STEAM EDUCATION IN HIGH SCHOOL AND BEYOND: A QUANTITATIVE INVESTIGATION OF ARTS AND STEM USING THE HIGH SCHOOL LONGITUDINAL STUDY OF 2009

by

Erin R.T. Forbes, M.Ed.

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APPROVED BY

____
Sandra Browning, PhD, Chair

____
Carol Carman, PhD, Committee Member

____
Brenda Weiser, EdD, Committee Member

____
Ann Waltz, EdD, Committee Member

RECEIVED BY THE COLLEGE OF EDUCATION:

____
Joan Pedro, PhD, Associate Dean

____
Mark Shermis, PhD, Dean

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ABSTRACT

STEAM EDUCATION IN HIGH SCHOOL AND BEYOND: A QUANTITATIVE INVESTIGATION OF ARTS AND STEM USING THE HIGH SCHOOL LONGITUDINAL STUDY OF 2009

Erin R.T. Forbes
University of Houston-Clear Lake, 2017

Dissertation Chair: Sandra Browning, PhD

Science, Technology, Engineering, and Mathematics (STEM) plays an important part in the United States and global economy, but students are not persisting in STEM careers, often opting out of higher level STEM studies. Education policies and programs have witnessed an increased interest in integrating arts into STEM programs with some districts and educational institutions creating STEAM (science, technology, engineering, arts, and mathematics) programs. These programs are developed with the premise that students with creative aptitude should be engaged in STEM to boost creative thinking and problem solving in STEM fields. STEAM education is a relatively new field to education and no research links students with arts preference and their persistence into STEM after high school. This quantitative study seeks to address this gap in research utilizing data from the High School Longitudinal Study of 2009 (HSLS:09) to determine the STEM perceptions of students with preference for arts or STEM courses and also determine their persistence in STEM after high school. Data from HSLS:09 was selected due to the large and representative sample as results of the study could be generalized to students in the United States.

Surveys, a mathematic assessment, and transcript data from HSLS:09 were analyzed using correlation and multiple regression analyses. Results show that student favorite subject in ninth grade (mathematics, science, art, music, or computer science) yielded weak correlations with students' perception of STEM. Additionally, students' favorite subject in high school proved to be a poor predictor of most STEM persistence variables. This raises the question of why students' preference for mathematics and science is not a stronger predictor of STEM persistence and hints at a leaky STEM pipeline from high school into college. Additionally, art and music often negatively correlated to STEM preference variables illustrating the lack of student efficacy and interest in STEM. This study serves as an illustration of the status quo in STEM and arts inclined students and STEM perceptions as well as STEM longevity.

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INTRODUCTION

Introduction

In a 2011 speech at the signing of the America Invents Act, President Barack Obama highlighted the recent educational focus to improve Science, Technology, Engineering, and Mathematics (STEM) education by stating “to help this country compete for new jobs and businesses, we also need to invest in basic research and technology, so the great ideas of the future will be born in our labs and in classrooms” (Office of the Press Secretary, 2011, n.p.). The president emphasized that America should be more innovative than other countries and continue to be a leader in the global economy. Over the last decade, STEM employment grew nearly three times faster than non-STEM jobs and STEM employment is expected to continue to grow at a rate twice that of non-STEM employment (Langdon, McKittrick, Beede, Khan, & Doms, 2011). With pressure from the global market to stay competitive, there is a growing concern that American students are not persisting in STEM fields and are opting out of higher-level mathematics and science courses because they are too rigorous or students lack interest in the field (Sanders, 2009).

Though many researchers agree with the need to increase STEM education (Bybee, 2007; Gonzalez & Kuenzi, 2012; LaMore et al., 2013; Langdon et al., 2011; Sanders, 2009), STEM initiatives across the country vary greatly in design and in purpose. In 2012, Gonzalez and Kuenzi wrote a report for Congress detailing the state of STEM education and current legislation supporting these types of programs. The researchers found that different governmentally funded initiatives define STEM differently, and STEM efforts are difficult to distinguish from traditional mathematics or science programs. Further, the primary objective of STEM education projects and programs varies widely. A majority of government funded STEM education programs stress degree attainment and career development for college students, but only one in five programs focus on learning and engagement in STEM education. The most alarming contents of the report highlight achievement gaps for minority students. White males historically occupy a majority of STEM careers. A need exists to increase female and minority success in STEM fields. The authors state that some of the possible ways to increase minority successes are “early exposure to STEM fields, interest in STEM careers, [and] self-efficacy in STEM subjects” (Gonzalez & Kuenzi, 2012, p. 24).

Need for the Study

Current means of identifying students for targeted STEM programs include aptitude for science or mathematics but often overlook aptitude for art or spatial/visual ability. According to Kerr and McKay (2013), spatial ability is a key trait demonstrated by adolescents who excel in STEM. However, spatial and visual ability is commonly considered to be artistic ability and is overlooked as STEM potential (Kerr & McKay, 2013). In addition to spatial ability, some feel art can be the missing link for sparking creativity, critical thinking, and hands-on expression. In a study conducted by LaMore et al. (2013), STEM professionals recognized that art skills are “critical to developing their professional problem-solving ability” (p. 228). Root-Bernstein and Root-Bernstein (2013) suggest we must challenge students to think creatively and critically on authentic tasks. Nobel Prize laureates in science fields were found to be 15 to 25 times more likely to have engaged in the arts than average scientists. The authors also argued that fine arts foster four key skills which allow for creative and innovative scientific discoveries: observation, visual thinking, recognizing and forming patterns, and manipulative ability. Invention, engineering, and scientific endeavors require the ability to imagine and create new possibilities (Root-Bernstein and Root-Bernstein, 2013).

Educators, STEM professionals, and some lawmakers have begun to support integrating the arts into STEM (known by the acronym STEAM with A standing for arts) and believe STEAM education can provide the creative piece missing from STEM instruction (Boy, 2013; Delaney, 2015). STEAM education programs, STEAM education centers, and STEAM initiatives have emerged all over the country including STEAM being taught in a reoccurring segment on the 43rd season of Sesame Street, in which music was used to discuss mathematical concepts and included links to a STEAM curriculum page for parents (Maeda, 2012; Stemtosteam.org, 2015; Sesame Street Workshop, 2015). Increased U.S. government attention on the STEAM movement has led to the creation of the congressional STEAM caucus in 2013 ("On Capitol Hill", 2014). The influence of the STEAM caucus can be seen in recent political moves such as arts integration into STEM courses being added as an amendment to the Elementary and Secondary Education Act (ESSA) (Zubrzycki, 2015). However, while there is increasing attention to the STEAM movement, there is still a need to research into links between students with artistic talents and their STEM success.

In a recent study using a sample of roughly 2,000 high school students, Forbes, Murray, Oliver, and Riggs (2014) sought to determine if any relationship existed between fine arts-enrolled students and their participation and achievement in Advanced Placement (AP) STEM subject courses. No relationship was found between fine arts involvement and achievement on AP exams in STEM subjects in high school. Additionally, no relationship was found between student involvement in fine arts art and electing to take upper-level STEM courses. Though the sample size was adequate, there was only a small percentage of students in the sample who elected to take AP STEM courses. Even with this limitation, the results of the study raise questions regarding arts students and their current involvement in STEM education. There is a need for research regarding how arts-inclined students feel about STEM, their self-efficacy levels in STEM, and whether, in the current education system, they persist in STEM into college-level classes and in postsecondary education.

Purpose of the Study

There is currently no published research to determine if arts-inclined students enter STEM jobs or majors. The purpose of this study is to utilize longitudinal data to quantify the relationship between ninth grade student preference for arts or science, mathematics, or technology and student perceptions of science and mathematics. This study also seeks to determine if student preference for arts or STEM-related courses in the ninth grade is a predictor of student involvement in college credit science and mathematics courses, students registering for college, and determine if it is a predictor of students choosing a STEM field of study in college or obtaining a postsecondary job in a STEM field.

Constitutive Definitions

STEM

The acronym STEM references science, technology, engineering, and mathematics though there is no agreed upon comprehensive standard as to which jobs and fields of study fall into this category. STEM fields of study include "computer science and mathematics, engineering, and life and physical sciences" (Langdon et al., 2011, p. 2). In education, STEM often references classes in which science, technology, engineering, and mathematics are woven together into integrated fields of study (Sanders, 2009).

STEAM

The acronym STEAM stands for science, technology, engineering, arts and mathematics and references a curriculum model which emphasizes the integration of arts, design, and creative artistic problem solving into STEM disciplines (Kim & Song, 2013).

Fine Arts

Fine Arts is an umbrella term for classes such as visual art, art history, music, orchestra, band, choir, music theory, music history, drama or theater, theater production, and dance (Eccles & Barber, 1999). The terms "fine arts" and "arts" are often used interchangeably and in the STEAM movement, arts and fine arts typically include visual arts, music, orchestra, band, choir, drama or theater, and dance.

Identity

Identity can be defined as a sense of self and in adolescents is closely tied to social and peer group identification. An adolescent's personal identity is often formulated through voluntary participation in activities in which the adolescent explores their sense of self as it pertains to "one's talents, values, interests, and place in the social structure" (Barber, Eccles, & Stone, 2001, p. 431). Science or mathematics identity can be defined as a person feeling confident in the subject, feeling they have the requisite skills to master the subject, and recognizes themselves or others recognize them as a "science person" or "math person" respectively (Carlone & Johnson, 2007).

Self-efficacy

One's belief in their ability to do certain tasks. In this study, self-efficacy refers to a student's confidence in their ability to do science or mathematics related tasks. Self-efficacy differs from identity as it is entirely internal and does not relate to social views of the individual or how others view the individual's abilities (Wagstaff, 2014).

Utility

Utility is defined as being useful or worthwhile to reach some end (Meriam-Webster.com, 2015). As it relates to science or mathematics, utility can be defined as the perception that science or mathematics will be useful to the student in the future (Andersen & Ward, 2014).

Interest

Interest is defined as wanting to know more about a subject, gaining enjoyment out of learning about a topic, or wanting to be involved in some endeavor (Meriam-Webster.com, 2015).

Persistence

Persistence is to "continue firmly or obstinately in a state, opinion, purpose, or course of action, [especially] despite opposition, setback, or failure" (OED Online, 2015). Persistence in STEM can, therefore, be defined as continuing in a STEM field despite obstacles.

Research Questions

This study seeks to answer the following research questions:

Research question one

What are the relationships between student preference for science, technology, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic interest, science identity, science utility, science self-efficacy, and science interest?

Research question two

Which student subject preference in ninth grade (science, technology, mathematics, art, or music) has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors?

CHAPTER II

REVIEW OF RELATED LITERATURE

In the previous chapter, the current status of science, technology, engineering, and mathematics (STEM) education and professions were discussed including concerns expressed by researchers and educators that interest in STEM fields wanes in the later years of K-12 schooling. Some researchers propose identifying students with Fine Arts inclinations and supporting them to pursue STEM should be the focus of K-12 STEM initiatives. These concepts are explored in this chapter.

STEM Education

Science, technology, engineering, and mathematics (STEM) courses can be taught in isolation or as an integrated program with the subjects interwoven together. Though many researchers agree with the need to increase STEM education (Bybee, 2007; Gonzalez & Kuenzi, 2012; LaMore et al., 2013; Langdon et al., 2011; Sanders, 2009), secondary schools struggle to maintain student interest in the field (Byrne, Brodie, & Price, 2011; Carlone & Johnson, 2007). In an analysis of two of their qualitative studies, Bevins, Byrne, Brodie, and Price (2011) found that, overall, students expressed enjoyment from science classes but felt that science classes did not hold relevance to their everyday life. Additional findings of the study included: students struggle the most in physics; males are more attracted to science than females; students express that there is no practical application for science; and interest in science declines in the later primary school years through high school. They also found that a majority of the students surveyed did not plan to pursue a STEM-related field after the age of 18 (Bevins, Byrne, Brodie, & Price, 2011). Another explanation offered for students not persisting in STEM in the United States, specifically as it relates to females and people of color, is that they lack science identity and do not recognize themselves as a science person (Carlone & Johnson, 2007). When one does not confidently identify as a science person they may not pursue it as a field of study in college and beyond (Carlone & Johnson, 2007).

Wieman (2012) suggested the approach to student learning as the major problem with current STEM education. He believes students are still being taught in a teacher-centered manner without collaboration or hands-on experimentation, and he feels only the students with the most interest and aptitude toward STEM will benefit from teacher-centered STEM instruction. Students without STEM interest are not engaged by such lesson delivery styles. Additionally, he states that this method is contrary to current brain research which supports teaching students to *think*, not *absorb* (Weiman, 2012). Weiman (2012) argues that the focus of STEM education should be teaching in a manner that engages all learners, not just those with STEM aptitude, in using complex reasoning and problem solving across STEM disciplines. Students need to learn how to solve problems the way an expert in the field would by "making decisions in the presence of limited information" (p. 27).

Some feel changes made to instructional practices in STEM programs will improve STEM education and avoid problems that STEM programming has had in the past. It is argued that STEM is too often taught in a nonintegrated, disconnected manner which heavily emphasizes only mathematics and science. (Atkinson & Mayo, 2010; Sanders, 2009). Sanders (2009) emphasizes that STEM subjects should be truly integrated with one another and teach science, mathematics, engineering, and technology skills concurrently to have a positive impact on the United States' future economic success in STEM fields.

Research of STEM programming conducted at an urban, majority African American high school illustrates this integrated instructional approach. Duran and Şendağ

(2012) studied the critical thinking skills of students entering a magnet STEM program and compared students in the magnet program to the general population. The structure of the STEM program at this high school was, as Weiman (2012) recommends, inquiry-based with collaborative, hands-on lessons that provided authentic STEM learning opportunities. Results of the study showed students completing the program had higher gains in inductive reasoning and inference skills than the national sample. The implications of this study are that a STEM program structured in a student-centered, inquiry-based manner has the potential to increase student's critical thinking skills.

Some question the need to teach STEM to all students and believe STEM should be taught to the students most likely to become STEM professionals. It is argued that exposing all students to STEM is inefficient as only a few students exposed to STEM education will complete the program or become STEM professionals (Duran & Şendağ 2012). Additionally, many current STEM initiatives spread monetary resources thin by teaching all students some level of STEM whereas Atkinson and Mayo (2010) argue it would be more efficient to hone in on those with aptitude and interest in the subject and give those students an authentic and thorough STEM education.

With some suggesting a focus on STEM educational efforts on students with interest and ability in mathematics and science, there is need to examine how high ability students feel about STEM currently. In a 2014 study utilizing the High School Longitudinal Study of 2009, Andersen and Ward identified ninth grade students within the 90th percentile in algebraic reasoning in Black, Hispanic, and White ethnicity groups respectively. Within this sample, the researchers set out to determine what variables are predictors of student plans to persist in a STEM field. Interestingly, researchers found that, amongst the algebraically high achieving students, students' plans to persist in STEM were not predicted by socioeconomic status or gender. The authors noted the underrepresentation of women in STEM professions, but the lack of significance of gender as a predictor of STEM persistence plans implies that something happens to discourage women with high mathematics ability from persisting in STEM after ninth grade. In addition, the authors found intrinsic value – having the intrinsic motivation to seek knowledge for knowledge's sake – was significantly higher in the White high ability group than the Hispanic and Black groups. They also found that identifying as a science person as a significant predictor of STEM persistence plans for White, Black, and Hispanic student groups, but STEM utility was only significant in the Hispanic student group. This suggests that Hispanic students place more value than other ethnicity groups on "practical concerns of college and career" (p. 236) over enjoying STEM courses. Andersen and Ward (2014) found that students identifying as a mathematics or science person (attainment value) as part of their identity positively and significantly predicted persistence in STEM in all three race/ethnicity groups. With attainment value significant for all groups, the study suggests that students' perceptions of STEM as part of their identity are key to students' persistence in STEM. As a result, Andersen and Ward suggest there is a need to develop STEM identity. The authors suggest that elementary-level and middle-level schools should focus on inspiring students in STEM and locating students with STEM talent.

In another study utilizing the High School Longitudinal Study of 2009, Wagstaff (2014) found that, overall, a student identifying them self as a "science person" and having science identity was a predictor for both the student's confidence in their science ability (science self-efficacy) and their intent to pursue STEM in as a career. However, contradictory results were found for African American students. Although being African American was a predictor of having science self-efficacy, it was also a negative predictor of intent to persist in STEM. Wagstaff found gender to have a negative relationship with science self-efficacy and intent to persist in STEM which contradicts Andersen and Ward's (2014) findings that gender was not significant. The key difference between the two studies is that Anderson and Ward sampled the top mathematics ability in each of their chosen demographics whereas Wagstaff did not use mathematics ability as a grouping variable. Between the two studies, HSLS:09 data show that gender is not significant amongst high mathematics ability ninth graders but is significant amongst the general sample of ninth grade students. Additional findings from Wagstaff's study included that attending an urban school was a predictor of intent to pursue STEM as a career (presumably because they have access to more science and mathematics resources); school level variables such as offering Advanced Placement (AP) courses, being a STEM magnet school, and having a high number of teachers with science and mathematics backgrounds predicted student intent to enter a STEM career; and parental confidence in helping their student with science homework predicted science self-efficacy in students. These additional findings point to areas in which a school could focus to encourage students to persist in STEM fields.

Benefits of Arts Involvement

Student involvement in arts has been found to have positive correlations to academics. Eccles and Barber (1999) administered interviews and surveys and collected school data such as course enrollment, grades, attendance, and behavior referrals of high school students. They found that students involved in performing arts were less frequently engaged in risky behavior, enjoyed school, maintained higher than average GPAs, and had a greater likelihood of attending college and being enrolled at age 21. Similar results were found for students in school-involvement activities. These students reported they like school, had a better than average GPA and a "greater than expected likelihood of attending college at 21" (Eccles & Barber, 1999, p. 25). Students involved in extracurricular activities (including arts) for a longer duration also were found to have positive peer groups and relationships and less likely to interact with peers involved in risky or negative behavior (Fredricks & Eccles, 2006).

Additional researched academic benefits to arts involvement include higher achievement on college readiness exams like the SAT (Vaughn & Winner, 2000). SAT data shows an established correlation between taking fine arts for any amount of time and academic achievement in verbal, mathematics, and overall composite SAT scores (Vaughn & Winner, 2000). However, students who took four years of a fine art scored significantly higher than those who took less than four years of fine art. Acting classes were associated with the highest verbal and mathematics scores, followed by music (Vaughn & Winner, 2000).

Studies show that involvement with music specifically is linked to higher academic achievement (Yoon, 2000; Johnson, 2000), higher SAT scores (Johnson, 2000), and an increase in time spent developing critical thinking skills (Duran & Sendag, 2012). Involvement in music enhances spatial reasoning in elementary age students and producing music uses "at least six of the intelligences by Howard Gardner…musical, visual-spatial, bodily-kinesthetic, logical/mathematics, interpersonal, and intrapersonal" (Hetland, 2000, p. 181). Additionally, participation in visual arts programs leads to higher scores across all subject areas; some districts report up to a 20% improvement in achievement for students involved in fine arts programs (Walker, Tabone, & Weltsek, 2009; Respress & Lutfi, 2006).

Brain research also cites academic benefits for students involved in arts (Hardiman, Magsamen, McKhann, & Eilber, 2009). At a conference hosted by Johns Hopkins University, research on neuroscience as it relates to arts-involved students was presented and the implications of these research endeavors were discussed as they relate to education. Arts participation amongst students was found to increase the ability to attend to tasks and focus, long-term memory, and participation in dance supports "the organization of complex actions…[which] may transfer to other cognitive skills" (Hardiman, Magsamen, McKhann, & Eilber, 2009, p.14). Additionally, researchers found that "music training is tightly correlated with phonological awareness—the ability to differentiate and manipulate speech sounds—which is the major predictor of reading fluency" (Hardiman, Magsamen, McKhann, & Eilber, 2009, p. 6). Researchers also found that using arts to reinforce core subject content encourages students to manipulate key concepts of the subjects creatively (Hardiman, Magsamen, McKhann, & Eilber, 2009).

Integrating arts into core subjects, as opposed to art being taught in isolation, promotes academic achievement in core subjects through problem solving and increases skills in both the art and core subject (Chappell & Cahnmann-Taylor, 2013). Arts integration helps students visualize their learning and helps students develop metacognitive awareness of their learning processes (Burnaford, 2001). Furthermore, there is strong evidence that supports a positive relationship between drama integration and verbal skills; dramatization helps students master skills required for tests and enhances understanding of new texts (Podlozny, 2000).

In recent years, pressure from the No Child Left Behind (NCLB) act has led some schools to increasingly place arts subservient to tested courses in effort to close the achievement gap (Chappell & Cahmann-Taylor, 2013; Mishook & Kornhaber, 2006). Chappell and Cahmann-Taylor found that youth engagement in fine arts has dropped since the 1980s. This decrease was more profound in minority populations than in White populations: White youth were nearly twice as likely to be involved in fine arts as African American or Hispanic youth (Chappell & Cahmann-Taylor, 2013). Limited access to arts disproportionately affects marginalized youth as they tend to be segregated into schools and communities with limited budgets and highly controlled curriculum (Chappell & Cahmann-Taylor, 2013). The devaluing of arts was found to be cyclical which is fueled by a fear-based reaction of losing accreditation. Mishook and Kornhaber (2006) established that leaders at schools with low socioeconomic status (SES) are more likely to place arts subservient to core subjects. Subsequently, schools that placed arts as a lesser focus had lower scores on high stakes tests (Mishook & Kornhaber, 2006).

Though NCLB and pressure to increase standardized test achievement sometimes leads administrators to eliminate fine arts to focus on core tested subjects (such as mathematics and English language arts), it has been found that increasing students' involvement in art helps marginalized students academically. Chappell and Cahmann-Taylor (2013) found that the arts have a unique way of promoting problem solving, seeing relationships and finding patterns, creating, judging, and meaning making. Specifically, the authors stated that the benefits of integration go both ways: integrating arts into core subjects increases not only critical thinking in the core subject but promotes critical thinking in the arts as well. Finally, the authors concluded that the arts help marginalized students with self-expression and empowered students with tools to critique social justice.

Catterall, Dumais, and Hampdon-Thompson (2012) analyzed students' levels of involvement in arts in four longitudinal data sets to determine the benefits of arts to student overall as well as to students with low socioeconomic status (SES). Student participants in this study were given a scale score from no arts involvement to high arts involvement based on their frequency and level of engagement in arts. The researchers found that adults with high arts involvement are more likely to obtain employment in which a bachelor's degree is required when compared to students who were not involved in arts. They also found that "intensive arts involvement was found to correlate strongly with higher academic achievement— a clear precursor of many higher-paying, professionally rewarding jobs" (p. 23). Students with no fine arts involvement were found to be five times more likely to not graduate from high school than those with high arts involvement (Catterall, Dumais, & Hampdon-Thompson, 2012). It was concluded that at-risk students with high-arts involvement academically achieve closer to non-at-risk students when compared to at-risk students with low involvement in arts. This led the authors to conclude that arts involvement can help close the achievement gap. However, they noted that the relationship between arts involvement and achievement is only seen in at-risk students, not high SES students; however, both at-risk and high SES students saw an increase in civic engagement when highly involved in arts. Among students with low socioeconomic status, high arts involvement was found to have a positive relationship to grades, college attendance, high-level mathematics enrollment, and college degree attainment. Furthermore, among low SES students, high arts involved students were twice as likely as low arts involved students to major in a degree which "aligns with preparation for a professional career" (Catterall, Dumais, & Hampdon-Thompson, 2012, p. 22).

Linking Arts and STEM

As STEM programs gain popularity and funding, across the country arts programs struggle for funding as they are viewed as not core and thus expendable when budgets tighten. Williams (2011) stated that the emphasis on science and mathematics leaves little room for social sciences and arts. In an effort to keep their discipline relevant, many arts educators have begun advocating adding arts into STEM, creating what is known as STEAM (Bequette & Bequette, 2012; Stemtosteam.org, 2015; Root-Bernstein and Root-Bernstein , 2013; Gershon and Ben-Horin, 2014; Conley, Trinkley, & Douglass, 2014; Kim & Song, 2013). The creative and critical thinking skills developed in art are linked to STEM success. Root-Bernstein and Root-Bernstein (2013) found that Nobel Prize winners in the area of science were 15 to 25 times more likely to have engaged in the arts than average scientists. They argued the arts foster four key skills which allow for creative and innovative scientific discoveries: observation, visual thinking, recognizing and forming patterns, and manipulative ability. Bequette and Bequette (2012) called these thinking dispositions “habits of mind” (p. 44) and emphasized that arts develop encourage students and professionals to "attend to relationships, engage and persist, remain flexible, shift direction, imagine possibilities, and express ideas, feelings, or personal meaning" (p.44) all of which they note as important in STEM problem solving.

According to Hadzigeorgiou, Fokialis, and Kabouropoulou (2012), both scientists and science educators express the belief that science and creativity are linked. The authors reviewed research exploring creativity in science and acknowledged that, in the moment of creating, both scientists and artists are engaged in the same imaginative process. They state that, in general, artistic and scientific creativity fall into different categories of creativity: artistic creativity is often spontaneous and emotional while scientific creativity requires sustained focus on a cognitive task. Art also teaches students to appreciate aesthetics. An appreciation of aesthetic notions like beauty and wonder is essential to scientific creativity since it helps people to “see things in novel or unusual ways” (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012, p. 607).

A further study seeking to understand the link between artistic creativity and scientific creativity in a magnet engineering public high school found that there was no statistically significant difference in student perception of creativity of artist and engineers (Harlow, Nylund-Gibson, Iveland, & Taylor, 2013). In this study, students were asked to draw and describe an engineer and draw and describe an artist as part of the qualitative study. The drawings and short answers were coded and then statistically analyzed. Results of the study revealed three models for engineers based on student perception: engineer as a logical thinker, engineer as a creative thinker, and engineer as “people who maintain things” (Harlow, Nylund-Gibson, Iveland, & Taylor, 2013, p. 320) with students as logical thinker representing the largest group. Art was viewed in two ways: expressing emotion and physical product (Harlow, Nylund-Gibson, Iveland, & Taylor, 2013).

Kerr and McKay (2013) pinpoint the need to identify creative students with STEM aptitude as creativity in STEM leads to innovation. In their study, it was found that a significant number of creative students were not identified for gifted programs. This was due to a flaw in the identification process. Current means of identifying students for STEM aptitude identify science or mathematics inclined students but often overlook aptitude for art, visual, and spatial ability. The authors argue there is a need for a better means of identifying STEM inclined students and this should include spatially, artistically talented students.

Ultimately, the skills developed in participation in the arts lead to higher-levels of creative development in adults. LaMore et al. (2013) surveyed Michigan State University Honors College science and technology graduates about their experience with arts and crafts. When comparing the STEM majors to the general public, STEM majors had a higher percentage of exposure to arts in their lifetime. A significant 93% of STEM majors were exposed to music lessons at some point in their life. Also, adult participation in arts and crafts by STEM majors was dependent on exposure to arts and crafts as a child, indicating that early childhood arts exposure is important to sustained arts involvement. Innovation and creative capital (founding companies and obtaining product patents) were found to be significantly correlated to arts involvement. The authors conclude that cutting arts programs in schools have possible negative implications for our economy and suggest students' early exposure to the arts "may be an essential component to their creative capital potential" (p. 227).

STEAM Education in Practice

Proponents of STEAM education state it is important to integration of arts into STEM. Richard and Triechel (2013) argue STEM arts integration must encourage teachers to communicate, to collaborate, and to co-teach to authentically combine the art and STEM subject. This integration of arts into STEM in both research and educational programs can be seen in various locations across the United States (Stemtosteam.org, 2015). In a map of STEAM initiatives by regions in the United States, Stemtosteam.org (2015) reports integration of arts and design into STEM education and research in companies and institutions such as Texas Instruments, Sesame Street, Reading is Fundamental, Boeing, Kohler Co., Intel, Apple Inc., and Crayola. Furthermore, STEAM educational programs have been created by Texas Instruments, Drew Charter School in Georgia, the Art Institute of Chicago, and High Tech High in California (Stemtosteam.org, 2015).

STEAM education was utilized by the Columbus Museum of Art to instruct pre-service mathematics teachers on utilizing works of art to teach mathematic inquiry lessons. Researchers found that this arts-based model supported students' ability to dialogue about the problem-solving process, increased students' ability to identify multiple processes to solve mathematical problems, and supported abstract mathematical thinking (Conley, Trinkley, & Douglass, 2014). In a study of educational projects which integrated music creating into inquiry-based science lessons, Gershon and Ben-Horin (2014) reported that the creative process of music creation and science inquiry overlap. They concluded that integrated music and science lessons make science more engaging and scientific creative thinking a more spontaneous process for students.

The STEAM movement is not isolated to the United States. In Korea, researchers integrated visual arts into a computer science educational program for elementary school scientifically gifted and talented (GT) students (Kim & Song, 2013). The researchers measured student perceptions of 148 GT students before and after a summer camp program in which they used visual programming to build computer games. They found students preferred STEAM based computer science programs to non-arts-integrated computer science programs. The STEAM program significantly and positively affected female students' perceptions of computer science careers. The researchers concluded that STEAM based computer science education should be utilized in elementary education settings to open opportunities for young students to pursue computer science (Kim & Song, 2013).

Gap in the Research

The research outlined above provides evidence that arts increase key STEM skills such as critical thinking skills, problem solving, and achievement (LaMore et al., 2013; Root-Bernstein & Root-Bernstein, 2011; Duran & Sendag, 2012; Chappell & Cahmann-Taylor, 2013; Catterall, Dumais, & Hampdon-Thompson, 2012; Bequette & Bequette, 2012; Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Conley, Trinkley, & Douglass, 2014; Gershon and Ben-Horin, 2014). In addition, some studies have found that integrating arts into STEM in the form of STEAM curriculum have positive outcomes for students (Gershon and Ben-Horin, 2014; Conley, Trinkley, & Douglass, 2014; Kim & Song, 2013). However, there are holes in the research concerning arts students and their STEM goals and perceptions. There are currently no published large-scale studies of the relationship between students who prefer arts or STEM and how they view their STEM abilities.

In addition, some studies such as LaMore, et al. (2013) and Root-Bernstein and Root-Bernstien (2011) have measured success in artistic STEM professionals, but little has been done to measure student preference for arts or STEM subjects and their relationship to persistence in STEM from the K-12 setting into adulthood. With the increasing educational interest in art integrated STEM classrooms, it is necessary to determine if student preference for arts or STEM subjects in the K-12 setting can predict persistence in STEM fields.

Research Questions

This study seeks to answer the following research questions:

Research question one

What are the relationships between student preference for science, technology, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic interest, science identity, science utility, science self-efficacy, and science course interest?

Research question two

Which student subject preference in ninth grade (science, technology, mathematics, art, or music) has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors?

Hypotheses

Based on the review of literature and the research questions, the following hypotheses were formulated:

Hypothesis one

There is a relationship between student preference for science, technology, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest.

Hypothesis two

Student preference for mathematics has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors.

CHAPTER III

METHODOLOGY

In the previous chapter, current research in science, technology, engineering, and mathematics (STEM) education, arts education, and integration of arts into STEM (known as STEAM) was discussed. A gap in research exists in the field of STEAM education as there are no published studies which investigate the preferences for and persistence in STEM subjects among arts inclined students. The following two hypotheses were developed:

Hypothesis one: There is a relationship between student preference for science, technology, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest.

Hypothesis two: Student preference for mathematics has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors.

The following chapter outlines the methodology that was designed to test these hypotheses.

Population and Sample

Population

The High School Longitudinal Study of 2009 (HSLS:09) identified students to be sampled in the United States in a two-stage sample process: identification of schools followed by identification of student participants. The initial step in the sample process utilized a stratified random sample to identify eligible schools. Stratification variables included first, school type (public, private –catholic, private –other); second, region in the United States (Northeast, Midwest, South, or West); and third, locale (city, suburban, town, or rural) (Ingles, et al., 2011). A representative sample of 1,889 schools was identified and 944 schools participated. Within the 944 schools, enrolled 9th grade students were randomly sampled for a total of 25,206 selected students, 548 of which were ineligible due to language barriers or severe disabilities (Ingels, Dalton, Holder, Lauff, & Burns, 2011b). In total, "24,658 students were classified as questionnaire-capable" (Ingles, et al., 2011b, p. vi). The nature of the selection process in HSLS:09 created a sample of students with representativeness which will allow results of studies using the dataset to be generalized to students in the United States.

Sample

Within the 24,658 students in the HSLS:09 sample, the researcher utilized all questionnaire-capable participants for whom completed the student survey in the base year (2009). As shown in Table 1, 51% of participants were male and 48.77% were female. The sample consisted of 6.9% American Indian/Alaska Native, 11.03% Asian, 15.75% Black/African-American, 15.87% Hispanic, 2.5% Native Hawaiian/Pacific Islander, and 71.32% White. The sample was selected for representativeness in demographic percentages and percentages are similar to those reported in the 2010 U.S. census (Hanes, Jones, & Ramirez, 2011). 9.1% of the sample population were reported to have an Individualized Educational Program (IEP) and assumed to be in the special education (SPED) program, however, this was an underreported category with 56.7% of participants with missing values. Additionally, 5.8% of participants were enrolled in a program for English Language Learners (ELL) at some point in time in their grade school career.

Table 1
Sample demographics

	N	Percentage of sample
Male	12860	51
Female	12290	48.77
American Indian/Alaska Native	1740	6.9
Asian	2780	11.03
Black/African-American	3960	15.73
Hispanic	4000	15.87
Native Hawaiian/Pacific Islander	630	2.5
White	17980	71.32
Special education	2300	9.1
ELL	1240	5.8

Note: N values have been rounded to protect data security

As represented in Table 2, the reported birth year of participants was used to determine participants' age in the initial collection year (2009, participants' 9th grade year). Ages ranged from age 12 to age 19 with 91.9% of participants within the age range of 14 to 15 years old.

Table 2
Participant age in 2009

Participant birth year	Age numerical value assigned	N	Percentag e
1990	19	30	.1
1991	18	40	.2
1992	17	200	.8
1993	16	1220	4.8
1994	15	9430	37.4
1995	14	19730	54.5
1996	13	100	.4
1997	12	10	.0

Note: N values have been rounded to protect data security

For each research question, criteria were set regarding which participants would be used. Sampling for each question included all the participants who met the research set requirements. For research question one, the researcher utilized all students who completed the base year (2009) student survey. For research question two, the researcher examined base year survey data from HSLS:09 and identified students with a preference for arts or science, technology, engineering, and mathematics (STEM) courses. As such, students were identified who answered either art, music, mathematics, science, or “computer education or computer science” to the question “What is your favorite school subject?” (Variable S1FAVSUBJ) (Ingels, et al., 2011b, p. A-28). Within this variable, 1930 students responded “art”, 1810 students responded “music”, 3220 responded “mathematics”, 2090 responded “science”, and 500 responded “computer education or computer science” (Ingles, et al., 2011b). All of the aforementioned students were utilized in the question two analyses bringing the total number of students included from that variable to 9550. Additionally, question two uses the 2013 update to HSLS:09. Though 21,444 participated in the base-year questionnaire, a total of 18,558 completed the 2013 update (Ingles et al., 2015).

Operational Definitions and Measurement of Variables

Student subject preference

For the purpose of this study, "student preference for science, technology, mathematics, art, or music" and "student subject preference in 9th grade" are defined as students selecting science, computer science, mathematics, art, or music in response to the base year questionnaire question "What is your favorite school subject?" (Variable S1FAVSUBJ) (Ingels et al., 2011b, p. A-28). This variable was measured categorically.

Student perception of STEM variables

For the purpose of this study, the variables mathematics identity, mathematics utility, mathematics self-efficacy, mathematics course interest, science identity, science utility, science self-efficacy, and science course interest are defined as students' answers to questions regarding their perceptions of mathematics and science. Questionnaire answers were reverse coded and students' responses to perception questions in each of these variables were then combined to create scales for mathematics identity, mathematics utility, mathematics self-efficacy, mathematics course interest, science identity, science utility, science self-efficacy, and science course interest. (Variables X1MTHID, X1MTHUTI, X1MTHEFF, X1MTHINT, X1SCIID, X1SCIUTI, X1SCIEFF, X1SCIINT respectively.) These variables were measured continuously. (Ingels et al., 2011b). Sample questions for each of these variables can be found in Table 3.

Table 3
Constructed student perception variables

Variable	Variable label	Example survey questions*
X1MTHID	Math identity	"You see yourself as a math person"; "Others see me as a math person" (p .F-15)
X1MTHUTI	Math utility	"What students learn in this course... is useful for everyday life"; "What students learn in this course...will be useful for college." (p. A-17)
X1MTHEFF	Math self-efficacy	"You are confident that you can do an excellent job on tests in this course"; "You are certain that you can master the skills being taught in this course" (p. A-18)
X1MTHINT	Math course interest	"You are enjoying this class very much"; "You think this class is boring" (p. A-16)
X1SCIID	Science identity	"You see yourself as a science person"; "Others see me as a science person" (p. F-18)
X1SCIUTI	Science utility	"What students learn in this course... is useful for everyday life"; "What students learn in this course...will be useful for college." (p. A-24)
X1SCIEFF	Science self-efficacy	"You are confident that you can do an excellent job on tests in this course"; "You are certain that you can master the skills being taught in this course" (p. A-25)
X1SCIINT	Science course interest	"You are enjoying this class very much"; "You think this class is boring" (p. A-23)

*Quotations from Ingles et al., 2011, page numbers notated

Algebraic reasoning

Algebraic reasoning ability is defined as the student’s theta score on the administered algebraic reasoning assessment (variable X1TXMTH) (Ingels et al., 2011b). This variable was measured continuously.

Persistence variables

Multiple variables were utilized to determine students’ overall persistence in high school, into higher education, and in upper-level STEM courses in high school, postsecondary career, and postsecondary education. In this study, student persistence through high school is defined as a student obtaining a high school diploma and was measured using the high school completion variable X3HSCOMPSTAT (Ingels et al., 2011b).

Persistence in higher-level mathematics and science classes is defined as students taking college credit level classes in high school. This was measured utilizing three different categories of classes including Advanced Placement (AP) courses, International Baccalaureate (IB) courses, and courses which counted as both high school and college credit (dual credit) in both mathematics and science - variables S3APMATH, S3APSCIENCE, S3IBMATH, S3IBSCIENCE, S3DUALMATH, and S3DUALSCIENCE(Ingels et al., 2011b).

Persistence into higher education is defined as a student reporting that they are taking postsecondary classes in the 2013 update survey, variable S3CLASSES (Ingels et al., 2011b).

Persistence in postsecondary STEM is defined as a student reporting they are majoring in a STEM field in college or students reporting that they are currently working in a STEM field job. Majoring in a STEM field is measured using variable (S3FIELD_STEM) and STEM field job is measured using the two variables indicating the participant is currently employed in a STEM job (S3CURJOB_STEM1) (Ingels et al., 2011b).

All persistence variables are dichotomous.

Table 4

Variables list

Demographic variables from the base year student survey	
X1SEX	Student's sex
X1AMINDIAN	Student is American Indian/Alaska Native-composite
X1PACISLE	Student is Native Hawaiian/Pacific Islander-composite
X1HISP	Student is Hispanic/Latino/Latina-composite
XIWHITE	Student is White-composite
X1BLACK	Student is Black or African American-composite
X1ASIAN	Student is Asian-composite
X1SES	Composite socio-economic status
X1IEPFLAG	Student has an IEP (Individualized Education Program) indicating special education program participation
X1STDOB	Student date of birth
Demographic variables from the base year parent survey	
P1ELLEVER	Student was ever an English Language Learner
Grouping variable from the base year student survey	
S1FAVSUBJ	Student's favorite subject
Mathematics and science perception variables from the base year student survey	
X1MTHID	Math identity
X1MTHUTI	Math utility
X1MTHEFF	Math self-efficacy
X1MTHINT	Math course interest
X1SCIID	Science identity
X1SCIUTI	Science utility
X1SCIEFF	Science self-efficacy
X1SCIINT	Science course interest
Mathematics algebraic ability from the base year algebraic reasoning assessment	
X1TXMTH	Student algebraic ability assessment score
Persistence variables from the 2013 update	
S3APMATH	Took math AP course
S3APSCIENCE	Took science AP course
S3IBMATH	Took math IB course
S3IBSCIENCE	Took science IB course
S3DUALMATH	Took dual credit math course
S3DUALSCIENCE	Took dual credit science course
X3HSCOMPSTAT	Completed high school
S3CLASSES	Taking postsecondary classes

S3FIELD_STEM	Majoring in a STEM field
S3CURJOB_STEM1	Currently employed in STEM field job

(Ingles et al., 2011b)

Research Design

This study utilized a non-experimental research design which involving correlation and regression elements. Each of these statistical designs were utilized to answer one of the study's two research questions.

Data Collection

The researcher first obtained consent from the University of Houston-Clear Lake Committee for the Protection of Human Subjects (CPHS). There was no foreseen risk to the subjects as the researcher utilized archival data. Upon approval by CPHS, the researcher's dissertation chair applied to the Institute of Education Sciences (IES) National Center for Educational Statistics for a restricted-use data license of the High School Longitudinal Study of 2009. In the application, the researcher's dissertation chair provided justification for the use of the data, submitted legal documents, and agreed to certain restrictions in place to protect the privacy of the study participants. On the application, the researcher, dissertation chair, and dissertation methodologist were listed as authorized users on the license.

When the license was obtained, the researcher was provided the data on a CD-ROM and loaded the data onto a non-networked computer and stored the computer in a locked office at the University of Houston-Clear Lake (UHCL) in accordance with IES regulations of restricted-use data (Nces.ed.gov, 2015). IES guidelines for data protection were followed including rounding restricted data to protect confidentiality. The researcher reported on groups of students and not individual cases, further protecting participants. In accordance with IES regulations, the data was analyzed and then destroyed.

Instrumentation

This study utilized four instruments from the High School Longitudinal Study of 2009: the base year student questionnaire, the base year parent questionnaire, the base year student mathematics assessment, and the 2013 update questionnaire with transcript data. The validity of each questionnaire and all instruments was ensured through a multi-step development process (Ingels et al., 2011b).

Development of questionnaire instruments

First, a review of literature was compiled to provide a framework for question development and grouping of variables to create constructs and question clusters (Ingles et al., 2011). In some cases, previous high school longitudinal studies were utilized for question development. Though successful questions and constructs from previous national studies were favored in the instrument development process, HSLS:09 measured many new themes and constructs which were not previously explored in high school longitudinal studies (Ingels et al., 2011b). As such, new constructs, questions, and clusters were field tested and "new items were subject to cognitive interviews" (Ingels et al., 2011b, p. 12).

The next steps in the development of the questionnaire instruments included consultation of government agencies and interest groups, a draft review process utilizing contractors and National Center for Educational Statistics (NCES) staff, a panel review by methodology and technical experts, and justification to the Office of Management and Budget (Ingles et al., 2011b). Further, the computer software used to run the computer-based survey was tested and final revisions were completed based on feedback from the aforementioned groups and information gathered from the initial field test. Field testing was used to establish reliability of questionnaires including "examination of test-retest reliabilities, calculation of scale reliabilities, and examination of correlations between theoretically related measures" (Ingles et al., 2011b, p. 13).

The questionnaires combine demographic questions, various scale questions including Likert Scales, yes-no questions, multiple choice, check all that apply questions, and, in the case of the 2013 update, numerous questions with a large amount of options which related to colleges, college fields, and career fields (Ingles et al., 2011b). The final versions of the questionnaires were divided into sections with each section collecting information in a single category.

Base year student questionnaire design

The base year student questionnaire consisted of the questions clustered into nine sections: student demographics; school experiences; self-efficacy and identity in mathematics; self-efficacy and identify in science; attitudes about school; future plans after high school; educational expectations; and two sections which assist in locating contacts to reach the students in future surveys (Ingles et al., 2011b). Students were randomly assigned to two groups which determined the order in which the sections were administered in the questionnaire (Ingles et al., 2011b). The first wave of student questionnaire completion took place on campus using the computer administered survey. A second wave of questionnaires was administered using telephone interviews specifically to solicit responses from students who, for whatever reason, did not participate in the first wave. Telephone questionnaires asked the same questions as the first wave administration (Ingles et al., 2011b).

The first research question of this study analyzed student answers to questions in the self-efficacy and identity sections (both mathematics and science). The instrument was designed in a way that multiple questions were combined to create scale scores for the concepts math identity, math utility, math self-efficacy, math course interest, science identity, science utility, science self-efficacy, and science course interest (Ingles et al., 2011b). Sample questions from these scale variables were listed in Table 3 and reliability measures are listed in Table 5.

Table 5
Constructed student level variable scale scores and reliability

Variable	Variable label	Cronbach's Alpha
X1MTHID	Math identity	.84
X1MTHUTI	Math utility	.78
X1MTHEFF	Math self-efficacy	.9
X1MTHINT	Math course interest	.75
X1SCIID	Science identity	.83
X1SCIUTI	Science utility	.75
X1SCIEFF	Science self-efficacy	.88
X1SCIINT	Science course interest	.73

(Ingles et al., 2011b)

Parent questionnaire

The parent questionnaire was formulated in a similar manner in that there are a variety of types styles of questions and questions were grouped into thematic sections. Parents were given the option of an online or telephone administration of the questionnaire. In this study, the parent questionnaire instrument was only utilized to identify student demographic information such as income and English Language Learner status and special education status.

Development of mathematics assessment

The mathematics assessment was designed to establish students’ algebraic reasoning abilities and was administered in both 2009 and 2012. For the purpose of this study, only the first administration will be utilized. The assessment was drafted at the

American Institutes of Research. The draft was reviewed and validated by a panel of experts. The assessment was divided into two sections: algebraic content domains including “the language of algebra; proportional relationships and change; linear equations, inequalities, and functions; systems of equations; [and] sequences and recursive relationships” (Ingles et al., 2011b, p. 23), and algebraic process including “demonstrating algebraic skills; using representations of algebraic ideas; performing algebraic reasoning, [and] solving algebraic problems” (Ingles et al., 2011b, p. 23). 264 items were field tested and the final instrument consisted of a total of 73 unique items due to questions based on algebraic ability levels, questions which were distinctly written for 9^{th} grade, questions which were distinctly written for 11^{th} grade, and questions which were written to be administered in both the 9^{th} and 11^{th} grade assessments (Ingles et al., 2011b).

Students answered a total of 40 questions on the algebraic assessment. The assessment was administered to students by computer in two stages. The first administration stage consisted of 15 questions and determined student algebraic ability level. The second stage of the administration consisted of questions based on student’s ability level from the first stage and several linking questions which were the shared in common between the low and moderate test or the moderate and high level test (again dependent on initial student level) (Ingles et al., 2011b).

2013 update

The 2013 update was designed to be administered immediately following the graduation of a majority of student participants (at the four-year high school graduation point). Though some students would have graduated in less than four years, some would not have graduated in four years, and some would have dropped out, the survey is designed to ascertain students’ high school completion and postsecondary plans and experiences. Questions in the 2013 update questionnaire were written to be answered by either the parent or the student (Ingles et al., 2015). The development process for the 2013 questionnaire followed the same process as the development of the base year questionnaires including review of literature, use of questions from previous longitudinal studies, panel review, field testing, revision, and development of a web-based administration. The questionnaire consisted of five sections including high school completion and course credits; current activities as of November 2013 including college enrollment, military, or career; and three more sections which detailed enrollment, employment, and (if applicable) continued high school enrollment or GED programs (Ingles et al., 2015).

Collection of the 2013 update questionnaire data presented challenges as students from the base year documentation had to be located and participant nonresponse was more of a significant issue than in the base year. Participants and their parents were contacted through mail, email, or phone. They had the option of computer or telephone administration, and, after a designated time frame of nonresponse, were offered various monetary incentives to respond. In total, 18,558 participated in the 2013 update (Ingles et al., 2015).

The 2013 update also consisted of transcript information for student participants which covered all high school credit classes taken including some courses which were taken previous to 9th grade for high school credit as well as courses taken in high school which can be applied as college credit (Ingles et al., 2015). Transcript data is the most reliable source of information on student high school course credits, but is subject to data problems such as errors made by school administration and the fact that school courses may be the same in title across the United States but may vary in both content and rigor from classroom to classroom (Ingles et al., 2015).

Item nonresponse. Overall, high levels nonresponse did not occur in the data collection process in HSLS:09. Nonresponse was most prevalent in demographic questions in the parent questionnaire. Imputation was used to address missing items and imputed values are flagged in the database (Ingles et al., 2011b).

Data Analysis

The researcher utilized Statistical Package for the Social Sciences (SPSS) software to perform data analysis.

The grouping variables utilized in the two research questions were derived from the HSLS:09 survey question "What is your favorite school subject?" (Variable S1FAVSUBJ) (Ingels, et al., 2011b, p. A-28). Participant responses were recoded into one ordinal variable indicating student preference for mathematics, science, computer science, art, or music. All other responses and missing responses were coded as "system missing". The number of participants in each group is listed below in Table 6.

Table 6

Recoding variable FAVSUB

Original numerical value	Original description	N	Percentage	New value	New description
1	English	1760	7.00	-	System Missing
2	Foreign Language	100	4.36	-	System Missing
3	Science	2090	8.30	1	Science
4	Art	1930	7.66	2	Art
5	Music	1810	7.18	3	Music
6	Mathematics	3220	12.80	4	Mathematics
7	Physical education or gym	3920	15.56	-	System Missing
8	Religion	200	.80	-	System Missing
9	Health Education	480	1.93	-	System Missing
10	Computer education or computer science	500	2.00	5	Computer education or computer science
11	Social studies, history, government, civics	1860	7.39	-	System Missing
12	Career prep	430	1.73	-	System Missing
13	Other	1760	6.99	-	System Missing
-8	Unit non-response	760	14.93	-	System Missing
-9	Missing	50	1.39	-	System Missing

This student preference variable was then recoded into artificially dichotomous variables named “science only”, “art only”, “music only”, “math only”, and “computer only”.

To answer research question one, a correlational design was used. According to Salkind (2011), a correlational design should be utilized to determine the direction of relationships between variables. The artificially dichotomous student preference variables were used to in a Pearson product moment correlation with the continuous variables

X1MTHID, X1MTHUTI, X1MTHEFF, X1MTHINT, X1SCIID, X1SCIUTI, X1SCIEFF, X1SCIINT, and X1TXMTH.

To answer research question two, multiple regression analyses were used. Multiple regression is used when a researcher seeks to predict an outcome using more than one predictor variable (Salkind, 2011). Researchers have determined that a significant relationship exists between STEM persistence and demographic variables such as gender, ethnicity, and socioeconomic status (Carlone & Johnson, 2007; Duran & Şendağ, 2012; Gonzalez & Kuenzi, 2012; Ingels, et al., 2011a). Multiple regression analyses can account for these initial differences to allow the effect other variables to be measured by inputting them as covariates (Salkind, 2011). As such, demographic variables were used as covariates and the aforementioned persistence variables will be input as criterion variables. Model one of the regression analyses determined the variance caused by demographic factors (the covariates) and model two of the multiple regression analyses determined the amount of variance to STEM persistence variables (X3HSCOMPSTAT, S3APMATH , S3APSCIENCE, S3IBMATH, S3IBSCIENCE, S3DUALMATH, S3DUALSCIENCE, S3CLASSES, S3FIELD_STEM, and S3CURJOB_STEM1) caused by the artificially dichotomous student preference variables.

Conceptual Model

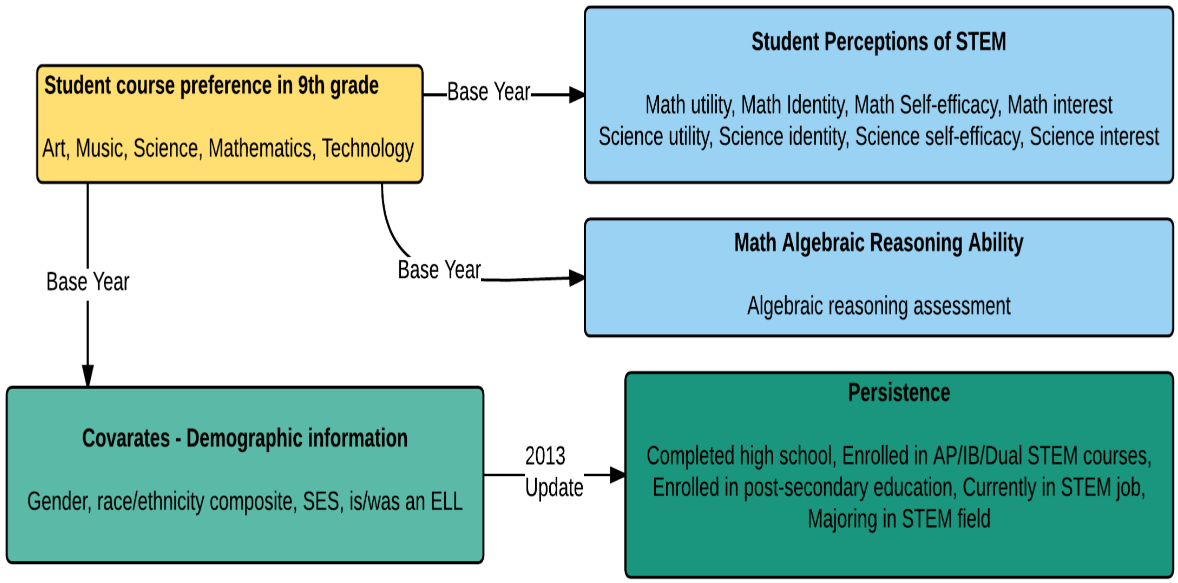

Figure 1. Conceptual Model. Flow-chart of variables and constructs by collection year and data analysis.

CHAPTER IV

RESULTS

The purpose of this study is to utilize the longitudinal data from the High School Longitudinal Study of 2009 (HSLS:09) to quantify the relationship between ninth grade student preference for arts or science, mathematics, or computer science and student perceptions of science and mathematics. This study also seeks to determine if student preference for arts or science, technology, engineering, and mathematics (STEM) related courses in the ninth grade is a predictor of student involvement in college credit science and mathematics courses, students registering for college, and determine if student preference is a predictor of students choosing a STEM field of study in college or obtaining a postsecondary job in a STEM field. The analyses in this chapter investigate two research questions. Question one examines relationships between student preference for science, computer science, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest. Question two examines which student subject preference in ninth grade (science, computer science, mathematics, art, or music) has the highest contribution to predicting students persisting in STEM including graduating high school, taking college level mathematics or science courses, registering for postsecondary education, and pursuing a STEM college major, or a job in the STEM field.

Data Preparation for Analysis

The quantitative data collected from HSLS:09 included data which was not utilized in this study. The data collected was imported into Statistical Package for the Social Sciences (SPSS) and data not utilized in these analyses were removed. Some of the HSLS:09 data came coded to include negative numbers which represent missing answers, skipped questions, and answers which are not relevant to the topic of the question. Each affected variable was recoded to remove these missing and unrelated participant answers. Table 7 shows the extraneous codes that were recoded to "system missing" in SPSS.

Please note that all N values in the tables in this chapter have been rounded to protect data security.

Table 7
Variable extraneous codes recoded to "system missing"

Variable name	Variable description	Original code	Code description	N	N remaining
X1SEX	Student's Sex	-9	Missing	58	25150
X1SES	Composite socio-economic status	-8	Unit non-response	3210	21990
X1IEPFLAG	Special education flag	-9	Missing	14300	10910
P1ELLEVER	Student was an English Language Learner	3 -8 -9	Don't know Unit non-response Missing	240 8210 1050	15940
X1MTHID	Math identity	-8 -9	Unit non-response Missing	3760 280	21160
X1MTHUTI	Math utility	-7 -8 -9	NA Unit non-response Missing	2110 3760 520	18800
X1MTHEFF	Math self-efficacy	-7 -8 -9	NA Unit non-response Missing	2110 3760 570	18760
X1MTHINT	Math course interest	-7 -8 -9	NA Unit non-response Missing	2110 2760 930	18390
X1SCIID	Science identity	-8 -9	Unit non-response	3760 330	21110

			Missing		
X1SCIUTI	Science utility	-7	NA	3610	17300
		-8	Unit non-response	3760	
		-9	Missing	530	
X1SCIEFF	Science self-efficacy	-7	NA	3610	17260
		-8	Unit non-response	3760	
		-9	Missing	570	
X1SCIINT	Science course interest	-7	NA	3610	16930
		-8	Unit non-response	3760	
		-9	Missing	900	
X1TXMTH	Student algebraic ability	-8	Unit-non response	3760	21440
S3CLASSES	Taking postsecondary classes	-6	Component not applicable	1700	13480
		-8	Unit non-response	4940	
		-9	Missing	50	
S3FIELD_STEM	Majoring in a STEM field	-1	Don’t know	1140	2940
		-4	Item not administered	580	
		-6	Component not applicable	1700	
		-8	Unit non-response	4940	
		-9	Missing	210	
S3CURJOB_STEM1	Currently employed in STEM job	-6	Component not applicable	1700	170
		-7	NA	9160	
		-8	Unit non-response	4940	
		-9	Missing	360	
Composite race variables					
X1AMINDIAN	American Indian	-9	Missing	940	
X1PACISLE	Pacific Islander	-9	Missing	940	
XIWHITE	White	-9	Missing	940	
X1BLACK	Black/African-American	-9	Missing	940	
X1ASIAN	Asian	-9	Missing	940	
X1HISP	Hispanic	-9	Missing	1970	

In all variables indicating AP/IB/Dual credit mathematics or science class participation, extraneous values “Item not administered”, “Component not applicable”, “NA”, “Unit non-response”, and “Missing” were recoded to system missing.

Recoding was also conducted for the variables HSCOMPSTAT and CURJOB_STEM1. For the purpose of this study, student persistence through high school is defined as a student graduating from high school. As such, all values in the variable HSCOMPSTAT other than “high school diploma” were considered extraneous values and were recoded to 0 – did not graduate with a high school diploma. This study is only concerned with whether or not a participant currently has a STEM job, not the field in which they have a STEM job. In response to this, all positive answers (values 1 through 5) in the variable CURJOB_STEM1 were recoded to 1 – currently in a STEM job.

Research Question One

Research Question One explored: What are the relationships between student preference for science, computer science, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest?

Hypothesis one: There is a relationship between student preference for science, computer science, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest.

To answer this research question, a Pearson Product Moment Correlation Test was conducted to determine if a correlation exists between student preference for science, mathematics, computer science, art, or music in the 9th grade and algebraic reasoning ability, mathematic identify, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest. Correlation coefficients were computed among the mathematics and science scales and the student subject preference variables. A *p* value of less than .05 was required for significance. The results of the correlational analyses presented in Table 8 show that 34 out of the 45 correlations were statically significant. Furthermore, 30 of the 45 correlations were significant at the .01 level.

Table 8
Correlation coefficients between student perceptions and subject preference

	Art	Science	Music	Mathematics	Computer science
Mathematics ability	-.050**	.047**	.018*	.121**	.013
Mathematics identity	-.091**	-.003	-.026**	.345**	.005
Mathematics utility	-.051**	.025**	-.044**	.166**	.016*
Mathematics self-efficacy	-.084**	.008	-.036**	.262**	.005
Mathematics course interest	-.101**	-.034**	-.053**	.482**	-.015
Science identity	-.038**	.229**	.000	-.036**	.020**
Science utility	-.037**	.207**	-.026**	.028**	-.007
Science self-efficacy	-.052**	.219**	-.018*	-.004	.002
Science course interest	-.056**	.403**	-.024**	-.019*	-.014

* $p < .05$
** $p < .01$

The correlations between mathematics identity and preference for mathematics, mathematics course interest and preference for mathematics, and science course interest and preference for science were significant and moderately positive. All other statistically significant relationships were weakly correlated. Significant weak positive relationships were found between the following correlations: mathematics ability and science subject preference; mathematics ability and music subject preference; mathematics ability and mathematics subject preference; mathematics utility and science subject preference; mathematics utility and mathematics course preference; mathematics utility and computer science subject preference; mathematics self-efficacy and mathematics subject preference; science identity and science subject preference, science identity and computer science subject preference; science utility and science subject preference; science utility and mathematics subject preference; and science self-efficacy and science subject preference. Significant weak negative relationships were found between the following correlations: mathematics ability and art subject preference; mathematics identity and art subject preference; mathematics identity and music subject preference; mathematics utility and art subject preference; mathematics utility and music subject preference; mathematics self-efficacy and art subject preference; mathematics self-efficacy and music subject preference; mathematics course interest and art subject preference; mathematics course interest and science subject preference; mathematics course interest and music subject preference; science identity and art subject preference; science identity and mathematics subject preference; science utility and art subject preference; science utility and music subject preference; science self-efficacy and art subject preference; science self-efficacy and music subject preference; science course interest and art subject preference; science course interest and music subject preference; and science course interest and mathematics subject preference.

If organized by subject preference groups, art was the only subject preference with which all correlational analyses were statistically significant. The correlations between art and all mathematics and science student preference as well as mathematics ability correlations were significant weak negative relationships. Science subject preference had significant correlations which were weakly positive with mathematics ability, mathematics utility, science identity, science utility, science self-efficacy, and moderately positive with science course interest. Science subject preference also had a weak significant relationship with mathematics course interest. Music subject preference had a significant weak positive relationship with mathematics ability and significant weak negative relationships with mathematics identity, utility, self-efficacy, and course interest as well as with science utility, self-efficacy, and course interest. Mathematics subject preference had significant moderate positive relationships with mathematics identity and mathematics course interest, as well as weak positive relationships with mathematics ability, utility, self-efficacy and science utility. Mathematics subject preference has a weak significant correlation with science identity, self-efficacy, and course interest. Only two computer science subject preference correlations were significant and both weak positive relationships: mathematics utility and science identity.

Research Question Two

Research Question Two explored: Which student subject preference in ninth grade (science, computer science, mathematics, art, or music) has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors?

Hypothesis two: Student preference for mathematics has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors.

To answer this research question, multiple regression analyses were conducted. Prior to conducting the multiple regression analyses, a Pearson Product Moment Correlation Test was conducted to determine if a correlation exists between STEM persistence variables and the predictor variables student subject preference and demographic factors. Correlation coefficients were computed among the STEM persistence variables (obtained high school diploma, took AP mathematics, took IB mathematics, took dual credit mathematics, took AP Science, took IB science, took dual credit science, taking postsecondary classes, considering STEM major in college, and currently working a STEM job), the student subject preference variables (art, science, mathematics, music, and computer science), and the demographic factor variables (sex, American Indian/Alaska Native-composite, Native Hawaiian/Pacific Islander-composite, Hispanic/Latino/Latina-composite, White-composite, Black or African American-composite, Asian-composite, socioeconomic status composite, individualized IEP plan/special education (SPED), and English Language Learner (ELL)). A *p* value of less than .05 was required for significance. The results of the correlational analyses presented in Table 9, Table 10, and Table 11 show that 50% (75 out of the 150 correlations) were statically significant. Furthermore, 59 of the 150 correlations (39%) were significant at the .01 level.

Table 9
Correlation coefficients between demographic variables and STEM persistence variables

	Sex	SES	SPED	ELL
Took AP mathematics	.113**	.115**	-.014	.047**
Took AP science	.064**	.152**	.000	.032*
Took IB mathematics	.041	-.049	-.078	-.063
Took IB science	.043	.045	-.113	.002
Took dual credit mathematics	.011	.055**	.002	.012
Took dual credit science	-.047**	.048**	-.029	.020
Obtained high school diploma	-.066**	.231**	-.125**	-.053**
Taking postsecondary classes	-.094**	.272**	-.195**	-.022*
Considering STEM major	.222**	.146**	-.037**	.015
Currently in a STEM job	-.012	.033**	.006	-.002

* $p < .05$
** $p < .01$

Table 10
Correlation coefficients between race/ethnicity variables and STEM persistence variables

	Black/ African-American	White	Hispanic	Asian	Native Hawaiian / Pacific Islander	American Indian/ Alaska Native
Took AP mathematics	-.033**	-.082**	-.077**	.142**	-.022	-.020
Took AP science	-.061**	-.089**	-.081**	.161**	-.006	-.022
Took IB mathematics	-.010	-.128*	-.063	.078	-.003	.087
Took IB science	-.048	-.118*	-.093	.146**	-.091	-.053
Took dual credit mathematics	-.008	-.018	-.042*	.035*	.011	-.006
Took dual credit science	.002	-.027	-.030	.041*	.002	.013
High School graduation	-.075**	.047**	-.073**	.048**	-.016*	-.058**
Taking postsecondary classes	-.032**	-.026**	-.049**	.086**	.000	-.058**
Considering STEM major	-.078**	-.045**	-.039**	.136**	.010	-.026**
Currently in a STEM job	-.012	-.027*	-.013	.042**	-.006	-.021*

* $p < .05$
** $p < .01$

Table 11
Correlation coefficients between subject preference variables and STEM persistence variables

	Art	Science	Music	Mathematics	Computer science
Took AP mathematics	-.51**	.025	-.018	.153**	.025
Took AP science	-.049**	.102**	-.015	.063**	.226
Took IB mathematics	.018	.036	-.018	.080	.057
Took IB science	.051	-.002	-.020	.121*	.067
Took dual credit mathematics	-.029	-.001	-.003	.062**	.020
Took dual credit science	-.012	.073**	-.012	.029	.007
Obtained high school diploma	-.021**	.016*	.014	.020**	-.017*
Taking postsecondary classes	-.017*	.021*	-.002	.022**	-.020*
Considering STEM major	-.056**	.100**	-.026**	.091**	.072**
Currently in a STEM job	-.012	.015	-.017	.043**	.028*

* *p< .05*
** *p< .01*

The results of the Person Product Moment Correlations Tests will be discussed by STEM persistence variables in the analyses sections below.

Following the Pearson Product Moment Correlation Test, multiple regression analyses were conducted to predict student persistence variables: AP/IB/dual credit courses in mathematics or science, high school graduation, registration in postsecondary education, considering major in STEM-related field of study in college, and acceptance of a job in a STEM field**,** all of which have N values represented in Table 12. In each multiple regression analysis, model 1 included the following demographic factor variables as predictor variables: sex, American Indian/Alaska Native-composite, Native Hawaiian/Pacific Islander-composite, Hispanic/Latino/Latina-composite, White-composite, Black or African American-composite, Asian-composite, socioeconomic status composite, individualized IEP plan/special education (SPED), and English Language Learner (ELL). Model 2 included the five created student subject preference variables including art only, science only, music only, mathematics only, and computer science only.

Table 12
Total students responding with a positive answer (e.g. "Yes") in persistence variables

Variable	N
Took AP Mathematics	3480
Took IB Mathematics	250
Took Dual Mathematics	1160
Took AP Science	3370
Took IB Science	230
Took Dual Science	900
Obtained high school diploma	19300
Taking postsecondary classes	13480
Considering STEM major in college	2940
Currently working a STEM job	170

Analyses predicting participation in Advanced Placement (AP) Mathematics

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) showed a significantly significant strong negative relationship was found between student subject preference for art and taking AP mathematics classes. Taking AP mathematics had significant weak positive relationships with sex, socioeconomic status, English Language Learner, Asian, and mathematics subject preference. Additionally, taking AP mathematics had significant weak negative relationships with the race/ethnicity variables Black, White, and Hispanic.

Two multiple regression analyses were conducted to predict participation in AP Mathematics from demographic factors and student subject preference. The results present an equation of how well participation in Advanced Placement Mathematics is predicted by demographics (model 1) and how well student subject preference for art, science, mathematics, or computer science (model 2) predicts participation in Advanced Placement Mathematics above demographics.

Based on the research, the equation believed to predict participation in Advanced Placement Mathematics was $APMath_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$

Overall, the analyses were significant at the .01 level. The first set of predictors (model 1) indicated that demographics accounted for a significant amount of participation in Advanced Placement Mathematics variability, $R^2 = .05$, $F(10,2150) = 10.78$, $p < .01$. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the participation in AP Mathematics variability after controlling of the effects of demographics R^2 change = .03, $F(15,2150) = 11.85$, $p < .01$. Of the variable variation in participation in AP Mathematics, 5% was explained by demographics and, after accounting for demographics, an additional 3% was explained by subject preference.

Of the predictor variables, sex, Asian, SES, English language learner (ELL), science, and mathematics were significant at the .01 level and computer science was significant at the .05 level. The result of the analysis showed that participation in AP Mathematics can be predicted by the equation $APMath = .11_{sex} + .02_{AmericanIndian} - .08_{PacificIslander} - .07_{Hispanic} - .03_{White} - .02_{Black} + .13_{Asian} + .06_{SES} - .05_{SPED} + .12_{ELL} + .01_{Art} + .11_{Science} + .06_{Music} + .21_{Mathematics} + .15_{Computer} + .40$

As can be seen in the statistical sentence above, of the significant regression weights, science, mathematics, and computer science subject preference had significant positive regression weights. This indicates that, after controlling for demographic variables in the model, student preference for science increased the likelihood of participation in AP mathematics by .11, student preference for mathematics increased the likelihood of participation in AP mathematics by .21, and student preference for computer science increased the likelihood of participation in AP mathematics by .15.

Analyses predicting participation in International Baccalaureate (IB) Mathematics

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated the only significant relationship with taking IB mathematics was a weak negative relationship with the race/ethnicity variable White.

Two multiple regression analyses were conducted to predict participation in International Baccalaureate (IB) Mathematics from demographic factors and student subject preference. The results present an equation of how well participation in International Baccalaureate Mathematics is predicted by demographics (model 1) and how well student subject preference for art, science, music, mathematics, or computer science (model 2) predicts participation in International Baccalaureate Mathematics above demographics. Based on research, the question believed to predict participation in International Baccalaureate Mathematics was: $IBMath_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$.

Overall, the analyses were not significant at the .05 level for both model 1 and model 2.

Analyses predicting participation in dual credit mathematics

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated taking dual credit mathematics had a statistically significant weak positive correlation with socioeconomic status, the race/ethnicity variable Asian, and the student subject preference variable mathematics. Taking dual credit mathematics was found to have a significant negative correlation with the race/ethnicity variable Hispanic.

Two multiple regression analyses were conducted to predict participation in dual credit mathematics from demographic factors and student subject preference. The results present an equation of how well participation in dual credit mathematics is predicted by demographics (model 1) and how well student subject preference for art, science, mathematics, or computer science (model 2) predicts participation in dual credit mathematics above demographics.

Based on the research, the equation believed to predict participation in dual credit mathematics was $DualMath_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$

The analyses in model 1 were not significant. The analyses in model 2 were significant at the .05 level. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the participation in dual credit mathematics variability after controlling of the effects of demographics (though the effects of demographic factors were not significant) R^2 change = .01, $F(15,1060) = 2.64$, $p < .05$. Though demographics did not significantly contribute to the variance in participation in dual credit mathematics, 1% was explained by subject preference.

Of the predictor variables, only mathematics was significant ($p < .01$). The result of the analysis showed that dual credit mathematics participation can be predicted by the equation $DualMath = -.03_{sex} - .004_{AmericanIndian} + .14_{PacificIslander} - .08_{Hispanic} - .03_{White} -$

$.01_{Black} + .07_{Asian} + .02_{SES} + .02_{SPED} + .07_{ELL} - .01_{Art} + .08_{Science} + .02_{Music} + .13_{Mathematics} + .10_{Computer} + .34$

As can be seen in the statistical sentence above, of the significant regression weights, mathematics subject preference had significant positive regression weight. This indicates that, after controlling for demographic variables in the model, student preference for mathematics increased the likelihood of participation in dual credit mathematics by .13.

Analyses predicting participation in Advanced Placement (AP) Science

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) showed that taking AP science classes had a significant weak positive relationship with sex, socioeconomic status, and English Language Learner as well as the race/ethnicity variable Asian and the subject preference variables science and mathematics. Significant weak negative relationships were found between taking AP science and race/ethnicity variables Black, White, Hispanic and subject preference variable art.

Two multiple regression analyses were conducted to predict participation in AP Science from demographic factors and student subject preference. The results present an equation of how well participation in Advanced Placement Science is predicted by demographics (model 1) and how well student subject preference for art, science, mathematics, or computer science (model 2) predicts participation in Advanced Placement Science above demographics.

Based on the research, the equation believed to predict participation in Advanced Placement Science was $APScience_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} +$

$b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$

Overall, the analyses were significant at the .01 level. The first set of predictors (model 1) indicated that demographics accounted for a significant amount of participation in Advanced Placement Science variability, $R^2 = .06$, $F(10,2150) = 12.85$, $p < .01$. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the participation in AP Science variability after controlling of the effects of demographics R^2 change = .01, $F(15,2140) = 5.95$, $p < .01$. Of the variable variation in participation in AP Science, 6% was explained by demographics and, after accounting for demographics, an additional 1% was explained by subject preference.

Of the predictor variables, sex, Asian, SES, ELL, science, and mathematics were significant at the .01 level. The result of the analysis showed that participation in AP Science can be predicted by the equation APScience = $.06_{sex} + .09_{AmericanIndian} + .01_{PacificIslander} - .03_{Hispanic} - .03_{White} - .08_{Black} + .16_{Asian} + .09_{SES} + .004_{SPED} + .12_{ELL} - .04_{Art} + .14_{Science} + .06_{Music} + .09_{Mathematics} + .12_{Computer} + .39$

As can be seen in the statistical sentence above, of the significant regression weights, science and mathematics subject preference had significant positive regression weights. This indicates that, after controlling for demographic variables in the model, student preference for science increased the likelihood of participation in AP science by .14 and student preference for mathematics increased the likelihood of participation in AP science by .09.

Analyses predicting participation in International Baccalaureate (IB) Science

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated taking

IB science was found to have a significant weak positive relationship with the race/ethnicity variable Asian and the student subject preference variable mathematics. A significant weak negative relationship was found between taking IB science and the race/ethnicity variable White.

Two multiple regression analyses were conducted to predict participation in International Baccalaureate (IB) Science from demographic factors and student subject preference. The results present an equation of how well participation in International Baccalaureate Science is predicted by demographics (model 1) and how well student subject preference for art, science, music, mathematics, or computer science (model 2) predicts participation in International Baccalaureate Science above demographics. Based on research, the question believed to predict participation in International Baccalaureate Science was: $IBScience_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$.

Overall, the analyses were not significant at the .05 level for both model 1 and model 2.

Analyses predicting participation in dual credit science

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated taking dual credit science was found to have a significant weak positive relationship with socioeconomic status, the race/ethnicity variable Asian, and student subject preference for science. Taking dual credit science was found to have a significant weak negative relationship with sex.

Two multiple regression analyses were conducted to predict participation in dual credit science from demographic factors and student subject preference. The results present an equation of how well participation in dual credit science is predicted by demographics (model 1) and how well student subject preference for art, science, music, mathematics, or computer science (model 2) predicts participation in dual credit science above demographics. Based on research, the question believed to predict participation in dual credit science was: $DualScience_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$.

Overall, the analyses were not significant at the .05 level for both model 1 and model 2.

Analyses predicting high school graduation

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) showed high school graduation had significant weak positive relationships with socioeconomic status, the race/ethnicity variables White, and Asian, and the student subject preference variables science and mathematics. High school graduation had significant weak negative relationships with demographic variables sex, special education, and English Language Learner as well as race/ethnicity variables Black, Hispanic, Pacific Islander, and American Indian. High school graduation also significantly correlated weakly negatively with art and computer science subject preferences.

Two multiple regression analyses were conducted to predict high school graduation from demographic factors and student subject preference. The results present an equation of how well high school graduation is predicted by demographics (model 1) and how well student subject preference for art, science, music, mathematics, or computer science (model 2) predicts high school completion above demographics. Based on research, the equation believed to predict high school graduation was:

$$HSGrad_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$$

Overall, the multiple regression analyses were significant at the .01 level. The first set of predictors (model 1) indicated that demographics accounted for a significant amount of high school graduation variability, $R^2 = .07$, $F(10,6140) = 47.49$, $p < .01$. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the high school graduation variability after controlling for the effects of demographics, R^2 change = .002, $F(15,6140) = 2.50$, $p < .01$. Of the variable variation in high school graduation, 7% was explained by demographics and, after accounting for demographics, an additional .2% was explained by subject preference.

Of the predictor variables, sex, SES, and special education were significant at the .01 level. Asian, American Indian, art, and mathematics were significant at the .05 level. The result of the analysis showed that high school graduation can be predicted by the equation $HSGrad = -.02_{sex} - .04_{AmericanIndian} + .02_{PacificIslander} + .003_{Hispanic} + .02_{White} - .02_{Black} + .04_{Asian} + .08_{SES} - .10_{SPED} - .02_{ELL} - .03_{Art} - .01_{Science} - .004_{Music} + .02_{Mathematics} - .01_{Computer} + .88$.

As can be seen in the statistical sentence above, of the significant regression weights, mathematics subject preference had significant positive regression weights, indicating that after controlling for demographic variables in the model, student subject preference for mathematics increased the likelihood of graduating from high school by .02. Student subject preference for art has a significant negative weight, indicating that after accounting for demographic variables, student subject preference for art decreases the likelihood of high school graduation by .03.

Analyses predicting enrollment in postsecondary classes

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated enrolling in postsecondary classes was found to have significant weak positive relationships with socioeconomic status, the race/ethnicity variable Asian, and the student subject preference variables science and mathematics. It was found to have significant weak negative relationships with demographic variables sex, special education, and English Language Learner, as well as with race/ethnicity variables Black, White, Hispanic, and American Indian. In addition, enrolling in postsecondary classes was found to have a significant weak negative relationship with the student subject preference variables art and computer science.

Two multiple regression analyses were conducted to enrollment in postsecondary classes from demographic factors and student subject preference. The results present an equation of how well enrollment in postsecondary classes is predicted by demographics (model 1) and how well student subject preference for art, science, mathematics, or computer science (model 2) predicts enrollment in postsecondary classes above demographics.

Based on the research, the equation believed to predict enrollment in postsecondary classes was $\text{Postsecondary}_i = b_0 + b_{1\text{sex}} + b_{2\text{AmericanIndian}} + b_{3\text{PacificIslander}} + b_{4\text{Hispanic}} + b_{5\text{White}} + b_{6\text{Black}} + b_{7\text{Asian}} + b_{8\text{SES}} + b_{9\text{SPED}} + b_{10\text{ELL}} + b_{11\text{Art}} + b_{12\text{Science}} + b_{13\text{Music}} + b_{14\text{Mathematics}} + b_{15\text{Computer}} + \varepsilon_i$

Overall, the analyses were significant at the .01 level. The first set of predictors (model 1) indicated that demographics accounted for a significant amount of enrollment in postsecondary classes variability, $R^2 = .12$, $F(10,4950) = 66.78$, $p < .01$. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the enrollment in postsecondary classes variability after controlling of the effects of demographics R^2 change = .003, $F(15,4940) = 3.50$, $p < .01$. Of the variable variation in enrollment in postsecondary classes, 12% was explained by demographics and, after accounting for demographics, an additional .3% was explained by subject preference.

Of the predictor variables, sex, Asian, special education, and SES were significant at the .01 level and American Indian, music, and mathematics were significant at the .05 level. The result of the analysis showed that enrollment in postsecondary classes can be predicted by the equation Postsecondary= $-.06_{sex} - .05_{AmericanIndian} - .03_{PacificIslander} + .002_{Hispanic} - .01_{White} + .001_{Black} + .06_{Asian} + .11_{SES} - .16_{SPED} + .03_{ELL} - .02_{Art} - .01_{Science} - .04_{Music} + .03_{Mathematics} - .05_{Computer} + .87$

As can be seen in the statistical sentence above, only mathematics subject preference had a significant positive regression weight. This indicates that, after controlling for demographic variables in the model, student preference for mathematics increased the likelihood of taking postsecondary classes by .03. Student subject preference for music had a significant negative weight, indicating that after accounting for demographic variables, student subject preference for music decreases the likelihood of taking postsecondary classes by .04.

Analyses predicting pursuit of a STEM major in college

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated that considering a STEM major had significant weak positive relationships with the demographic variables sex, socioeconomic status, as well as with the race/ethnicity Asian. It had significant weak negative relationships with the demographic variable special education, race/ethnicity variables Black, White, and American Indian, as well as the student subject preference variables art and music.

Two multiple regression analyses were conducted to pursuit of a STEM major in college from demographic factors and student subject preference. The results present an equation of how well pursuit of a STEM major in college is predicted by demographics (model 1) and how well student subject preference for art, science, mathematics, or computer science (model 2) predicts pursuit of a STEM major in college classes above demographics.

Based on the research, the equation believed to predict pursuit of a STEM major in college classes was $STEMMajor_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$

Overall, the analyses were significant at the .01 level. The first set of predictors (model 1) indicated that demographics accounted for a significant amount of pursuit of a STEM major variability, $R^2 = .08$, $F(10,3600) = 34.67$, $p < .01$. The second set of predictors (model 2) indicated that student subject preference accounted for a significant portion of the pursuit of a STEM major variability after controlling of the effects of demographics R^2 change = .02, $F(15,3600) = 19.38$, $p < .01$. Of the variable variation in pursuit of a STEM major, 8% was explained by demographics and, after accounting for demographics, an additional 2% was explained by subject preference.

Of the predictor variables, sex, Black, Asian, SES, science, mathematics, and computer science were significant at the .01 level and English Language Learner (ELL) and special education were significant at the .05 level. The result of the analysis showed pursuit of a STEM major can be predicted by the equation $STEMMajor = .18_{sex} - .02_{AmericanIndian} - .01_{PacificIslander} + .02_{Hispanic} - .03_{White} - .08_{Black} + .17_{Asian} + .06_{SES} - .05_{SPED} + .06_{ELL} + .02_{Art} + .17_{Science} + .04_{Music} + .11_{Mathematics} + .25_{Computer} + .12$

As can be seen in the statistical sentence above, of the significant regression weights, science, mathematics, and computer science subject preference had significant positive regression weights. This indicates that, after controlling for demographic variables in the model, student preference for mathematics increased the likelihood of pursuit in a STEM major by .11, student subject preference for science increased the likelihood of pursuit of a STEM major by .17, and student preference for computer science increased the likelihood of pursuit in a STEM major by .25.

Analyses predicting obtaining a job in a STEM field

Correlation and multiple regression analyses were conducted to examine the relationship between high school graduation and several potential predictors. Results of the correlation analyses (illustrated in Table 9, Table 10, and Table 11) indicated being currently employed in a STEM job had significant weak positive relationships with socioeconomic status, the race/ethnicity variable Asian, and the student subject preference variables mathematics and computer science. Currently in employed in a STEM job was found to have a significant weak negative correlation with the race/ethnicity variable American Indian.

Two multiple regression analyses were conducted to predict obtaining a job in a STEM field from demographic factors and student subject preference. The results present an equation of how well obtaining a job in a STEM field is predicted by demographics (model 1) and how well student subject preference for art, science, music, mathematics, or computer science (model 2) predicts obtaining a job in a STEM field above demographics. Based on research, the question believed to predict obtaining a job in a STEM field was: $STEMField_i = b_0 + b_{1sex} + b_{2AmericanIndian} + b_{3PacificIslander} + b_{4Hispanic} + b_{5White} + b_{6Black} + b_{7Asian} + b_{8SES} + b_{9SPED} + b_{10ELL} + b_{11Art} + b_{12Science} + b_{13Music} + b_{14Mathematics} + b_{15Computer} + \varepsilon_i$.

Overall, the analyses were not significant at the .05 level for both model 1 and model 2.

CHAPTER V

SUMMARY, IMPLICATIONS, AND CONCLUSIONS

Summary of Findings

The research sought to examine what relationships, if any, exist between students who have an inclination for the arts or STEM (science, technology, engineering, mathematics) and their perceptions of and persistence in STEM. The following research questions were asked:

Research question one: What are the relationships between student preference for science, computer, mathematics, art, or music class in the ninth grade and algebraic reasoning ability, mathematic identity, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest?

Research question two: Which student subject preference in ninth grade (science, computer science, mathematics, art, or music) has the highest contribution to predicting student registration in AP/IB/dual credit courses in mathematics or science, registration in postsecondary education, pursuit of a STEM-related field of study in college, and acceptance of a job in a STEM field, after accounting for demographic factors?

The study utilized data from the High School Longitudinal Study of 2009 (HSLS:09), which was designed with a large sample size and stratified random sampling techniques for sample representativeness to student populations of the United States. The results of a study utilizing HSLS:09 can be generalized to high school students in the United States. The following discussion addresses those findings that are those most significant in relation to the research questions and review of literature.

Research question one

A Pearson Product Moment Correlation Test was conducted to determine if a correlation exists between student preference for science, mathematics, computer science, art, or music in the 9^{th} grade and algebraic reasoning ability, mathematic identify, mathematic utility, mathematic self-efficacy, mathematic course interest, science identity, science utility, science self-efficacy, and science course interest. Correlation coefficients were computed among the mathematics and science scales and the student subject preference variables. The relationships found in these analyses are discussed below.

Mathematics ability. Mathematics ability was the only variable in the correlations which was not derived from a student questionnaire and was measured using a mathematics assessment. Preference for mathematics, science, and music all were found to have weak positive correlations with mathematics ability. This finding is supported by the conclusions of both Johnson (2000) and Vaughn (2000) who also found a positive correlation between music and mathematic achievement. Vaughn and Winner (2000) found that fine arts correlated with achievement in mathematics. The current study contradicts Vaughn and Winner (2000) in that student preference for art was found to have a weak negative relationship with mathematics ability in the current study. Though these relationships were all significant, most were very weak. This indicates that student preference is not a good indicator for mathematic aptitude. Additionally, the contradiction between the current study's results and the results of Vaughn and Winner may lie in the difference in identification of fine arts students. Vaughn and Winner focused on the amount of time in fine arts, not on reporting a favorite subject to be a fine arts subject. Participation in arts and self-report of enjoying arts over other subjects are two different constructs. This is a theme which will be woven throughout the discussion of results: student self-reported preference for art or music may not be the best determining factor of arts inclination, ability, or STEM/STEAM (science, technology, engineering, arts, mathematics) persistence.

Identity. The results of the identity analyses suggest a link between 9^{th} grade students' answer to a question such as "What is your favorite school subject?" and their identity. For mathematics identity, only mathematics subject preference was positively correlated. Music and art negatively correlated with very weak relationships to mathematics identity. For science identity, only science subject preference positively correlated and both mathematics and music subject preference had very weak negative correlations. The mathematics and science identity scales were composed of questions such as "You see yourself as a science person"; "Others see me as a science person" (Ingles et al., 2011, p. F-18).

With only those stating that their favorite subject is science found to positively correlate with science identity and the same with mathematics and mathematic identity, the concepts of identity and favorite subject appear to be linked. These findings are problematic for the STEAM (science, technology, engineering, arts, and mathematics) movement as researchers have found science identity a key factor in persistence in STEM (Carlone & Johnson, 2007; Wagstaff, 2014). If, by the 9^{th} grade, students' identities are formed in such a way that being a "music person" means that you cannot also be a "math person", then more needs to be done to develop a duality in student subject identity. This might be achieved by beginning in lower grades to develop a mathematic and science identity as suggested by Andersen and Ward (2014) then subsequently making connections between arts and STEM must begin in lower grade levels to break this barrier as suggested by Kim and Song (2013).

Self-efficacy. Preference for science courses was found to have a moderate positive relationship with science self-efficacy but was not significant to mathematics self-efficacy. Similarly, mathematics subject preference had a moderate positive relationship with mathematics self-efficacy but no significant relationship existed between mathematics subject preference and science self-efficacy. Music and arts subject preference were both found to have a weak negative relationship with mathematics self-efficacy and science self-efficacy.

These results highlight the fact that students' self-report of their favorite subject may reflect their overall belief in their ability to be successful in a course, with arts students feeling ill-equipped for success in mathematics and science. The results of the self-efficacy correlations are particularly important as Gonzalez and Kuenzi (2012) suggested that increasing self-efficacy in STEM subjects would increase female and minority success in STEM fields. Using student self-report of their favorite subject could be a simple meter stick to identify students' confidence in their mathematics and science ability.

Utility. Utility, or the belief that something is useful, had weak positive correlations with mathematics, science, and computer science subject preference. In fact, of the correlations run with computer science subject preference, only mathematics and science utility were significant and were very weak relationships at that. Art and music both had very weak negative correlations with mathematics and science utility. These findings are congruent with the findings Bevins, Byrne, Brodie, and Price (2011) in that they found students felt that science classes did not hold relevance or usefulness to their life. Bevins, Byrne, Brodie, and Price noted that students found science classes enjoyable but could not see the utility of the classes.

The finding of weak negative correlations with student subject preference and utility alludes to the notion that more should be done to integrate real world experiences into STEM subject classes. Making real world connections might strengthen the relationships between students with STEAM subject preferences and utility in mathematics and science. Research corroborates this theory and several researchers have argued for increasing real-world, authentic STEM tasks in the classroom: Root-Bernstein and Root-Bernstein (2013), advocates for STEAM education, argue that STEM classes need more authentic tasks and Weiman (2012) also advocates for more integrated and hands-on activities to engage students in STEM.

STEM subject preference. The lack of significant relationships between mathematics subject preference and science self-efficacy and vice versa with science subject preference and mathematics self-efficacy suggests that STEM subject interested students may not see the link between skills used in mathematics, science, and computer science. Indeed, computer science subject preference computer science subject preference only weakly correlated with mathematics utility and science identity. If, in the current schooling system, STEM courses were taught in a synergetic manner, one would expect both subject preferences to positively correlate with mathematics and science self-efficacy. It was also hypothesized that computer science would have positive correlations with all student preference variables. These findings highlight Sanders' (2009) conclusion that STEM subjects are taught in a disconnected manner and should be more integrated to develop STEM skills and interest.

However, in the current study, the strength of the relationships between mathematics subject preference and the student preference scales were mostly weak. This suggests that preference for the subject alone is may not be a good determining factor of student confidence in and perception of mathematics and science. This contradicts Andersen and Ward's (2014) findings using the HSLS:09 dataset showed that students identifying as a mathematics or science person was part of their identity positively and significantly predicted persistence in STEM in high mathematics ability students.

Andersen and Ward suggest that developing science and mathematics identity at the elementary level may be key to promoting STEM persistence. An explanation for the conflicting results of the two studies is that the Andersen and Ward study sampled only participants with high mathematic ability. In the larger general sample, student preference for mathematics and science, this pattern was not clear. This contradiction also suggests that the current study may be flawed by using student subject preference as a grouping variable (their study utilized a combination of race and mathematics ability while examining the student preference variables). Since Andersen and Ward found significant results with the mathematics identity student preference variable in their correlation analyses, perhaps using a single question "What is your favorite school subject?" is too simplistic for issues dealing with student identity and preferences.

Moreover, student subject preference (as reported by the students in the question "what is your favorite subject?") for mathematics was found to have only a moderate positive relationship with mathematics course interest and the same was found for science subject preference and science course interest. With the two constructs being similar in nature (favorite subject and interest in the course) it would be expected for these to have a strong positive correlation. With only moderate positive relationships, the conclusion can be drawn that students' self-report of their favorite subject has other underlying factors than just their interest in taking the courses. This also suggests that even students' whose favorite subjects are mathematics and science may not have abounding enthusiasm for all science and mathematics courses they take in high school. This parallels the assertions of Byrne, Brodie, & Price (2011) and Carlone and Johnson (2007) that secondary schools struggle to maintain student interest in STEM fields.

Arts preference. All significant relationships between both art and music with the STEM preference variables were very weak and only one (music and mathematics ability) was positive. The weak positive relationship between mathematics ability and music subject preference is in line with current research. According to Vaughn (2000), the correlation between music and mathematics achievement is well documented and a moderate positive relationship. In the current large sample study, only a weak relationship was found. However, the current study did not measure participation in music, only student expressed favoritism for music.

Perhaps this can be explained by the fact that visual art students are not being identified and thus developed for STEM potential. The findings of Kerr and McKay (2013) state that visual ability is commonly considered to be artistic ability and is overlooked as STEM potential.

With that said, all of the mathematics and science student preference variables having a negative weak relationship with STEM perceptions illustrates the uphill battle the STEAM movement has in the current educational system. As documented by Williams (2011), the emphasis on science and mathematics performance in K-12 accountability systems leaves little room for social sciences and arts. The findings of these correlational analyses illustrates that, though the relationships are weak, fine arts students may feel distanced from and unconfident with mathematics and science courses.

Williams (2011) stated that arts are often placed subservient to mathematics and science courses in schools. This may factor into the perceptions of arts inclined students. With educators and researchers advocating for adding arts into STEM (Bequette & Bequette, 2012; Stemtosteam.org, 2015; Root-Bernstein and Root-Bernstein, 2013; Gershon and Ben-Horin, 2014; Conley, Trinkley, & Douglass, 2014; Kim & Song, 2013), educators should be aware that fine arts inclined students may not see the link between fine arts and STEM as clearly as some researchers. The first step should be changing student perceptions of STEM and helping them identify the links between their artistic skills and scientific pursuits.

Research question two

Multiple regression analyses were conducted. Prior to conducting the multiple regression analyses, a Pearson Product Moment Correlation Test was conducted to determine if a correlation exists between STEM persistence variables and the predictor variables student subject preference and demographic factors. Correlation coefficients were computed among the STEM persistence variables (obtained high school diploma, took AP mathematics, took IB mathematics, took dual credit mathematics, took AP Science, took IB science, took dual credit science, taking postsecondary classes, considering STEM major in college, and currently working a STEM job), student subject preference variables (art, science, mathematics, music, and computer science), and demographic factor variables (sex, American Indian/Alaska Native-composite, Native Hawaiian/Pacific Islander-composite, Hispanic/Latino/Latina-composite, White-composite, Black or African American-composite, Asian-composite, socioeconomic status (SES) composite, individualized IEP plan/special education (SPED), and English Language Learner (ELL)). Following the Pearson Product Moment Correlation Test, multiple regression analyses were conducted to predict student persistence variables. In each multiple regression analysis, model 1 included the following demographic factor variables as predictor variables. Model 2 included the five created student subject preference variables including art only, science only, music only, mathematics only, and computer science only.

In their 2014 study using the base-year HSLS:09 data, Andersen and Ward found that students identifying as a mathematics or science person (attainment value) as part of their identity positively and significantly predicted persistence in STEM in high mathematics ability students. Though the current study uses all students in the HSLS:09 database who completed the 2013 follow-up (not just high mathematics ability students as used by Andersen and Ward), it was hypothesized that mathematics subject preference will have the highest contribution to students persisting in STEM. This hypothesis was true for participation in AP mathematics, dual credit mathematics, obtaining a high school diploma, and enrolling in postsecondary classes. Mathematics subject preference was a significant predictor of both course participation in AP science and intent to pursue a STEM major. However, subject preference for science was the highest subject preference contributing factor for participation in AP science and subject preference for computer science was a higher contributing factor for pursuit of a STEM major. The hypothesis was not true for enrollment in IB mathematics, enrollment in IB science, enrollment in dual credit science, and employment in a STEM job as all of these regression analyses were not significant.

International Baccalaureate (IB) STEM courses. There was only one significant correlation between taking IB Mathematics (a negative weak correlation with the race variable White). No correlations were found between IB mathematics and subject preference. The only significant correlations found between taking IB Science were a positive weak correlation with race indicator Asian, a weak negative correlation with the race indicator White, and a weak positive correlation with subject preference for mathematics (though interestingly not with subject preference for science). The multiple regression analyses were both not significant, which was most likely due to lack of statistical power. For both IB Mathematics and IB Science, 1.7% of respondents answered “yes” or “no” to the question leaving 98.3% of the roughly 24,000 having “other” type responses such as skipping the response to do IB not being offered to their school or not responding to the question. In contrast, AP Mathematics and AP Science both had more than 6000 "yes" or "no" answers.

Using such a large sample and yet yielding such small results in the IB category highlights the lack of participation in these courses in the current educational system. Forbes, Murray, Oliver, and Riggs (2014) had very similar results with their study, finding that even with an adequate sample size, there were not enough students electing to take upper-level mathematics and science courses for statistical significance to be found. In the HSLS:09 data, AP mathematics, and AP science participation fared better with 14 times more students elected to take AP in mathematics and science than an IB course in the same subject. The lack of statistical power in the multiple regression analyses in such a large sample size suggests it would take a sample of a different sort to determine if subject preference is a predictor of IB science and mathematics enrollment. Future research on this thread should sample a large number of students who are all known to have access to IB courses in their high school.

Advanced Placement (AP) STEM courses. Of the correlational analyses in this study, only one found a strong relationship and that was a strong negative relationship between preference for art and taking AP Mathematics. With that said, only an additional 3% of the variation in AP Mathematics was explained by subject preference with significance found between preference for science, mathematics, and (contrary to correlation data) computer science. Though art was found to have a strong negative correlation with taking AP mathematics, after taking into account the unique variance of each facet of the predictor variables, art does not uniquely predict taking AP mathematics. Furthermore, art subject preference had a very weak negative relationship with taking AP Science. Only an additional 1% of the variance in taking AP Science was explained by subject preference with only science and mathematics found to have significance.

Ultimately, subject preference was a poor predictor of students taking AP mathematics and science. Demographics were not as bad as predictors of students taking AP courses with 5% of AP mathematics variance and 6% of AP science variance due to demographic variables. However, neither demographics nor subject preference were good predictors for AP science and mathematics course involvement. Other factors must be involved which were not accounted for in the current study.

These findings are similar to those in the Forbes, Murray, Oliver, and Riggs (2014) study of arts involvement and AP course enrollment. Forbes, Murray, Oliver, and Riggs did not find significant results of their analyses and concluded that AP STEM courses and arts involvement could not be linked. The researchers argued that a larger sample size was necessary to determine if a link exists in a larger context. Based on the current study, a link between arts preference (not necessarily level of involvement) may not exist. Future research on this element should measure arts involvement based on transcript data and use it as a predictor variable in a large national dataset such as HSLS:09.

Dual credit STEM courses. Correlational analyses of both taking dual credit mathematics and dual credit science courses found only very weak correlations with a few of the demographic variables ($-.047 \leq r \leq .055$). Additionally, of the subject preference variables, only subject preference for mathematics significantly correlated with taking dual credit mathematics and course preference for science significantly correlated with taking dual credit science; both correlations were weak positive. Multiple regression analyses showed that demographics and subject preference were not significant predictors of taking dual credit science.

Interestingly, results of the multiple regression analyses of dual credit mathematics showed demographics were not significant predictors of taking dual credit mathematics but subject preference was a significant predictor. Of the variable variation in participation in dual credit mathematics, 1% was explained by subject preference. Subject preference for mathematics was the only significant predictor variable. Ultimately, subject preference is a significant but poor predictor of participation in dual credit mathematics. Unlike the IB course analyses, both dual credit analyses had enough statistical strength for significance to be found.

The lack of significance in demographic variables contradicts the commonly held and research-backed belief that demographics such as race, gender, and socioeconomic status are barriers to students from persisting in STEM (Carlone & Johnson, 2007; Duran & Şendağ, 2012; Gonzalez & Kuenzi, 2012; Ingels, et al., 2011a). However, the results of these analyses parallel those of Andersen and Ward's 2014 study utilizing HSLS:09 which found that 1) gender and socioeconomic status were not significant predictors of student intent to persist in STEM among high mathematics ability students and 2) students identifying as a mathematics or science person positively and significantly predicted persistence in STEM in high mathematics ability students. Though science subject preference was not found to be a significant predictor in the current study, HSLS:09 data has yielded interesting results in significant predictor variables of STEM persistence.

Obtaining a high school diploma. Correlational analyses of obtaining a high school diploma found all demographic and subject preference variables had significant relationships with high school diploma except music preference. Higher socioeconomic status, the race variables White and Asian, and subject preference for science and mathematics had weak positive correlations with obtaining a high school diploma. Being male, having a special education indicator, being an English language learner, the race variables Hispanic, Native Hawaiian/Pacific Islander, and American Indian/Alaska Native, and subject preference art and computer science had weak and negative correlations with obtaining a high school diploma. With that said, all correlations were very weak ($-.075 \leq r \leq .048$) except SES ($r = .231$) and SPED ($r = -.125$).

Of the variable variation in high school graduation, 7% was explained by demographics and, after accounting for demographics, an additional .2% was explained by subject preference with mathematics having positive regression weights and art having negative regression weights. Demographic variables sex, special education, and American Indian were found to be significant negative contributors to taking postsecondary classes. Socioeconomic status and the race variable Asian were positive contributors.

Though the subject preference regression model was significant, student course subject preference is a very poor predictor of a student obtaining a high school diploma. As hypothesized in sections above, student self-report of their favorite subject may be more related to their self-efficacy in that subject than their actual participation or investment in it. Both Eccles and Barber (1999) and Catterall, Dumais, & Hampdon-Thompson (2012) found that participation in fine arts was linked to high school graduation and attending college. Future research should include levels of involvement in arts or STEM, as favoritism for one of those subjects is not an adequate predictor.

Taking postsecondary classes. With the exception of Native Hawaiian/Pacific Islander, all demographic variables significantly correlated with taking postsecondary classes. Being sex (being male), having a special education indicator, being an ELL, and the race variables Black/African American, White, Hispanic, and American Indian/Alaska Native all negatively correlated with taking postsecondary classes. Positive correlations were found between socioeconomic status and the race variable Asian. Results of the multiple regression analyses show 12% of the variable variation in enrollment in postsecondary classes was explained by demographics and, after accounting for demographics. This is the highest demographic factors contributed to any of the STEM persistence variables.

Subject preference, however, is a very poor predictor of enrollment in postsecondary classes predicting only an additional .3% of the variation in enrollment in postsecondary classes. Only mathematics subject preference had a significant positive regression weight. Student subject preference for music had a significant negative weight. Studies by both Eccles and Barber (1999) and (Catterall, Dumais, & Hampdon-Thompson, 2012) found arts participation to positively link to postsecondary enrollment. As has been discussed at length and will be discussed further in this section, the current study's contradiction of these findings may be due to the grouping variable chosen. A student's favorite subject being mathematics, science, computer science, art, or music does not measure the students' level of involvement or confidence in the subject. This was evidenced by the lack of strong correlations in the first research question between subject preference for mathematics and mathematics self-efficacy and vice versa for science. Additionally, demographics play a much larger role in this STEM persistence variable than in the others. Presumably, additional factors such as these also play a part in students' enrollment in postsecondary classes. Wagstaff (2014) found additional variables which contributed to intent to persist in STEM such as urbanicity, having a high number of teachers with science and mathematics backgrounds, offering Advanced Placement (AP) courses, and being a STEM magnet school. Future research utilizing the HSLS:09 dataset should include these variables when investigating student persistence in STEM.

Pursuit of a STEM major. Correlational analyses of pursuit of a STEM major found significant weak positive correlations with being male, socioeconomic status, the race variable Asian, and subject preference variables science, mathematics, and computer science. Significant weak negative correlations were found with special education, English language learner, the race variables Black/African-American, White, Hispanic, and American Indian/Alaska Native, and subject preferences for art and music. The multiple regression analyses were found to be significant and, of the variable variation in pursuit of a STEM major, 8% was explained by demographics and an additional 2% was explained by course preference. The only subject preference variables which were found to be significant positive predictors of pursuit of a STEM major were mathematics and computer science preference. Art, science, and music preference were not significant predictors of pursuit of a STEM major.

Science course preference and science self-efficacy were moderately and positively correlated. It would be expected that, with a moderate positive correlation to self-efficacy in a STEM subject, science course preference would also be a predictor of purist of a STEM major but it was not. Additionally, favoritism for science did not correlate strongly with self-efficacy in science and did not correlate with self-efficacy in mathematics. The opposite was true for subject preference for mathematics and self-efficacy variables. Students with preference for STEM subjects may not be confident in their ability to be successful in all STEM fields. Carlone and Johnson (2007) found that when one does not confidently identify as a science person they may not pursue it as a field of study in college and beyond. The lack of efficacy across STEM subjects may be a factor in pursuit of a STEM major which was not accounted for in this study.

Employed in a STEM job. A weak positive significant relationship between STEM employment and subject preference for mathematics and computer science was found. However, as with IB subjects, employment in a STEM job did not have enough statistical power to yield a significant result in the multiple regression analyses. Of the 2013 follow-up responses, 1% responded they were employed in a STEM job. This is contradictory to Wagstaff's (2014) findings that, overall in the HSLS:09 base year data, a student identifying them self as a "science person" and having science identity was a predictor of their intent to pursue STEM in as a career. However, this matches Bevins, Byrne, Brodie, & Price (2011) conclusion that a majority of the students they surveyed did not plan to pursue a STEM-related field after the age of 18.

This result is predictable considering Gonzalez and Kuenzi's (2012) report that a majority of government funded STEM education programs stress degree attainment and career development for college students. Finding that students are not employed in STEM jobs right out of high school shows that first, employment in STEM fields would more likely occur after the participants gain experience in employment or post-secondary school and second, that STEM job focus is more heavily supported in the postsecondary realm (as noted by Gonzalez and Kuenzi (2012)). With STEM job opportunities expected to grow at a faster rate than non-STEM employment (Langdon, McKittrick, Beede, Khan, & Doms, 2011), more research is needed to determine ways to boost employment in a STEM field right out of high school. Considering a weak relationship was found between mathematics and computer science subject preference and STEM job employment, future research may want to start with analyses (both quantitative and qualitative) STEM inclined student participants.

Student subject preference as predictors of STEM persistence. Though art negatively correlated with all STEM persistence variables in the correlational analyses, it was found to only significantly contribute to the high school graduation regression analyses. This was a small (-.03) negative contribution in a model which only explained for .2% of the variable variation in high school graduation after accounting for demographics. Subject course preference for art is not a predictor of most subject variables studied and a poor negative contributor to high school graduation. Similar results were found with subject preference for music. Music significantly contributed to students registering for postsecondary courses with a negative regression coefficient of -.04, with course preference only accounting for 3% of subsequent the variable variation after accounting for demographic variables. The regression coefficient of music predicting postsecondary course enrollment is so small that it could almost be considered to have a neutral effect. Other than those discussed above, art and music preference were not significant contributors to any other STEM persistence and are, overall, not a good predictors of STEM persistence.

The regression analyses results for music and art as predictors of STEM persistence are contrary to Eccles and Barber's (1999) conclusion that arts involvement to have positive academic correlations such as a greater likelihood of attending college. Catterall, Dumais, and Hampdon-Thompson (2012) also found those with high arts involvement were more likely to graduate from high school and were more likely obtain employment with a bachelor degree requirement. Results of the current study contradict both Eccles and Barber (1999) and Catterall, Dumais, and Hampdon-Thompson (2012). This contradictory finding may be the result of the predictor variable "what is your favorite subject". This grouping variable may be too simplistic when referencing fine arts inclination and participation. Both the Eccles and Barber and Catterall, Dumais, and Hampdon-Thompson studies looked at participation in arts classes and not at student preference for arts classes. Asking students their favorite subject in school does not equate with measuring their involvement in fine arts over time. Additionally, other reported benefits of arts involvement concern critical thinking and metacognitive skills

(Hardiman, Magsamen, McKhann, & Eilber, 2009; Duran & Sendag, 2012; Hetland, 2000; Burnaford, 2001; Chappell & Cahmann-Taylor, 2013), verbal skills (Hardiman, Magsamen, McKhann, & Eilber, 2009; Podlozny, 2000), problem solving ability (Chappell & Cahnmann-Taylor, 2013; Chappell & Cahmann-Taylor, 2013; Bequette & Bequette, 2012; Root-Bernstein and Root-Bernstein , 2013; Conley, Trinkley, & Douglass, 2014), and creativity (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Root-Bernstein and Root-Bernstein, 2013; Harlow, Nylund-Gibson, Iveland, & Taylor, 2013; Kerr & McKay, 2013; LaMore et al., 2013; Gershon and Ben-Horin, 2014) none of which are measured in the current study.

Preference for mathematics was a positive predictor of AP mathematics, AP science, dual credit mathematics, high school graduation, postsecondary courses, and pursuit of a STEM major. Subject preference for science was a positive predictor of AP mathematics, AP science, and pursuit of a STEM major. However, across significant regression models, subject preference was a poor predictor of STEM persistence. Involvement in upper level mathematics and science classes was reported in the 2013 HSLS:09 update. Future investigating student interest in science and mathematics should utilize participation in upper level STEM courses as a grouping variable to determine persistence in STEM into college and beyond.

Implications and Conclusions

Overall results of this study show that student subject preference moderately correlates, at best, with student STEM perceptions and is not a good predictor of long-term student persistence in STEM. Researchers such as Atkinson and Mayo (2010) suggest it would be more efficient to hone in on students with aptitude and interest in the STEM subjects, directing school resources to these students. However, the results of this study suggest that student interest and preference in a subject are not efficient factors for identifying students who should be encouraged in STEM pursuits. Since this study provided evidence that student preference is overly simplistic when dealing with STEM identity and persistence, student interest in a subject should not be used to limit the number of students exposed to STEM. Instead, educators should place focus on building STEM interest and identity in a larger spectrum of students. Even demographics, which have been found as contributing factors to students remaining in or leaving STEM fields, at their highest, only predicted 12% of one of the persistence variables (taking postsecondary classes). Persistence into upper-level education and higher-level STEM is multifaceted. Educational practitioners and policymakers should use caution when developing initiatives designed to address only one single contributing factor in STEM persistence (such as demographics or STEAM subjects interest).

Furthermore, data collection with this study began when students entered the 9^{th} grade, it should be considered that perhaps students' identities are set by 9^{th} grade. Andersen and Ward (2014) advocate for developing STEM identity in elementary and middle grades to boost STEM persistence. Though student preference was not a good predictor of STEM persistence, it was still significant with science, mathematics, and computer science favoritism positively contributed to some persistence variables. Building STEM identity as well as building students' efficacy in STEM subjects in younger students should be a continued focus for STEM education policies.

It is critical to note that the results of this study are in no way denouncing STEAM programs or arts integration into STEM. Rather, the results of this study show the uphill battle educators face as they work toward integration of subjects. In the current school system, students are not making the connection between STEAM interest and their ability to be successful in those classes and they appear to be opting out of upper-level STEM endeavors. Additionally, students are not leaving high school prepared to go straight into STEM professions. In a perfect world, students whose favorite subject is mathematics would be confident in their ability to do mathematics, would believe it is useful to their lives, and would continue into college and a career in STEM. The results of this study should be used to illustrate the continued need for subject integration to promote STEAM resilience in students.

Analysis of the first research question provides insight into how students currently perceive mathematics and science. Mathematic course preference only positively correlated to science utility and that was a very weak relationship. Science course preference only positively correlated with mathematics utility and mathematics ability with those being very weak relationships. Similarly, computer science course preference only correlated significantly with mathematics utility and science identity. Students with STEM preference are not making connections between their favorite subject and those subjects which share similar processes and skills. As Sanders (2009) asserts, STEM professions integrate these subjects together on a day to day basis depending on the job or task. If STEM students cannot see the interconnectedness, it stands to reason that schools are not demonstrating the interconnectedness. Along those lines, researchers are making connections between fine arts skills and processes and those skills and processes used in STEM. Fine arts preference negatively correlated with student perceptions of mathematics and science which also points to a lack of awareness or confidence in those skills which bind STEAM subjects together.

Educators and policy makers can begin to change the weak negative perceptions of STEAM students by looking at how schools are traditionally structured. Traditionally, students are required to complete a set number of courses in four core areas: mathematics, English, science, and social studies. These courses are categorized separately and taught separately. Once a student reaches the required number of courses, students no longer have to pursue these subjects. Within the traditional four-year high school experience, students are limited to a number of classes and these classes are placed into semesters. Each class is allotted a set time of instruction in a school year. Once a student passes a course, the courses thereafter may or may not revisit what student previously learned. Forcing students into course tracks and requiring courses taught in isolation from other courses may limit the ability of students to perceive connections between subjects.

Furthermore, the traditional school setting may stifle subject integration. Students sitting in art class are not sitting in science class. Though the teacher may do his or her best to show the connections between science and art, the student knows that they are there to learn art in their art class. In a traditional high school setting, teachers are often divided into departments by subject. Teachers may work in interdisciplinary teams and some schools may work to bridge the gap between departments, but the natural segregation sets up a system of silos. This is also seen in teacher preparation programs. Art teachers are taught how to plan art lessons; computer teachers are taught to teach computer lessons; mathematic teachers are taught to teach mathematic lessons. We should consider breaking down the silos in traditional high schools and traditional teacher preparation programs to help teachers see and understand the interconnectedness between subjects, especially STEAM subjects. If teachers can become more knowledgeable and comfortable with all STEAM subjects, or at the least, understand where the intersections of these subjects lie, schools may be able to begin increasing student interest and confidence in those subjects which are not their chosen favorite.

It is a simple thing to write in an academic paper that teachers should begin integrating fine arts into STEM and STEM into fine arts, but the implementation is more complex. Teachers can begin with conversations amongst teachers and out of silos, but it must also start with reflection on the structures of schools. Policy makers set the traditional or non-traditional tone of the school system when they determine required classes and credits required for graduation. Innovative classes which integrate STEAM subjects may not fit within the traditional four core classes model. Though this paper falls far short of having enough evidence to advocate for the structure needed in high schools to promote STEM, Wagstaff (2013) did find that enrollment in a STEM magnet school was a predictor of intent to pursue STEM as a career. If policy makers look to the professions in which we would like to see our students persist, they may consider structuring schools and requirements in a way that mirror those professions.

Ideally, students who state their favorite subject is science would perceive the link between science and mathematics and would continue into upper-level science courses in both high school and college. Further, artistically creative students would perceive STEM in a positive light and consider STEM as a career. When longitudinally measuring student persistence through school and into STEM professions, there are many limiting factors involved which are difficult to account for statistically. Student access to resources, support at home, the teaching style of their teachers, and individual events in their lives can play a part in the choices they make and their persistence. With the call to increase STEM education efforts, it has become the job of educators and policy makers to ensure that students persist in STEM regardless of adversity. Though limitations exist, results of this study allude to a leaky pipeline in STEM. A student with a STEM subject favorite course in their formative teenage years should be given the support and resources necessary to continue a STEM pursuit. The questions lingering due to the lack of strong results are “Why are these students not making STEM connections?” “Where is the leak in the pipeline?” and “What can be done to develop persistence in our creative and STEM-inclined students?”

Limitations

External validity

Stratified random sampling techniques used to identify participating schools and random sampling procedures used to identify eligible participating students in the High School Longitudinal Study of 2009 were utilized so that the results of a study utilizing HSLS:09 can be generalized to high school students in the United States, specifically as students enter the 9th grade. The sample sizes of each group of the utilized grouping variable were all large enough to be generalized to the wider United States.

Internal validity

The second research question was affected by mortality. Between 2009 and the 2013 update, 248 student participants were labeled "study withdrawal, deceased, or study ineligible" (Ingles, et al., 2015, p. 21). Other mortality issues include students being temporarily out of scope or not responding at the 2013 update. As a result, a total of 23,415 student respondents participated in the 2013 update (Ingles, et al., 2015).

Other limitations

Student self-report. Data collected through surveys rely on participant honesty. Their perception of the purpose of the survey may color their responses. For example, a student may prefer athletics over other subjects but believes that mathematics is valued higher by our society. In this case, the student may answer the question in a way that would make them look better in the eyes of teachers or whoever they believe is their audience. The results of this study assume participants are reporting honestly, but complex concepts such as student identity may not be adequately explained through self-report.

Favorite subject grouping variable. Another factor limiting the results of this study is the student grouping variable. The variable does not identify the level of student fine arts or STEM involvement, only which subject the student prefers over all other listed subjects. Carrerall, Dumais, and Hampdon-Thompson (2012) determined that level of fine arts involvement has a significant relationship to academic indicators. However, results of this study are generalizable to students identifying with a fine art or STEM subject in the 9th grade, but not actual prolonged participation in that subject. Furthermore, dance and drama class were not listed options in the favorite subject question. Podlozny, A. (2000) and Walker, Tabone, and Weltsek (2011) both found academic benefits to drama participation. Vaughn and Winner (2000) found that dance had the weakest relationship between student achievement and involvement in fine arts, but the relationship was still found to be significant. Exclusion of these subjects limits the fine arts generalizability of the study results.

In addition, the grouping variable of student reported favorite subject does not equate to student interest or aptitude in the course. A student may report that mathematics is their favorite subject because the teacher of their current course is inspiring or dynamic. Without exploring the reasons behind a student choosing one course over all other courses, the student grouping variable lacks transparency. Moreover, the lack of knowledge of how both STEM and fine arts classes were taught to students in the sample affects the student grouping variable, and also limits our knowledge of reasons behind student efficacy and persistence in the course. Some students in the study are likely benefitting from hands-on, dynamic teaching in their STEM courses. Others may be experiencing a classroom structure that is lecture only without student interaction or lacking in rigor. All of these classroom dynamics have effects on student perceptions of STEM and their persistence in STEM. The way a class is taught may also be limiting student perceptions of the connections between arts and STEM. While this study can investigate connections between student favorite subject and student perceptions, without information on the type of courses and the skill sets of the teachers, causes behind the results are still unknown.

Furthermore, the grouping variable utilized in this study may have missed the mark for measuring STEAM. STEAM is inherently a subject involving integration and combination of STEM and arts. The grouping variable in this study was falsely dichotomous, forcing students to choose only one subject, though they may have an interest in more than the one they chose as favorite. It is the intersections between subjects that are of interest when discussing STEAM as researchers assert that the integration of subjects together boosts creativity in STEM and arts (Root-Bernstein & Root-Bernstein, 2013; Bequette & Bequette, 2012; Conley, Trinkley, & Douglass, 2014; Gershon & Ben-Horin, 2014). Due to lack of focus on the integration of STEM and arts subjects, the results of this study should not be generalized to judge the quality or value in STEM and arts integration or STEAM programs.

Structure of high school credits system. Schooling systems in the United States very significantly in what courses are offered to students. In the 9th grade, students may or may not have been exposed to a variety of quality fine arts programs. They also may or may not have participated in rigorous STEM subject instruction. Their perceptions of STEM and their choice of favorite subject are directly limited by the offerings in their school system. Specifically limiting this study is the credits system in high school programs. Students may opt out of upper level mathematics and science courses because they do not have room in their schedule that school year. The number of courses in STEM subjects required for each student is unknown. Without data to correlate the number of required STEM courses to the number of upper level courses taken by each student, the reason a student chose to or not to persist into upper level STEM courses is unknown.

Recommendations for further research

Though a large and representative sample size was utilized in this research, many questions remain regarding STEAM education. Below are some suggestions for future research which may help explain or further elaborate on the results of this study.

Measure participation in a STEM and STEAM program for grouping variable

The purpose of the current study was to investigate relationships and predict persistence into STEM with a recently collected large sample with representativeness to students in the United States. The study found that student preference for STEM or arts courses is generally not a good predictor of STEM persistence. In an ideal world, all students with interest in STEM would become STEM professionals. This link was minor at best in regression analyses. However, the current study does not in any way measure STEM or STEAM program participation. With the increase in STEAM programs across the country (Stemtosteam.org, 2015), the next step in STEAM research should identify and compare students who participate in STEM and STEAM programs. Utilizing STEM and STEAM program participation as a grouping variable would provide more data regarding these programs and would assist in explaining the disparity between student interest in STEM subjects and their persistence in STEM courses and fields.

Utilize high level of arts involvement as a grouping variable

Catterall, Dumais, and Hampdon-Thompson (2012) determined that level of fine arts involvement has a significant relationship to academic indicators. This study could be replicated with the HSLS:09 data set and include student transcript data to identify students with high fine arts involvement. (For example, who participated four years of arts in high school would be considered highly involved.) Use of transcripts would eliminate bias from using self-report survey results variables as the grouping variable and would also specifically target students who persisted with arts.

Include student participation in drama in future studies

Podlozny, A. (2000) and Walker, Tabone, and Weltsek (2011) both found academic benefits to drama participation. Although Vaughn and Winner (2000) found that dance had the weakest relationship to student achievement of all the fine arts, the relationship was still found to be significant. Exclusion of these subjects limits the fine arts generalizability of the study results. In future research investigating STEAM, student participation or preference for drama needs to be an included factor.

Connect fine arts habits of mind and STEM persistence

Researchers have asserted that certain habits of mind and skills which are shared by both artists and STEM professionals are important to consider when discussing STEAM (Boy, 2013; Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Kerr & McKay, 2013; LaMore, et al., 2013; Maeda, 2012; Root-Bernstein & Root-Bernstein, 2013). The current instrument utilized does not measure these habits of mind such as creativity and spatial reasoning. As such, the results of this study do not determine the underlying connections between STEM and arts, if any. Further research will be needed to determine if, nationally, these habits of mind equate to student persistence in STEM.

Factors effecting visual arts and STEM perceptions and persistence

This study found visual art interest to be negatively correlated to STEM perception variables and, when it was found to be a significant predictor of STEM persistence, it was a negative predictor. Research provides evidence that arts increase key STEM skills such as critical thinking skills, problem solving, and achievement (LaMore et al., 2013; Root-Bernstein & Root-Bernstein, 2011; Duran & Sendag, 2012; Chappell & Cahmann-Taylor, 2013; Catterall, Dumais, & Hampdon-Thompson, 2012; Bequette & Bequette, 2012; Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Conley, Trinkley, & Douglass, 2014; Gershon and Ben-Horin, 2014). Furthermore, visual creativity and skills such as spatial ability were found to be closely associated with skills utilized in STEM (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012; Harlow, Nylund-Gibson, Iveland, & Taylor, 2013). Contrary to these findings, the current study does not reflect well on students with preference for art and their STEM persistence. Both quantitative and qualitative research is needed to determine the factors affecting visual arts students' perception of and persistence in STEM.

Expand studies on student favorite subject with identity and efficacy

The correlational data in research question one suggests students' answers to the favorite subject question have a link to both identity and self-efficacy in a subject. Exploring this thread of research further may help find a simple classification technique which can be used in high school. For example, if the answer to this question could illuminate both students' identity and self-efficacy in a key subject such as science and mathematics, this technique could be utilized in high school to determine what type of support students require in those subjects. The current research could be expanded to include scales which measure artistic identity and self-efficacy, musical identity and self-efficacy, technology identity and self-efficacy.

Expand analysis into STEM job employment straight out of high school

A weak relationship was found between mathematics and computer science subject preference and STEM job employment; however, regression analyses did not have the statistical strength to find significant results. Future studies should investigate why students are not obtaining STEM jobs out of high school. Considering correlational analyses found mathematics and computer science subject preference to be significant, future research may want to start with both quantitative and qualitative analyses of STEM inclined student participants.

REFERENCES

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students: A comparison between Black, Hispanic, and White students. *Science Education, 98*(2), 216-242. doi:10.1002/sce.21092

Atkinson, R. D., & Mayo, M. J. (2010). Refueling the US innovation economy: Fresh approaches to science, technology, engineering and mathematics (STEM) education. *The Information Technology & Innovation Foundation, Forthcoming.*

Barber, B. L., Eccles, J. S., & Stone, M. R. (2001). Whatever happened to the jock, the brain, and the princess? Young adult pathways linked to adolescent activity involvement and social identity. *Journal of Adolescent Research*, *16*(5), 429-455. doi:10.1177/0743558401165002

Bevins, S., Byrne, E., Brodie, M., & Price, G. (2011). English secondary school students' perceptions of school science and science and engineering. *Science Education International, 22*(4), 255-265.

Bonamici.house.gov. (2015). *Bonamici provisions included in bipartisan bill to strengthen public education | Representative Suzanne Bonamici.* Retrieved 22 November 2015, from https://bonamici.house.gov/press-release/bonamici-provisions-included-bipartisan-bill-strengthen-public-education

Boy, G. (2013). From STEM to STEAM: Toward a human-centered education. In Paper submitted to the European Conference on Cognitive Ergonomics, Toulouse, France.

Burnaford, G. E. (2001). *Renaissance in the Classroom: Arts Integration and Meaningful Learning*. Mahwah, N.J.: L. Erlbaum.

Bybee, R. W. (2007). Do we need another Sputnik? *American Biology Teacher, 69*(8), 454-457.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of research in science teaching, 44*(8), 1187-1218.

Catterall, J. S., Dumais, S. A., & Hampdon-Thompson, G. (2012). The arts and achievement in at-risk youth: Findings from four longitudinal studies. *Washington, D. C.: National Endowment for the Arts, Research Report #55.* Retrieved from http://arts.gov/sites/default/files/Arts-At-Risk-Youth.pdf

Chappell, S., & Cahnmann-Taylor, M. (2013). No child left with crayons: The imperative of arts-based education and research with language "minority" and other minoritized communities. *Review of Research in Education, 37*(1), 243-268.

Conley, M. c., Trinkley, R., & Douglass, L. (2014). Using inquiry principles of art to explore mathematical practice standards. *Middle Grades Research Journal, 9*(3), 89-102.

Delaney, M. (2015). *Schools shift from STEM to STEAM.* EdTech. Retrieved 7 September 2015, from http://www.edtechmagazine.com/k12/article/2014/04/schools-shift-stem-steam

Duran, M., & Şendağ, S. (2012). A preliminary investigation into critical thinking skills of urban high school students: Role of an IT/STEM program. *Creative Education, 3*(2), 241-250. doi:10.4236/ce.2012.32038

Eccles, J. A. & Barber, B. L. (1999). Student council, volunteering, basketball, or marching band: What kind of extracurricular involvement matters? *Journal of Adolescent Research, 14*(1), 10-43. doi: 10.1177/0743558499141003

Forbes, E. R. T., Murray, J., Oliver, K., & Riggs N. (2014) From STEM to STEAM: The relationship between student fine arts involvement and STEM subject achievement. Unpublished manuscript, School of Education, University of Houston-Clear Lake, Houston, Texas.

Fredricks, J. A. & Eccles, J. S. (2006). Extracurricular involvement and adolescent adjustment: Impact of duration, number of activities, and breadth of participation. *Applied Developmental Science, 10* (3), 132-146.

Gershon, W. S., & Ben-Horin, O. (2014). Deepening inquiry: What processes of making music can teach us about creativity and ontology for inquiry based science education. *International Journal of Education & the Arts, 15*(19/20), 1-37.

Gonzalez, H., & Kuenzi, J. (2012) Science, technology, engineering, and mathematics (STEM): A primer. CRS Report for Congress R42642.

Hadzigeorgiou, Y., Fokialis, P., & Kabouropoulou, M. (2012). Thinking about creativity in science education. *Creative Education, 3*(5), 603-611. doi:10.4236/ce.2012.35089

Humes, K., Jones, N. A., & Ramirez, R. R. (2011). *Overview of race and Hispanic origin, 2010*. US Department of Commerce, Economics and Statistics Administration, US Census Bureau. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf

Hardiman, M., Magsamen, S., McKhann, G., & Eilber, J. (2009). *Neuroeducation: Learning, arts, and the brain.* New York: Dana Press.

Harlow, D. B., Nylund-Gibson, K., Iveland, A., Taylor, L. (2013). Secondary students' views about creativity in the work of engineers and artists: A latent class analysis. *Creative Education, 4*(5), 315-321.

Hetland, L. (2000). Learning to make music enhances spatial reasoning. *Journal Of Aesthetic Education, 34*(3/4), 179-238. doi:10.2307/3333643

Ingels, S. J., Dalton, B., Holder Jr, T. E., Lauff, E., & Burns, L. J. (2011a). The High School Longitudinal Study of 2009 (HSLS: 09): A first look at fall 2009 ninth-graders. NCES 2011-327. *U.S. Department of Education.* Washington, DC: National Center for Education Statistics.

Ingles, S. J., Pratt, D. J., Herget, D. R., Bryan, M., Fritch, L. B., Ottem, R., … & Wilson, D. (2015). High School Longitudinal Study of 2009 (HSLS:09) 2013 update and high school transcript: Data file documentation. NCES 2015-036. *U.S. Department of Education.* Washington, DC: National Center for Education Statistics.

Ingels, S. J., Pratt, D. J., Herget, D. R., Burns, L. J., Dever, J. A., Ottem, R., ... & Leinwand, S. (2011b). High School Longitudinal Study of 2009 (HSLS: 09): Base-Year Data File Documentation (NCES 2011-328). *U.S. Department of Education.* Washington, DC: National Center for Education Statistics.

Interest. 2015. In *Merriam-Webster.com*. Retrieved September 20, 2015, from http://www.merriam-webster.com/dictionary/interest

Johnson, D. A. (2000). *The development of music aptitude and effects on scholastic achievement of 8 to 12 year olds*. (Order No. 9983062, University of Louisville). ProQuest Dissertations and Theses, 126-126 p. Retrieved from http://search.proquest.com/docview/304627204?accountid=7108. (304627204).

Kerr, B., & McKay, R. (2013). Searching for tomorrow's innovators: Profiling creative adolescents. *Creativity Research Journal, 25*(1), 21-32. doi:10.1080/10400419.2013.752180

Kim, S. H., & Song, K. S. (2013). Gifted Students' Perception Changes toward Computer Science after STEAM-based CS Education. *Journal of Convergence Information Technology*, *8*(14), 214.

LaMore, R., Root-Bernstein, R., Root-Bernstein, M., Schweitzer, J. H., Lawton, J. L., Roraback, E., & Fernandez, L. (2013). Arts and crafts: Critical to economic innovation. *Economic Development Quarterly, 27*(3), 221-229.

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future*. Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration.

Maeda, J. (2012, October 2). *STEM to STEAM: Art in K-12 Is key to building a strong economy.* Retrieved September 7, 2015, from http://www.edutopia.org/blog/stem-to-steam-strengthens-economy-john-maeda

Mishook, J. J., & Kornhaber, M. L. (2006). Arts integration in an era of accountability. *Arts Education Policy Review, 107*(4), 3-11.

Nces.ed.gov. (2015). *Statistical Standards Program – Getting started.* Retrieved 17 October 2015, from http://nces.ed.gov/statprog/instruct_gettingstarted.asp

Office of the Press Secretary. (2011). *Remarks by the President at Signing of the America Invents Act*. Retrieved from https://www.Whitehouse.gov/the-press-office/2011/09/16/remarks-president-signing-america-invents-act

On Capitol Hill, NAfME makes a case for adding the Arts to a STEAM education. (2014). *Teaching Music, 22*(1), 14.

Persist. 2015. In *OED Online*. Retrieved on November 8, 2015, from http://www.oed.com/view/Entry/141465?redirectedFrom=persist

Podlozny, A. (2000). Strengthening verbal skills through the use of classroom drama: a clear link. *Journal of Aesthetic Education, 34*(3/4), 239-275. doi:10.2307/3333644

Respress, T., & Lutfi, G. (2006). Whole brain learning: The fine arts with students at risk. *Reclaiming Children and Youth: The Journal of Strength-Based Interventions, 15*(1), 24-31.

Richard, B., & Treichel, C. (2013). Increasing secondary teachers' capacity to integrate the arts. *Clearing House*, *86*(6), 224-228. doi:10.1080/00098655.2013.826488

Root-Bernstein, R., & Root-Bernstein, M. (2013). The art & craft of science. *Educational Leadership, 70*(5), 16-21.

Sanders, M. (2009). STEM, STEM education, STEMmania. *Technology Teacher, 68*(4), 20-26.

Salkind, N. J. (2011). *Statistics for People Who (Think They) Hate Statistics* (4th ed.). Los Angeles, California: Sage.

Stemtosteam.org,. (2015). *STEAM by Region.* Retrieved 22 November 2015, from http://stemtosteam.org/wp-content/uploads/2013/07/STEAM-by-US-region.pdf

utility. 2015. In *Merriam-Webster.com*. Retrieved September 20, 2015, from http://www.merriam-webster.com/dictionary/utility

Vaughn, K. (2000). Music and mathematics: modest support for the oft-claimed relationship. *Journal of Aesthetic Education, 34*(3/4), 149-167. doi:10.2307/3333641

Vaughn, K., & Winner, E. (2000). SAT scores of students who study the arts: what we can and cannot conclude about the association. *Journal of Aesthetic Education, 34*(3/4), 77-89. doi:10.2307/3333638

Wagstaff, I. R. (2014). *Predicting 9th graders' science self-efficacy and STEM career intent: A multilevel approach* (Order No. 3584390). Available from ProQuest Dissertations & Theses Global. (1554724318). Retrieved from http://search.proquest.com/docview/1554724318?accountid=7108

Walker, E., Tabone, C., & Weltsek, G. (2011). When achievement data meet drama and arts integration. *Language Arts, 88*(5), 365-372.

Wieman, C. (2012). Applying new research to improve science education. *Issues in Science & Technology, 29*(1), 25-32.

Williams, P. (2011). STEM education: Proceed with caution. *Design and Technology Education, 16*(1), 26-35.

Yoon, J. N. (2000). Music in the classroom: Its influence on children's brain development, academic performance, and practical life skills. (ERIC Document Reproduction Service No. ED442707).

Zubrzycki, J. (2015). *In ESSA, Arts Are Part of 'Well-Rounded Education'*. *Education Week* - *Curriculum Matters*. Retrieved 4 February 2017, from http://blogs.edweek.org/edweek/curriculum/2015/12/esea_rewrite_retains_support_f.html

APPENDIX A - RESUME

Erin Forbes

@DrErinForbes

ADMINISTRATIVE EXPERIENCE

Associate Principal, Fulshear High School, Lamar Consolidated ISD, Fulshear, TX. 2016-present.

- Facilitated the creation and maintenance of the school Master Schedule in collaboration with the leadership team for the purpose of maximizing student choice and balancing class needs.
- Created a number of policies and procedures for our new campus including the faculty handbook, exam policies, bell schedules, parking policies, tardy policy, discipline procedures, attendance and lost credit procedures and documentation, etc.
- Facilitated professional development for staff for the purpose of increasing the use of data based decision making, increasing student engagement and student-centered teaching, and building teacher's capacity to use technology as a tool in their classroom.
- Coached the mathematics and English teams and implemented PLC protocols for the purpose of making student data-based decisions and planning data-driven remediation for struggling students.
- Coordinated supplemental services with other schools, district personnel, and outside businesses and agencies.
- Communicated to parents, students, and staff through the use of social media including email blasts, Twitter, and Remind.
- Assisted in the interviewing of new staff and conducted evaluation of school staff.
- Assisted in making recommendations relative to personnel placement, transfer, retention, promotion, and dismissal.

Assistant Principal, Foster High School, Lamar Consolidated ISD, Richmond, TX. 2014-2016.

- Coached Algebra I team and implemented PLC collaboration protocols which resulted in FHS Algebra having the highest gains in pass rate of all LCISD EOC tested courses.
- Designed targeted EOC remediation during the instructional day and on Saturdays for both Algebra I and struggling English Language Learners.
- Coordinated ESL program, acted as LPAC administrator, and coached teachers on research-based strategies for English Language Learners.
- Developed and managed school Twitter account which attracted 1,100 followers in the first year of implementation. Promoted a positive school image through publicizing academic achievements, sports, fine arts, and teacher achievements.
- Developed and managed collaborative Twitter account for all schools that feed into Foster High School.
- Analyzed discipline data and presented professional development for all secondary assistant principals promoting awareness of social justice challenges in LCISD.

	• Facilitated revisions of the LCISD secondary handbook to promote consistency and provide clarity of key issues such as bullying, discipline actions, and student expectations. • Standardized discipline procedures for our Assistant Principal team to reflect research-based PBIS strategies; a system which was adopted by the district in Spring 2016. • Facilitated revisions of the LCISD secondary handbook to promote consistency and provide clarity of key issues such as bullying, discipline actions, and student expectations.
INSTRUCTIONAL LEADERSHIP EXPERIENCE **Department Chair** Mayde Creek Junior High, Katy Independent School District, Katy, TX. 2012-2014.	• Designed and conducted instructional technology trainings before school and during conference periods. Collaborated with PLC teams on content specific, TEKS-based technology integration. • Trained district teachers (K-12) at the district iCamp summer PD sessions including the use of Nearpod, Evernote, AppleTV, Board Builder, and Google Apps. • Designed online bully and safety reporting system implemented across the district. • Created an efficient system to collaborate with faculty, administration, and PTA for e-newsletters and school webpage announcements. • Led regular meetings with fine arts and electives teachers to increase interdisciplinary collaboration and ensure department alignment with school vision. Oversaw budgets for all fine arts classes. • Committee member: Campus Advisory Team (CIC), Advisory Steering, Title I Planning, AYP Task Force, Safety Committee, 30th Anniversary Committee, Technology Vertical Planning, KISD Art Curriculum Development, KISD Employee Round Table.
EDUCATION	**Doctor of Education – Educational Leadership** – anticipated graduation, May 2017. Curriculum & Instruction specialization with a research focus in STEM and Arts (STEAM). University of Houston, Clear Lake, Houston, TX. 4.0 GPA. **Master of Education – Educational Administration** Lamar University, Beaumont, TX. 4.0 GPA. 2012. **Bachelor of Fine Arts – Visual Arts Studies (Art Education)** University of North Texas, Denton, TX. *Magna Cum Laude* 2006.
CURRICULUM Development Experience	**Teacher Fellow -** Museum of Fine Arts, Houston, 2011-present. • Collaborated with core subject teachers and museum staff to write Middle School curriculum writer for a new MFAH program which emphasizes the use of fine arts in core classes to increase project based learning and student inquiry. • Presented and modeled the new curriculum at the Houston Arts Partners Conference, Houston, TX. September, 2015

TEXAS CERTIFICATIONS

- Principal Certification, 2012. Art (P-12), 2006. ESL Supplemental, 2010.
- T-TESS, ILD, & PDAS certified.
- CPI and TBSI Core Team certified.

TECHNOLOGY CERTIFICATION

- Authorized Google Education Trainer

ACHIEVEMENTS

- 4.0 Doctoral GPA at University of Houston-Clear Lake
- Texas Council of Women School Executives Scholarship Winner, 2015
- Katy ISD Digital Star Teacher of the Year (2010-2011)
- Fund for Teachers Fellow (2009)
- Mayde Creek Junior High PTA Lifetime Membership Recipient (2012)

PROFESSIONAL PRESENTATIONS

Houston Arts Partners Conference, 2015. Sponsor: Museum of Fine Arts, Houston
Interactive professional development modeling strategies for science teachers to increase student talk and inquiry in the classroom through the use of artwork and the scientific method.

Texas Association of Black School Educators, 2015. Co-presenter.
Presented current research on the integration of art into STEM classes (STEAM) and facilitated a collaborative conversation regarding the future of art and STEM education.

Lamar CISD Assistant Principal Meeting, 2015. Co-presenter.
Presented discipline data by race/ethnicity, discipline code, and action code along with strategies at the AP level and school level to improve equity in discipline procedures.

iCamp, Katy ISD, summer 2013 and 2014.
Trained teachers on a variety of methods of integrating technology into their classroom for the purpose of increasing student participation, teacher organization, and overall engagement.

Texas Art Education Association Annual Conference, 2011. Co-presenter.
Shared classroom partnership I developed with teachers in my district in which we utilized video-conferencing to engage students in conversations students increasing academic language.

Texas Art Education Association Annual Conference, 2009.
Discussed content specific ways to integrate technology into the art classroom.

RESEARCH INTERESTS

- STEAM (Science, Technology, Education, Arts, Mathematics)
- Social equity in school management practices
- ESL programs and instructional best practices

PROFESSIONAL AFFILIATIONS

- Texas Council of Women School Executives, 2015 – present
- Texas Association of Secondary Principals, 2014 – present
- American Education Research Association, 2013 – 2015