By 1955, the College Board (2003) began to oversee the program, renaming it the College Board Advanced Placement Program.

The AP program has grown from 11 courses in 1952 to 34 courses in 2011 (College Board, 2003, 2012). More than 4,000 universities and colleges consider students' AP exam scores during the admissions process and offer advanced standing or college credit to students based on the results (College Board, 2011). In 2011, almost 2 million students from over 18,000 high schools took an AP exam (College Board, 2012). Overall, the number of students taking AP exams and scoring 3 or better on AP exams has increased from 2001 to 2011 (College Board, 2012). Present in Table 2 are the number and percentage of students taking AP exams, as well as the number and percentage of students scoring a 3 or better on at least one AP exam during high school.

Table 2 *Number and Percentage of Graduates Taking and Scoring a 3 or Higher on an AP Exam from 2001 to 2011*

Year	Taking an AP Exam	Percentage of Students Taking an AP Exam	Score a 3 or Higher on an AP Exam	Percentage of Students Scoring a 3 or Higher
2001	431,573	16.8	277,507	10.8
2006	645,277	22.3	402,610	13.9
2010	852,475	28.2	508,378	16.8
2011	903,630	30.2	540,619	18.1

Note. Information in Table 4 is synthesized from The College Board (2012).

As can be seen in Table 4, both the number and percentage of students taking AP exams has increased from 2001 to 2011. The number of students taking AP exams more than doubled from 2001 until 2011. Similarly, the number and percentage of students earning a score of 3 or higher has increased for the same time.

Traditional accelerated learning programs for high school students have included AP, IB, and dual credit. Researchers (e.g., Blanco, 2006; Eyring, 2011; Palaich, Blanco, Anderson, Silverstein, & Myers, 2006) argued that accelerated learning programs might increase student readiness for college and may increase enrollment, persistence, and graduation rates. Several researchers (e.g., Ewing, 2006; Geiser & Santelices, 2004; Hargrove, Godin, & Dodd, 2008) suggested that a relationship exists between AP exam performance and college preparedness. Klopfenstein and Thomas (2009) asserted that taking AP courses may predict college success, but warned that a causal relationship between participating in the AP program and college success has not been established. Students with high motivation and ability often enroll in more AP classes, and these students are often successful in college. Klopfenstein and Thomas (2009) predicted that the usefulness of participation in the AP program as a predictor for college success would be reduced as more students with lower abilities begin to take AP courses. Researchers (e.g., Lacy, 2010; Lichten, 2000, 2007, 2010; Sadler, 2010) cautioned against unprepared students taking AP courses and suggested that the reputation of the AP program will be diminished if increasingly larger numbers of unprepared students enroll and are unsuccessful in AP classes.

The College Board (2002) created a policy to encourage access to AP courses for traditionally underrepresented students. The *AP Equity Policy Statement* (College Board, 2002) reads:

The College Board and the Advanced Placement Program encourage teachers, AP Coordinators, and school administrators to make equitable access a guiding principle for their AP programs. The College Board is committed to the principle that all students deserve an opportunity to participate in rigorous and academically challenging courses and programs. All students who are willing to accept the challenge of a rigorous academic curriculum should be considered for admission to AP courses. The Board encourages the elimination of barriers that restrict access to AP courses for students from ethnic, racial, and socioeconomic groups that have been traditionally underrepresented in the AP Program. Schools should make every effort to ensure that their AP classes reflect the diversity of their student population. (p. 2)

Equitable access to AP courses is one of three parts of the College Board's (2012) College Completion Agenda to increase the "percentage of 25- to 34- year-olds who hold an associate degree or higher to 55 percent by 2025" (p. 17). The other two goals of the agenda are increased rigor and increased support of math, science, and technology related courses (College Board, 2012). The National Math and Science Initiatives (NMSI, 2012a) Training and Incentive Program and the National Governors' Association (2007) AP Expansion Project are two programs working with the College Board (2010) to increase enrollment and success for traditionally underserved students.

Together with the College Board, the NMSI created recommendations for improving and supporting STEM education at the school, district, state, and university level. The recommendations developed by the College Board and NMSI include suggestions for improvement at the school, district, state, and national levels. Schools should increase STEM related afterschool activities and clubs, increase the recruitment of traditionally underrepresented groups for STEM activities and AP classes, and increase hands-on learning and application to real-world problems in class. At the district level, grade-weighing policies for pre-AP and AP courses should be implemented, along with vertical teaming for teachers and increased laboratory skills in pre-AP classes. Recommendations for actions at the state level include providing fee subsidies for AP exams, requiring high school seniors to enroll in math and science classes, and rewarding school that increase participation and success of students in STEM related courses. Universities can improve STEM education by actively recruiting students who successfully completed AP exams, encouraging STEM faculty to work with local high schools, and providing inventives for STEM teachers (College Board, 2012). The strategies are included in the *8th Annual Report to the Nation* to support the emphasis on improving STEM education that is one of the three goals of College Board's (2012) College Completion Agenda.

National Math and Science Initiative

The NMSI, a non-profit organization, was founded in 2007 to "to address one of this nation's greatest economic and intellectual threats - the declining number of students who are prepared to take rigorous college courses in math and science and equipped for careers in those fields" (NMSI, 2012a, para. 1). Formed in partial response to the *Raising Above the Gathering Storm* report prepared by the Committee on Prospering in the Global Economy of the 21st Century (2007), the NMSI (2012a) is a public-private partnership funded by private donors such as the Michael and Susan Dell Foundation, the Bill and Melinda Gates Foundation, and Exxon Mobil Corporation. One of the primary goals of the NMSI is to assist with the implementation of the recommendations provided in the *Raising Above the Gathering Storm* report, and thereby, improve elementary and secondary math and science education in the United States (NMSI, 2012a, 2012b, 2012c). According to information provided on the NMSI (2012a) website, the purpose of the organization is to find existing programs that have "proven effectiveness and quantifiable results, and scale them up nationwide" (para. 4). To improve K-12 math and science education, the following actions are recommended: (a) increase the number of effective math and science teachers, (b) continue the training of current math and science teachers, and (c) increase the number of students with the interest and skills needed to pursue STEM careers (NMSI, 2012c).

The Advanced Placement Training and Incentive Program (APTIP) is one of the existing programs supported by the NMSI (2012c). The program, originally started in Texas as Advanced Placement Strategies (APS), was selected by the NMSI to be implemented in six states in 2008 (APS, 2012). Four main components are included in the APS (2012) model to increase student performance on AP tests: (a) improved teacher training, (b) increased student support, (c) incentive program, and (d) program management. The stated mission of APS (2012) is to improve the performance and increase the participation rate on AP exams of traditionally underserved Texas students.

Six states (i.e., Alabama, Arkansas, Connecticut, Kentucky, Massachusetts, and Virginia) were selected for a 5-year grant by the NMSI (2012c) out of the 28 states completing applications for the program. During the 2008-2009 school year, the APTIP program was in 67 public high schools in these six states. By the end of the 2010-2011 school year, 228 schools were utilizing the APTIP program (NMSI, 2012c). For the 2011-2012 school year, 13 states (i.e., Alabama, Arkansas, Colorado, Connecticut, Georgia, Hawaii, Kentucky, Massachusetts, North Carolina, Oklahoma, South Dakota, Texas, and Virginia) participated in the APTIP program. Since 2008, NMSI (2012c) has provided training to over 8,000 teachers who teach pre-AP and AP classes through APTIP.

Between 2008 and 2011, students attending schools in the original cohort participating in the APTIP program had an increase in average passing scores for math and science AP exams of 138%, over five times the national average increase on these scores (NMSI, 2012c). During the same time, the average math and science score increase for girls was 144%. Schools that began the program during the 2010-2011 school year also experienced increased average scores on math and science of 128% for all students and 126% percent for girls (NMSI, 2012c). Present in Figure 4 are the percentage increase in scores of 3 or better on AP exams for the three APTIP cohorts compared to the national average increase in scores of 3 or better.

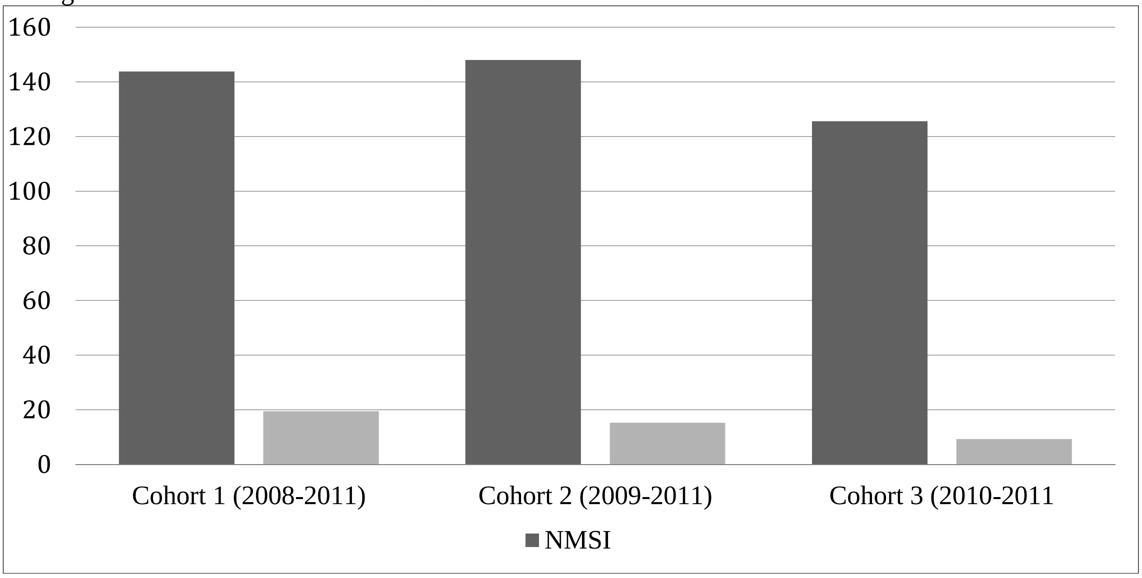

Figure 4. Percentage increase in scores of 3 or better on AP exams by APTIP Cohort. Data were synthesized from the NMSI (2012c).

The 228 high schools participating in the original cohort of the APTIP comprised only a small fraction of the over 23,000 high schools in the United States, but they accounted for almost 7% of the increase in passing scores on AP math, science, and English exams and about 6% of the increase in the passing scores of girls on the AP math and science exams (NMSI, 2012c).

Gender and Advanced Placement Performance

Willingham and Cole (1997) analyzed 1992 and 1993 AP exam data by gender and ethnic groups (i.e., Asian American, Black, Mexican American, other Hispanic, and White). Asian American girls did statistically significantly better than White girls relative to the boys in each group. Otherwise, the difference in performance on AP exams for boys and girls was 0.20 for multiple-choice questions and 0.06 for free response questions, with boys performing better than girls. No effect sizes were reported (Willingham & Cole, 1997). For participation rate, the ratio of girls to boys was close to 1.0 for all groups expect Black students. Even though almost twice as many Black girls took AP exams as Black boys, the relative difference in the performance of Black girls and boys was similar to the relative difference in the other four ethnic groups (Willingham & Cole, 1997). Thus, Willingham and Cole (1997) concluded that differences in exam performance were most likely due to differences in specific content knowledge rather than ethnic group.

Moore and Slate (2008) documented approximately 17% of girls enrolled in AP courses compared to about 13% of boys. Analysis of data from the College Board (2011, 2012) indicated that girls tend to enroll in history, language, and English courses at a higher rate than boys. However, boys tend to enroll in STEM-related courses with the exception of biology, environmental science, and statistics at a higher rate than girls (Amelink, 2009a, 2009b; College Board, 2011, 2012; Moore & Slate, 2008). Displayed in Figure 5 are the percentages of boys and girls taking 2007 AP science exams.

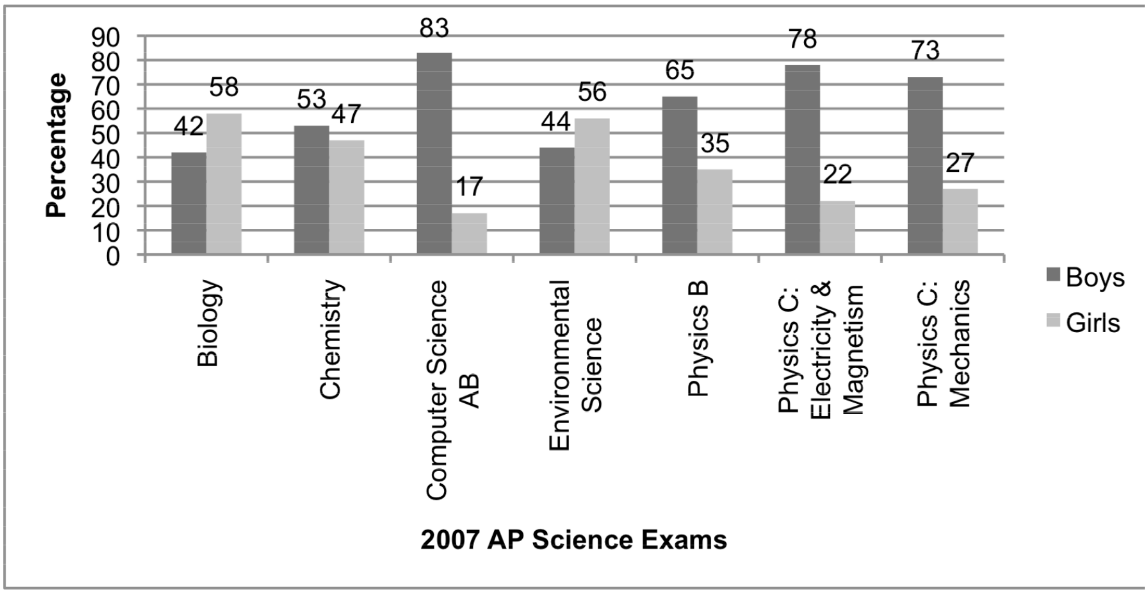

Figure 5. Percentage of boys and girls taking 2007 AP Science exams. Data were synthesized from Amelink (2009b).

As depicted in Figure 5, greater percentages of boys take Computer Sciences AB and all three physics exams than the percentage of girls taking these four exams. Presented in Figure 6 are the percentage of boys and girls taking 2007 AP math exams. A higher percentage of boys take the Calculus BC test, and the same percentage of students take the Statistics test.

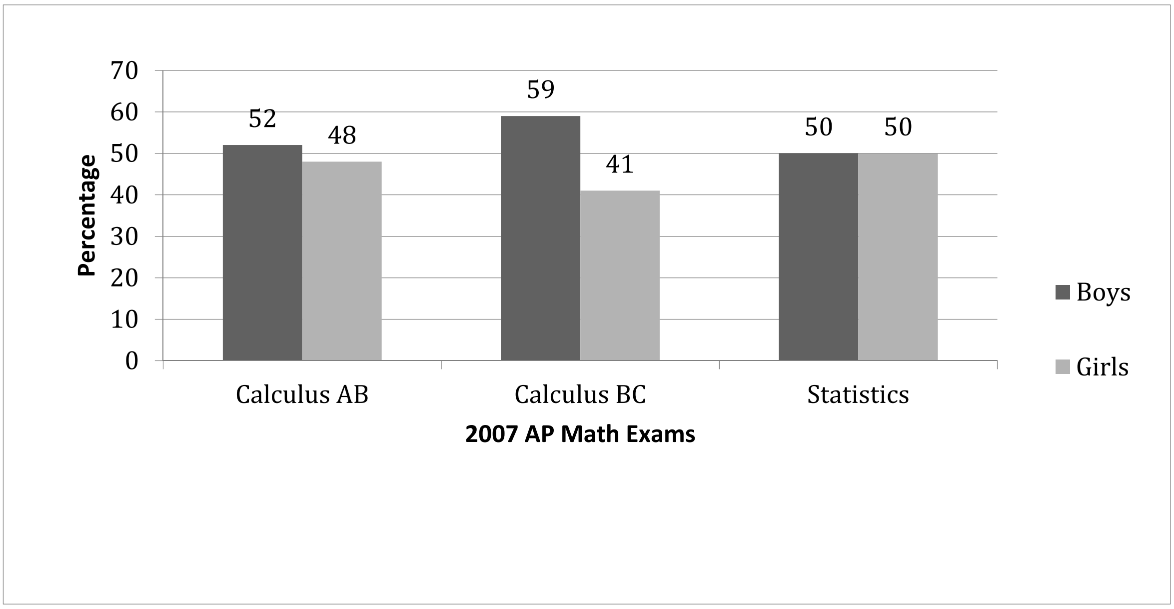

Figure 6. Percentage of boys and girls taking 2007 AP Math exams. Data were synthesized from Amelink (2009a).

In an investigation of performance of Texas students on the 2005 and 2006 AP exams, Moore and Slate (2008) documented a statistically significant difference with a very small effect size (0.08 and 0.11) between boys and girls. Boys scored better than girls both years. Moore, Combs, and Slate (2010) analyzed the performance of boys and girls on the 12 most popular AP exams in 2007 (i.e., English Literature & Composition; U.S. History; English Language & Composition; Calculus AB; Government Politics U.S.; Biology; Psychology; Spanish Language; World History; European History; Statistics; and Chemistry). Moore et al. (2010) concluded that for the May 2007 AP exam administration, boys performed better than girls on 10 of the 12 most popular AP exams. Only on the English Literature and Composition and Spanish Language exams did girls outperform boys. The effect size, Cramer's *V* (ranging from .03 to .15), was small for all analyses conducted (Moore et al., 2010). In their study of gender and AP math performance, Morris and Slate (2012b) documented that boys were more likely to score higher than girls on all three of the AP math exams, the effect size (Cramer's *V*) was small for each of the tests conducted. Boys were more likely to receive a score of 5 on the AP math tests than were girls (Amelink, 2009a). Similar to the math tests, boys had a higher average score than girls on AP science tests and boys were more likely than girls to receive a score of 5 on AP science tests (Amelink, 2009b). Brookhart (2009) asserted that a larger proportion of boys than girls scored 3 or better on the Biology and Calculus AB exams.

Buck, Kostin, and Morgan (2002), analyzed gender differences in scores on the biology test to determine if the format or content of the biology test was biased. Twelve categories that might influence performance were identified, and boys performed better than girls on 11 of the 12 categories. Girls scored better on the free-response questions and on content that was related to people (Buck et al., 2002). Buck et al. (2002) conducted a backwards stepwise multiple regression and determined that eight of the 12 categories (i.e., atmospheric science, experimental apparatus, structure and function relationships, cell division, experimental design, genetics and inheritance, human physiology, and zoology and classification) accounted for 65% of the variance in boys' superior performance on the biology test.

More Hispanic, Black, and American Indian girls participated in the AP program in 2010 than Hispanic, Black, and American Indian boys (College Board, 2011). A small decrease was present in the gap between White and Black students and between White and Hispanic students on mean AP scores and the percentage of students who scored a 5. However, White students tend to outperform Black and Hispanic students on AP exams (Plucker, Burroughs, & Song, 2010).

Moore and Slate (2010) examined gender differences between American Indian boys and girls on the 2007 administration of the AP exams. Overall, boys outperformed girls on AP exams with about 49% of boys scoring a 3 or better compared to only 41% of girls (Moore & Slate, 2010). The effect size for this statistically significant result was small (Cohen, 1988). In the same study, Moore and Slate (2010) determined that no statistically significant difference was present between American Indian boys and girls on the AP Biology exam.

In an analysis of 14 years of AP data, Moore and Slate (2011) concluded that Asian American boys had statistically significantly higher mean scores on AP exams than did Asian American girls for each year studied. The average 2010 AP score for Asian boys was 3.25 and the average 2010 AP score for Asian girls was 3.05. From 1997 until 2010, the average AP scores for Asian boys varied from 3.13 to 3.27. During the same time, the average AP scores for Asian girls ranged from 2.96 to 3.06, dropping below 3.00 for 9 of the 14 years. Displayed in Table 3 is a summary of the research into performance on AP exams as a function of gender.

Table 3 *Summary of Research into Performance on AP Exams as a Function of Gender*

Study	Significant Findings	Gender Favored	Effect Size
Willingham & Cole (1997)	Yes	Boys	Not reported
Moore & Slate (2008)	Yes	Boys	Very small
Moore et al. (2010)	Yes	Boys on 10 of 12 Exams	Small
Moore & Slate (2010)	Yes	Boys	Small
Moore & Slate (2011)	Yes	Boys	Small
Morris & Slate (2012a)	Yes	Boys	Small/Moderate
Morris & Slate (2012b)	Yes	Boys	Small

Plucker et al. (2010) asserted that the focus of the majority of testing in the United States has been meeting minimum standards and that achievement gaps for advanced students is not a priority. Traditionally underrepresented students are less likely to participate and be successful at the most advanced levels (Plucker et al., 2010). As documented in Table 5, several researchers have examined the overall performance of boys and girls on AP exams. However, few multi-year studies in which national data were analyzed have been completed to determine what patterns might be present in STEM related AP exam scores for boys and girls. Because of the large number of students participating in the AP program and in the importance of STEM education to the future of the nation, further study is needed to determine if a gender gap on STEM related AP exam performance exists.

The Economy and Education

Quality education is important to the future of the United States if the nation is to retain its competitive edge in the global economy (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011; Subotnik et al., 2010). To maintain an adequate STEM workforce, more students need to be encouraged to enter into STEM majors (Beede et al, 2011; Carnevale, Smiht, & Strohl, 2010; National Academy of Sciences, 2012). Carnevale and colleagues (2010) predicted a shortage of STEM workers for all 50 states in the future. California is an example of a state that acknowledged STEM shortages. "Despite record unemployment, California employers report being unable to find qualified candidates in science, technology, engineering and math" (California STEM Learning Network, 2012, para. 4).

Recently, the United States has been near the middle of international standings in educational attainment. The United States high school graduation rate for 2003 was 73%, 16th internationally and below the 90% high school graduation rate of several countries (Kirsch, Braun, Yamamoto, & Sum, 2007). In a 2009 analysis of over 60 countries, the United States was ranked 23rd in science and 31st in math (Organisation for Economic Co-operation and Development, 2009). The United States was ranked 12th in the world in the percentage of adults with a college degree in 2010 (Lee & Rawls, 2010). The authors of the STEM Summit 2010 Report (National Academy of Engineering, 2010) argued that the educational system must be reformed to improve math and science education for all students if the nation is to maintain its economic stability.

Careers in STEM related fields are among the highest paying jobs available (Carnevale et al., 2011). Women hold 24% of the STEM degrees awarded, despite receiving over 50% of bachelor's degrees earned (Beede et al., 2011). This disparity may have far reaching implications for women's earning potential and the ability of the United States to remain competitive in the global economy. In general, people holding jobs in STEM related fields earn about 26% more on average and are less likely to be unemployed than people in non-STEM careers (Langdon et al., 2011). Also, people earning STEM degrees tend to earn more than people without STEM degrees even if they do not have a job in a STEM related field (Langdon et al., 2011).

Roughly two thirds of STEM jobs require at least a college degree (Langdon et al., 2011). Thus, the rising cost of college is another hindrance for people seeking STEM degrees. College costs have increased at a rate higher than inflation, for the past 20 years, while state funding for colleges has decreased (U.S. Department of Education, 2006). The State Higher Education Executive Officers reported that:

> state and local support for a full-time-equivalent (FTE) student was $6,532, a $500 constant dollar (or 7 percent) decrease from 2009, and the lowest in the last 25 years. This trend continued in 2011 with state and local support per FTE at $6,290, an additional 3.7 percent decrease. (2012, p. 7)

Displayed in Figure 7 are the costs for tuition, room, and board for full-time undergraduate students for the 2000-2001 to the 2009-2010 school years.

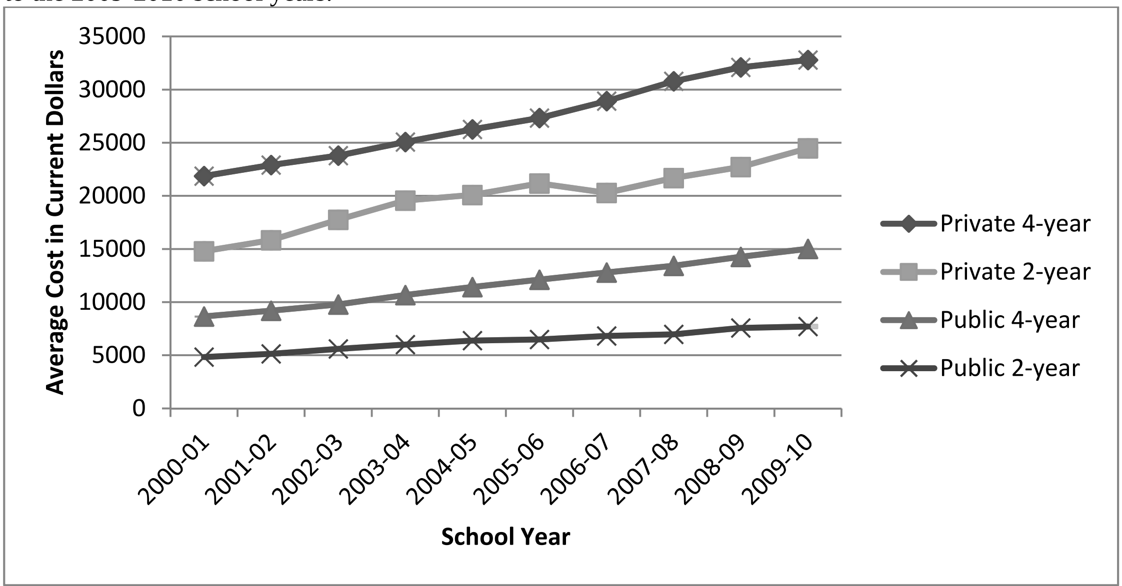

Figure 7. Total tuition, room, and board rates charged for full-time undergraduate students in current dollars by type from 2000-2001 to 2009-2010. Data were synthesized from the U.S. Department of Education, National Center for Education Statistics (2011). *Digest of Education Statistics, 2010* (NCES 2011-015).

Earning college credits while still in high school is one method of reducing the cost of a college degree (Palaich et al., 2006). Dual credit, AP tests, and IB exams are all ways for high school students to earn college credit (Blanco, 2006; Eyring, 2011; Hoffman, 2003; Mattern, Shaw, & Xiong, 2009). Several researchers (e.g., College Board, 2010; Hertberg-Davis, Callahan, & Kyburg, 2006; Robinson, 2003) argued that one of the reasons for the rapid growth of the AP program is that students who successfully complete AP exams are able to earn college credit, and thereby, reduce the cost of their education. However, Klopfenstein (2010) and Moore and Slate (2010) concluded that taking AP classes and passing AP exams does not necessarily increase the chances of an individual graduating early from college. Earning passing scores on AP exams does not guarantee that colleges or universities will grant students credit or advanced standing. Some colleges allow students to take a more advanced course after earning a high score on an AP exam, but do not grant credit toward graduation (Tilsley, 2013).

The AP program continues to be the primary means of providing advanced educational opportunities for secondary students. Inconsistencies in the performance of boys and girls in math and science documented in the literature reviewed in this chapter reveals the importance determining if a gender difference exists in the performance on STEM-related AP exams. Examining gender differences on STEM related AP exams might provide useful information regarding the effectiveness of AP courses and steps that can be taken to improve STEM education in the United States.

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