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Development and Impact of a STEM Educational Outreach Program for K-12 Students

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DEVELOPMENT AND IMPACT OF A STEM EDUCATION OUTREACH PROGRAM FOR K-12 STUDENTS

By

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Abstract

Studies show that K-12 students struggle more with math and science courses than other topics, which can deter K-12 students from pursuing opportunities in these fields. This leads to a shortage of STEM workers while job opportunities in STEM continue to grow at a faster pace than others. The STEM Ambassador program is designed to increase K-12 students' interest in and preparation for STEM opportunities through employing undergraduate students as mentors, STEM activity leaders and tutors in K-12 schools. Impact of the program was assessed by analysis of K-12 student test score data and survey data from K-12 students, K-12 teachers, and ambassadors. Data analysis revealed that students in classrooms with STEM ambassadors yielded significantly higher average test scores than those without. The STEM Ambassador program is an effective model for positively impacting K-12 student perceptions and knowledge of STEM concepts while improving critical skillsets with the Ambassadors as well.

Table of Contents

List of Tables

CHAPTER 1:

INTRODUCTION

In May 2015, 8.6 million jobs in the United States workforce were STEM oriented occupations. This is about 6.2% of total jobs in the country (US BLS 2). Although STEM employment may seem relatively small, employment in these fields is growing rapidly. Over the last decade, employment in STEM occupations grew by 24.4%, compared to 4.0% in non-STEM fields. Projections for growth in STEM employment show an 8.9% increase from 2014 to 2024, while non-STEM employment estimates an increase of just 6.4% (US ESA 4).

Similar to the national statistics, Tennessee is expecting an increase in STEM-related occupations in upcoming years. In 2012, 252,000 jobs in the state of Tennessee were STEM-related, and this number is projected to increase to 295,000 in the year 2022. Over this decade, additional STEM employment will account for 11% of the new jobs added to the state (TN Department of Labor and Workforce Development 3). On average, STEM occupations are going to be added at a rate of 1.6% per year for the state of Tennessee, while non-STEM jobs are added at an annual rate of only 1.2% per year. Not only will the number of STEM-related occupations continue to increase, but the demand for professionals with a STEM occupation will increase, due to the shortage of qualified STEM job applicants for these positions (TN Department of Education 5).

Students across the country are struggling in their math and science courses more than English and reading comprehension. According to the 2017 Nation's Report Card where scores from the National Assessment of Educational Progress results were analyzed, 62% of the nation's public graduating seniors performed at/above the basic level in their math course, where only 25% of twelfth graders scored at/above proficient (NAEP). Of the state of Tennessee's graduating seniors, only 30.5% reached the college readiness benchmark in math and 31.0% reached the science benchmark. In Shelby County, Tennessee, only 15.2% and 16% of graduating seniors reached the college readiness benchmark in math and science respectively (TN Department of Education). Poor performance in an area can deter students from pursuing a career in related fields. Since such a small number of students in the Shelby County area are reaching the college readiness benchmark in math and science courses, there is a shortage in the number of students feeding into the STEM pipeline from this area.

Another factor contributing to the shortage of people pursuing STEM-related occupations is the social barrier of certain groups trying to enter these professions. Women are severely underrepresented in STEM occupations. Nearly one half of scientists and engineers are white men, according to a 2014 study by the National Science Foundation (NSF 22). Although women make up nearly half of the workforce in the United States (48%), women only represent 26% of the STEM workforce in 2013, while 74% of the same workforce are men (Landivar 5). According to census data from 2011, women's employment is below average in nearly all STEM occupations. In addition to women, minorities (African American and Hispanics) are underrepresented in STEM occupations. These minorities are also less likely than their Caucasian and Asian counterparts to graduate from high school and earn a college degree. African Americans make up approximately 12% of the United States workforce, but only 5% of African Americans pursue a STEM-related occupation. Similarly, Hispanics comprise 16% of the entire workforce, but only 6% of the STEM workforce (NSF NCSES 12).

Misconceptions about job opportunities in STEM occupations may be another contributing factor to the shortage of people pursuing these opportunities. Although 73% of the STEM workforce is composed of people with Bachelors' Degrees, over half of the remaining workforce typically only require an associate degree or specialized certification(s) (US BLS 13). Some STEM jobs only require a high school degree or equivalent. Pursing a path in STEM careers is not only for the top academic achievers. There are plenty of different pathways to explore for each type of individual.

The STEM Ambassador program was designed to address the discrepancies and deficiencies in Shelby County Schools related to the STEM workforce. STEM Ambassadors are able to offer math and science support through tutoring, in-classroom aid, hands-on experience, and demonstrations. In addition to offering academic support, Ambassadors can open student's eyes to the variety of occupations available in all different sectors of STEM fields, as well as share with students' reference material and resources pertaining to the opportunities available in STEM. Since deficiencies in math and science are not the only hindrance of flow into the STEM pipeline, this program has been designed and modified to address all of the gaps.

CHAPTER 2:

LITERATURE REVIEW

2.1 Need for STEM

Job Projections: Although only a small fraction of the workforce in the United States is STEM-related careers, this number is rapidly growing. 6.1% of the workforce in 2015 were STEM careers, which is about nine million jobs in the country (US ESA 8). Between 2009 and 2015, STEM occupations grew by 10.5%, which is nearly one million additional jobs in the STEM community. Non-STEM occupations had a net growth of only 5.2% in the same time, which is more than a 5% difference (US BLS 7). The fastest growing type of occupation in the STEM category will be occupations relating to computer operations. This type of employment is expected to increase by 12.5% (500,000 new jobs) between 2014 and 2024.

Tennessee's growth in STEM opportunities reflects the nation's: Tennessee is and will continue to experience a rapid increase in STEM jobs available. From 2012 to 2022, the state of Tennessee has added 43,000 jobs in STEM fields, which will be a total of 11% of the total jobs added in the state (TDLWD 4). Non-STEM jobs are expected to grow at a rate of 1.2% per year in the state, while STEM occupations are expected to increase by 1.6% annually. Similar to the country, computer-related occupations will increase the most, with healthcare and mathematics related occupations following closely behind.

Pay Wage Gaps: STEM vs. Non-STEM: Not only is there a projected increase in the number of STEM career opportunities, but the pay wages associated with these jobs is statistically higher than other non-STEM job prospects. On average, STEM employees can expect to earn 26% more over the course of their careers than their non-STEM coworkers (NMSI 1). Even those with a STEM degree/certification will make statistically more money overall whether they hold a position in a STEM or non-STEM position. For those working in a STEM job with a high school education or less still more 69.8% more money than their equals in a non-STEM position. Those working in a STEM position with some college/associate degree make 61.3% more than their non-STEM counterpart with the same education level. People working in STEM jobs with a bachelor's degree make 38.6% more money than those with the same education in non-STEM fields, and finally, STEM workers with a graduate degree make 29.0% more money than their non-STEM coworkers (US ESA 5). These statistics show that employees in STEM occupations make statistically more money than those in non-STEM occupations, regardless of equal levels of education. The largest difference in pay wages can be seen between those in STEM versus non-STEM occupations at the less than or equal to high school education level with a pay wage difference of 40%. The difference between STEM and non-STEM occupations at the bachelor's degree level is slightly smaller (28%), and the difference in wages between STEM and non-STEM occupations for those at the graduate level is the smallest at a difference of 15% (US ESA 5).

Types of Workers in STEM Occupations: As technology is developed, it is continually being modified and improved. Just as technology is ever changing, the United States workforce is steadily evolving to address the changes in how products are made. New problems are arising as technology is developed that have never been encountered before - and these problems need completely innovative solutions. As the technology has expanded over the last decade, there are immense amounts of data that show the skillset required to address these challenges is much larger than initially imagined. Defining the STEM workforce has proven to be a challenging obstacle, as some occupations are sometimes classified as STEM while other times viewed as non-STEM (NSF 8). Often, those workers that have not received a STEM degree but are still

STEM-capable and experienced in this area are excluded from the "STEM workforce." Including all workers that are capable of contributing to the STEM workforce means looking at their technical and hands-on contribution, not just the degree or certifications they may hold. Various individuals working in STEM occupations have taken numerous pathways to get to their current position. There is not one single, clearly defined pathway to lead a person to any one specific occupation in the STEM workforce, which means there is not one specific type of person that fits each role in STEM. Various positions requiring different levels of education (either degrees earned or amount/extent of experience) are necessary to fill the knowledge/skills gaps that are present in the STEM workforce.

2.2 Challenges to Filling the Pipeline

Not Enough Interest in STEM: When in elementary and middle school, students' perceptions of math and science are based on the fun activities and experiments they get to take part in, such as the "egg drop" experiment, where students secure an egg in their designed protective packaging and drop it from several stories high hoping their egg survives the crash. However, as students move through their high school science courses (biology, chemistry, and physics) and math classes (algebra, geometry, and calculus), interests in these subjects decline as the courses shift from fun and creative to methodical and strict. Above average students in STEM are not properly motivated in high school and often fail to recognize their full potential, resulting in pursuing other pathways in college. As much as 50% of parents admit they would be happy for their child to pursue a career in STEM. However, less than half (24%) are willing to pay extra money on extra support for their child to excel in the STEM courses (Microsoft Corporation 3).

According to one study, approximately forty percent of college students planning on going into engineering or science end up switching to other majors after they begin the intense curriculum combination of calculus, physics, and chemistry classes their first few semesters (Drew). Another potential reason students' interest declines as they enroll in more science and math courses in college is the professor's teaching approach. A study was conducted to determine the outcome of student performance based on the difference in teaching method. A meta-analysis was conducted on 225 studies that measured students' examination scores or failure rates in their STEM courses. Results showed that failure rates were 21% for courses taught with an "active" approach, which is 10% lower than failure rates for courses taught with the usual lecture approach (31%) (Eddy, S. et. al. 1).

There are also extracurricular/after-school programs that offer engaging and hands-on introductions to various STEM opportunities to spark interest. One program is the Communication, Science, Technology, Engineering, and Math (CSTEM) program. His in-classroom and after-school program operates in six states and spans grades kindergarten to the twelfth grade. The goal of the CSTEM program is to abolish barriers to STEM disciplines while serving as a platform for communication of underrepresented students. In the formal classroom setting, students use critical thinking and investigation into STEM concepts to participate in a robotics competition, while preparing a presentation to showcase all of their work throughout project conception. Not only does CSTEM provide student support, but it provides after-school sessions on professional development for teachers leading the robotics teams. The final competition includes more than robotics: Geographical Information Systems (GIS) mapping, environmentally friendly challenges, sculpting, and creative writing. As a program designed to retain students in STEM-related activities, founders were pleased to find that 94% of students planned to continue in the STEM program, and 100% declared that the CSTEM program was their first STEM enrichment program (Afterschool Alliance 3).

Underrepresented People in STEM: Approximately 30% of the United States population is underrepresented minorities (URMs) - Indians/Alaska Natives, African Americans, Latinos - and this number is increasing rapidly. However, regardless of the large percentage of these people in the community, their presence in STEM disciplines remains relatively small. In 2011, only 12.5% of all STEM bachelor's degrees were awarded to URMs (National Action Council for Minorities in Engineering). About half of the total United States population are women, but only a small fraction of women chose to pursue a degree in STEM. In 2015, 47% of the United States workforce were women, but only 24% of women worked in STEM occupations (US ESA 2). Not only are women underrepresented in STEM, there is a substantial gap in differences of compensation for women and men. For every dollar a man earns, women only earn 84 cents in one study examining STEM occupations. One study that looked at 67 different countries determined that the reason for women not pursuing STEM careers was not due to aptitude; women performed as well as men did in math and science courses (Stoet 16). Many studies have been conducted as to why only a small number of women pursue STEM occupations, and the evidence points to social stigma and expectations, rather than performance in these areas.

Increase in Jobs Due to Rise in Technology: As technology rapidly evolves, it has caused a great deal of concern for some regarding the job market. Technology has replaced some jobs originally performed by workers, but the jobs replaced by machines are those that require few skills, involve repetitive tasks, and do not require a high level of cognitive effort. These are known as "low-skill" jobs, and technology can perform them faster at a much less expensive cost. "High-skill" jobs, those that are non-routine, cognitive, or social, have not widely been automated (Gibbs 2). STEM careers are almost all “high-skill” jobs, requiring abstract thinking, analysis, decision making, management, communication, and research. As new technology continues to advance, STEM jobs are growing and being created at an exponential rate. Nearly all STEM occupations are projected to grow over the next decade, and they are predicted to grow exponentially faster than their non-STEM counterparts (Vilorio 5).

2.3 Attracting Students to STEM

Research Regarding Existing Barriers: Barriers in STEM can be traced all the way back to elementary school education. There is a significant amount of literature that proves the traditional instruction methods are not as effective as new, reformed methods of teaching. However, faculty elect to continue to teach using these outdated methods (Dancy et al. 2). One study determines that failure rates under the traditional lecturing method would increase by 55% using the active teaching method and exam grades would be raised by half a letter (Eddy et al. 1). For URMs and low-income students, barriers in STEM education can be in the form of lack of adequate school funding, limited access to science resources/facilities, poor-quality teachers, lack of technology and advanced courses in STEM classes (Martin and Scott 2). Not only are there barriers existing in the framework of education, but there are social and psychological barriers than affect students ‘perceptions and decisions to go into STEM. For women, the stigma that “men are better in STEM disciplines than women,” is engrained from an early age (Martin and Scott 17). Mathematics proficiency, studying habits/engagement, and time management are all educational barriers than impact all students entering STEM. Lack of proficiency in mathematics courses contributes to a lack of basic knowledge in the fundamentals, leading to a negative perception of the material, high failure rates, and discourages students in these subjects (Bucklein et al. 50).

Interventions that are Successful: Several different things can be done to get more students considering a career in a STEM field. Outreach efforts by colleges, organizations, and companies can inform students of the various opportunities available in the STEM workforce. Often, students elect not to pursue a degree in STEM because it is perceived as being too difficult or time consuming (Hanover Research 6). Outreach efforts can spark an initial interest in these areas, erase stereotypes, and inform students of pathways through STEM that will translate into a career for them later. Information campaigns are another way to spread information about opportunities in STEM. Especially in information campaigns, it is important to show students the coursework each degree will require and show how STEM degrees will translate into careers later on. Another key component in outreach efforts is exposing students to people currently in the STEM workforce. Showing students a variety of role models allows them to identify with successful individuals in STEM through similar backgrounds, interests, and goals. Role models could be guest speakers the student can interact with, or they could be documented by answering a questionnaire. Pathways each role model took to complete their STEM degree and enter the workforce should be shared with the student audience (Hanover Research 10).

Special Considerations for Diverse Groups: According to one study, use of the popular media is critical to attracting a more diverse population to STEM. Casting a diverse range of URMs in prominent STEM roles in moves, shows, etc. helps correct the image of what society thinks a scientist should look like (US DOE). Program development targeting specific groups of URMs is another successful way of reaching the more diverse students. Several programs exist that are focused on women pursing STEM or other URMs interested in entering the workforce.

One program that has been developed specifically for women is the Techbridge Girls program. This program was started in the San Francisco Bay Area in 2000 that caters to girls in the fifth through twelfth grades. This program aims to support, encourage, and enlighten female students about the different opportunities available to them in STEM career fields. Since the National Science Foundation (NSF) supplied the initial grant to get this program off the ground, the after-school program has provided many training classes to STEM education faculty to share best practice information. The program also aims to bring high-quality STEM experiments to those underrepresented student populations typically found in these fields. Techbridge is an organization that focuses on training facilitators in the most effective methods to educate underrepresented populations in STEM fields. Not only do they share methods in educating these groups in STEM concepts, but the program educates how to create a culture that promotes confidence and encourages diverse girl participation (Techbridge Girls).

Project Focuses on Outreach to K-12 in Repeat Setting: The STEM Ambassador program developed by the West TN STEM Hub works by stationing ambassadors at various institutions across the SCS system throughout the school year and summer. Ambassadors are present in math and science classrooms to serve as assistant teachers during the school year, and the ambassadors lead additional summer camps or seminars during the summer months. In order to attract students to STEM opportunities, repeated exposure to this course material is critical.

2.4 Effective STEM Outreach Programs

It is imperative to identify many different characteristics of programs or schools that deem the school as a success. Test scores do not tell the entire story of a successful STEM outreach program. Documenting the number of students that elect to pursue a career in STEM is also an important factor when determining success.

North Carolina School of Science and Mathematics (NCSSM): One case study of a successful STEM-outreach program focuses on the STEM-focused School model. In North Carolina, there is a selective STEM-focused public high school where 99% of graduates attend college within the year after they graduate. The high school is called the North Carolina School of Science and Mathematics (NCSSM), which is a public school that can accommodate 680 selected students. Admission to the school is determined by each applying sophomore's interest and talent in the science courses. Other abilities are considered as well when applying, such as essays and special talents. Each student is required to take a certain number of math and science courses per semester, as well as participate in research and mentorship programs. Not only does the NCSSM serve the students in attendance, but the school also reaches out to 3000+ students across the state through videoconference enrichment activities (National Research Council of the National Academies). One alumni (class of 97) is Christina Hammock Koch, who is a NASA astronaut set to launch in 2019 to go to the International Space Station. Christina obtained bachelors degrees in electrical engineering and physics, then a masters degree in electrical engineering (National Aeronautics and Space Administration). There are several other notable alumni from NCSSM, but 68% of 2016's graduating class are attending college in the state of North Carolina, while the rest elected to go out of state for post-secondary education (NCSSM).

Spark 101: Evaluation of another program revealed positive outcomes in attitudes and understanding of STEM material/principles. The Spark 101 program that has reached approximately 500,000 students since 2013 (Keller 8). Spark 101 is a program easily accessible online and free to educators nationwide. Spark 101 is a collection of videos where real-life STEM professionals discuss actual case studies that require students to think critically about real world STEM problems. The case studies present problems with no "correct" answer, allowing students to discuss the problems and present alternative solutions to each problem. Along with the case study, each video contains information about the STEM focus and career pathway pertaining to the case study. Statistically significant effects were seen in students that had little understanding or interest in STEM prior to using Spark 101; over 70% of these students reported that these Spark 101 videos increased their interest and awareness in how their correct coursework relates to future careers in STEM. 80% of these students agreed that Spark 101 improved their STEM skills and how they would rely on these skills as a professional (Keller 6).

Architecture, Construction, and Engineering (ACE) Mentor Program: The ACE Mentor Program of America, Inc. is a program developed in the District of Columbia in 2002, and it now stretches across the United States from New York to Los Angeles. This organization is designed to "engage, excite, and enlighten" high school students in the vast career options available in construction, architecture, and engineering fields by providing these students with real-life design challenges, hands-on learning opportunities, and access to practicing professionals. Not only do these students obtain invaluable hands-on knowledge, but they are given opportunities to visit project offices and construction sights, giving them the "big picture" of how the design process works from conception to completion. When analyzing the results of the impact of the ACE Program on students' performance and involvement in high school, 59% of high school senior ACE students felt more motivated to study in high school versus 44% of national high school students. ACE senior students had a remarkable 99% graduation rate compared to a national average of 81% of high school seniors. 92% of high school ACE seniors graduated and transitioned directly into college compared to the 66% of national graduating high school seniors (ACE Mentor Program of America 3).

Institute of Student Achievement (ISA): In order to facilitate and develop a better environment for high school students to learn, the ISA's first priority is to transform a typical high school setting into several small learning communities. The principles of group-learning and personalized education are key in this design model. As one study shows, there is a significant decline of the probability of high school dropout if the student has a supportive learning environment (AED: Center for School and Community Services 10). ISA's new model was first integrated into public schools in New York City, and each institution implementing the ISA model offered additional school activities on a day to day basis as well as summer programs. Some of the after-school activities where enrichment clubs (school newspaper, art clubs, tutoring, etc.), while the summer programs were often more intensive where a student could potentially earn course credit. Data was collected by site visits to ISA programs, analysis of surveys completed by both faculty and students, and investigation of student achievement data (test scores, attendance, credit accumulation, etc.). ISA students attempted more credit hours, earned more credit hours, and failed less core-subject classes compared to those students in the comparison group. After a control factor was put in to account for differences in student characteristics, ISA students were found to attempt 2.9 credits more than their comparison students and earn on average 6.3 more credits. Not only were credits earned higher for ISA students, but attendance, grade promotion, and graduation rates were also consistently higher in the ISA students rather than their comparison peers (AED: Center for School and Community Services 18).

Connecticut Pre-Engineering Program (CREP) Summer Math Challenge: This organization was designed to expose underrepresented youth to the opportunities available for them in the Science, Technology, Engineering, and Mathematics fields. The program is five weeks long, and it serves 395 students at six different locations across the state of Connecticut. The students attending this program were from underrepresented demographics: 65% qualified for free or reduced lunch and 45% were female. This program is based on teacher instruction with the integration of game-based mathematics learning software, which creates a customized and differentiated learning experience. This software carefully integrates the properties that most teenagers enjoy in games (teams, points, badges, etc.), but it demands that students practice individual differentiation of math skills and records student performance. In addition to using this mathematics software, the students are put into teams to address four hands-on STEM challenges, where they must apply the engineering design process to reach a solution. To measure student improvement, a math assessment was distributed to the group at the beginning of the program and again at the conclusion. Analysis of these assessments indicated that scores improved by 31% from their initial assessment. Program participation led to an overall increase in math proficiency, and 97% of students showed growth in priority focus skills in math software (National Summer Learning Association 11).

Wayne State University (WSU) Math Corps: When this organization was founded, its purpose was simply to "do something" for the young people in Detroit, MI, whether it was coach a sports team, improve schools, etc. However, since its conception in 1992, it has developed into a mathematics enrichment program that serves 400 public school students in middle and high school each summer (Wayne State University). The program caters to underrepresented youth with 95% of all students being African American. Two WSU sites serve as the basecamps for this program and serve students that attend schools where the average ACT score is just a 16.5. The program is founded on the phrase, "We love you and believe in you – you're the whole reason we are here!" and has a strictly enforced positive environment that has a basis of kindness and integrity. The program's twenty-year history has yielded consistent results again and again. In 2015, seventh, eighth, and ninth grade students had pre-test scores of 32%, 29%, and 32% respectively. However, these same seventh, eighth, and ninth grade students scored 90%, 84%, and 84% respectively on their post-test scores. In comparison to their school peers averaging a score of 16.5 on their ACT, WSU Math Corps students score over a 21. Finally, 90% of the students attending this program graduate from high school, and 80% of these students continue on to college (Wayne State University).

2.5 Local Setting

Demographics: Memphis, TN is located in Shelby County, the most southwestern point in the state. The Memphis metropolitan area, which includes counties in north Mississippi and east Arkansas, has a population of about 1.34 million people (World Population Review). However, the county's actual population was just over 940,000 in 2017. The percentage of African American residents was highest at 54.1%, while Caucasians were the next largest group at 41.2%, followed next by Hispanics/Latinos at 6.4%, and every other recorded race was under 3%. Only 30.2% of those 25 years or older had a level of education equal to or higher than a bachelor's degree. In 2016, the average poverty rate for counties in Tennessee was 17.6%, compared to Shelby County's poverty rate of 20.8%. The unemployment rate in Shelby County in March 2018 was at 3.8%, the lowest it has been in the past decade (FRED), and the median household income is $47,690.

Shelby County Schools: Over the last decade, the Shelby County School system has undergone several reforms. Analysis of ACT test score data indicates that in the year 2017, less than 10% of high school seniors reach the ACT college readiness benchmark in all four subjects (math, science, reading, and English). For science alone, 16% of seniors reached the college readiness benchmark, while only 15.2% reached the benchmark in math (TN DOE). When reviewing college readiness benchmarks in math, science, and all four categories, the trend shows that students' benchmarks readiness has continued to decline over the last decade. Over time, students' understanding of math and science has continued to shrink, and this deficit in knowledge needs to be quickly addressed and rectified.

The STEM Ambassador program has a unique opportunity based on location to make a significant difference in the surrounding community. Because of demographics, ambassadors in SCS schools will be able to reach several URMs at one time in each class room. Near-peer mentoring will allow undergraduate students to not only help with school work, but they can also lead hands-on STEM activities with the students and perform in class demonstrations to show how STEM applies to real world situations. Having STEM Ambassadors present in schools also allows the high school students to ask questions about STEM opportunities and possible future careers. Ambassadors are armed with knowledge not only about their major concentration, but a variety of other STEM fields. Ambassadors are also equipped with a significant amount of resources and educational information to share with any prospective STEM students.

CHAPTER 3:

METHODOLOGY

3.1 Program Development

The STEM Ambassador program began in 2013 at the University of Memphis. A handful of undergraduate students enrolled in STEM majors were asked to participate in local K-12 school systems acting as tutors, teaching aides, and STEM activities facilitators. When this program was initially conceived, it consisted of 5 ambassadors, all engineering undergraduate majors at the university. Two high schools in the Shelby County Schools system were among the first places to receive ambassadors. Upon assignment of the undergraduate students, teachers and faculty were given instruction on how to use these ambassadors to help aid their classrooms. Ambassadors were used in an in-class setting as teaching aides – not as assistants for grading papers or organizing classroom materials. While in classrooms, STEM ambassadors were able to lead demonstrations regarding a STEM topic or facilitate fun and informative hands-on activities with the students. STEM Ambassadors also provided additional support to help keep students on task and attentive to lessons. Ambassadors were also encouraged to assist students who were struggling with material in a one-on-one setting. This allowed the teacher to continue through the lesson with the majority of the class, while providing extra support where needed. This initial model of the STEM Ambassador program was successful on a small scale, but expansion of the program was needed to reach students across Shelby County struggling with STEM concepts. A formal evaluation program was established to track impact and inform development of an operational model.

3.2 Assessing Impact

The STEM Ambassador program was designed to increase K-12 students' interest in and preparation for STEM majors and careers, while providing STEM content support for classroom teachers. Secondary impacts are also expected with the Ambassadors themselves in terms of developing a stronger STEM identity and improved leadership and communication skills. The data available to assess these impacts includes both longitudinal data on student, teacher, and Ambassador perceptions, numbers of students and organizations served, and perceptions of Ambassadors of program impact and efficacy. K-12 student performance data for math and science classes is also available for one year of the Ambassador program under a special research design. The primary research questions to be evaluated are:

1. Do STEM Ambassadors influence K-12 students' interest in STEM majors and careers?
2. Does working with a STEM Ambassador lead to increased understanding of math and science concepts in K-12 students?
3. How do STEM Ambassadors provide value to teachers?
4. How does the STEM Ambassador program impact their own STEM identity and perceptions of leadership and communication abilities?

Data Collection: To assess these research questions, quantitative and qualitative data have been collected each year since the STEM Ambassador program was established. The intent of the evaluation is to not only document impact but to also determine how the program model should be altered to better address the needs of the community being served. Generally, data has been collected via surveys, which were either completed online or on paper. The surveys were filled out anonymously by K-12 teachers and students and the Ambassadors, then entered into an online storage platform (SurveyMonkey.com) for easy export and analysis of large amounts of data. As the program developed, methods of collecting and tracking data have been added and modified to address future research possibilities on Ambassador impact. Table 1 below indicates the different data that has been collected since the beginning of the STEM Ambassador program.

Table 1. Collected STEM Ambassador Data

Year	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Number of STEM Ambassadors	X	X	X	X	X
Ambassador Retention (%)	X	X	X	X	X
Ambassador Impact (Hours Worked)	-	-	-	X	X
Ambassador Impact Surveys	-	X	X	X	X
Number of K-12 students impacted	-	-	-	X	X
K-12 Student Surveys	-	-	X	X	X
K-12 Teacher Surveys	-	X	X	X	X

Certain types of data were tracked since the conception of the program, while the need (and mechanism for tracking) for other data emerged in later years. In the table above, the length of time each type of data has been collected is represented. Longitudinal data, such as number of STEM Ambassadors, retention of participating ambassadors, and impact surveys, are examined in this study. Analysis of longitudinal data depicts growth the program has experienced since it began and the perceived impact of the program via all stakeholders involved.

Longitudinal Data Analysis: The increase in size of the program from year to year and percent of STEM Ambassadors retained each year was important for documenting how the program model was working and where changes were needed to ensure consistent support for those served by Ambassadors. Although the primary purpose of the STEM Ambassador program is to increase K-12 student performance and interest in STEM topics while providing an effective supplemental teaching tool for K-12 teachers to implement into their classrooms, a secondary goal is to enhance critical career skillsets of undergraduate STEM majors employed by this program. Analysis of K-12 teacher and student survey data will determine the effectiveness of Ambassadors in reaching the primary goal while also assessing the skillsets of the Ambassadors. Analysis of Ambassador survey responses measures the perceived increase in core skills (communication, leadership, etc.) as a result of participating in the program, as well as perceptions related to impact with K-12 students. Thus, all three survey collection efforts were designed to measure the primary and secondary goals of the STEM Ambassador program.

Surveys were distributed to both K-12 students and teachers in classrooms that hosted STEM Ambassadors. Surveys were generally brief at only five questions long for both the students and teachers. It was estimated that it would only take students and teachers five minutes or less to respond to the survey questions. Although the student and teacher surveys were the same length, the questions varied. For the students, the following statements were given to assess impact:

1. The STEM Ambassador that worked with my class made learning easier for me.
2. The STEM Ambassador that worked with my class made learning math and science interesting.
3. The STEM Ambassador that worked with my class made me more interested in studying science and math in college.
4. I am more confident in my math and/or science skills because of the help I received from the STEM Ambassador.
5. I would like to have a STEM Ambassador in my class again next year.

Students and teachers both responded with a number 1 through 4, where 1 means they disagree with the statement, and 4 means they strongly agree with the statement. The statements teachers responded to were different, as shown below:

1. Having a STEM Ambassador in my classroom made it easier for me to use project-based learning experiences with my students.
2. Having a STEM Ambassador helped me provide additional support to students struggling with math and/or science concepts.
3. The STEM Ambassador assigned to my classroom was a positive resource for helping me achieve my teaching goals.
4. The STEM Ambassador assigned to my classroom was a positive role model for my students.
5. I believe having a STEM Ambassador in my classroom increased my students' interest in STEM majors and careers.
6. I believe having a STEM Ambassador in my classroom increased my students' mastery of math and/or science concepts.
7. I would like to have a STEM Ambassador in my class again next year.
8. I would recommend the STEM Ambassador program to other teachers.

STEM Ambassadors received end of the year surveys as well, which varied in length and took a bit more time to answer. Responses to these statements were used to measure the success in reaching the secondary goal. Statements were fashioned to be ranked on the same point scale. Questions that appeared on the STEM Ambassador surveys are listed below:

1. In this role, I have helped improve academic skills of K-12 students.
2. In this role I was a good role model for K-12 students.

3. I have encouraged K-12 students to consider a STEM major/career.
4. I have made a positive impact on a student/students by being in this role.
5. I think my students plan to pursue a STEM major/career because of my role.
6. The program helped me develop strong leadership skills.
7. This program helped me develop speaking skills.
8. This program gave me real-world skills that I found very useful.
9. I'm more interested in my major because of the program.
10. This program helped me see that I can make an impact in my community.
11. The program helped me develop relationships with adults and students.
12. This program helped me with understanding other aspects of STEM.
13. I have learned better communication skills from my involvement in this program.
14. I feel like I gained valuable knowledge and insight from my involvement in this program that I could not get elsewhere.

In addition to statements that were responded to with a ranking, open-ended statements appeared at the end of the STEM Ambassador surveys. These questions allowed Ambassadors to share any ideas, comments, or concerns about different aspects of the program. The open-ended questions were as follows:

1. What did you expect to contribute or learn in this program when you started your position as an ambassador?
2. How is what you actually contributed or learned different from what you expected?
3. What is one outcome or benefit that you have experienced that you did not expect from serving as a STEM Ambassador?
4. List three ways you benefited from being a STEM Ambassador/mentor/leader.

5. What could the West TN STEM Hub do to improve Ambassador/Mentoring programs in future years?
6. Do you have any suggestions for improvement of the STEM Ambassador program (for the students and/or for the Ambassadors)?
7. Do you have any suggestions for how to measure the impact of the program?

2015-2016 Data Collection: In addition to data presented in Table 1, test score data from the 2015-2016 school year was collected as part of a pilot program with Shelby County Schools. The performance data obtained was from the Northwest Evaluation Association (NWEA). The NWEA is a progress assessment that is available for every subject (math, science, reading, and language). Unlike the traditional standardized testing method, which is subject to indiscretion (testing error, incorrect score reporting, incomprehensive results, or inconsistencies in various tests administered across grades), the NWEA uses a research-based assessment. This assessment, called the Measures of Academic Principles (MAP), is individualized to a specific students' growth and progress measured at three different points throughout the school year: beginning of the year (fall), halfway through the year (winter), and at the end of the year (spring) (Northwest Evaluation Association). Nine schools where Ambassadors were placed in the SCS system were selected as the sample for this specific 2015-2016 data collection initiative. For the purpose of this study, math and science scores only were analyzed. Table 2 below indicates the scores obtained from participating schools and classes. Participating schools are identified by type (elementary school - ES, middle school - MS, or high school - HS) as indicated in Table 2.

Table 2. Schools and Classes Analyzed

Class Type	ES1	ES2	MS1	MS2	MS3	MS4	MS5	MS6	HS1
Math	X	X	X	X	X	X	X	X	X
Science		X		X	X	X	X	X	

In order to better determine the impact of STEM Ambassadors in the affected classrooms, students' scores with a STEM Ambassador present in the class were compared to a group of their matched-peers that did not receive STEM Ambassador support. In order to address teacher impact on student performance, both groups of students (with and without a STEM Ambassador) had the same teacher for their class, ensuring teacher impact was equal for both groups.

An initial analysis of variance (ANOVA) test was conducted on data from the beginning of the year between the group of students with and without the ambassador to ensure that there was not a statistically significant difference in test scores between the groups. This means students with and without the ambassador started at the same knowledge level. Scores from later in the year (winter and spring) were also assessed between the different groups to determine the impact of ambassador presence on students' test scores. Excel was used to perform the analysis of test score data throughout the year.

CHAPTER 4:

RESULTS

4.1 Evidence of Impact

Do STEM Ambassadors influence K-12 students' interest in STEM majors and careers? The sample totaled 237 students that came from nine various elementary, middle, and high schools in the Shelby County School system. The students were surveyed across years 2015 – 2017. At the end of the school year, students completed these surveys on paper, and then the responses were stored in an online platform for analysis at a later data. Table 1 below shows the percentage of students that agreed with each statement on their survey.

Table 3. K-12 Student Responses to Survey Statements

Survey Statement	Percent Agree (%)
The STEM Ambassador that worked with my class made learning easy for me.	91
The STEM Ambassador that worked with my class made learning math and science more interesting.	77
The STEM Ambassador that worked with my class made me more interested in studying science and math in college.	68
I am more confident in my math and/or science skills because of the help I received from the ST$EM Ambassador.	80
I would like to have a STEM ambassador in my class again next year.	96

Via survey responses from the K-12 student surveys, STEM Ambassadors are having a positive impact on increasing student interest in pursuing math and science opportunities post high school. STEM Ambassadors increased interest in 68% of K-12 students – more than half of students surveyed. By making students more interested in math and science in general, STEM Ambassadors were able to increase the possibility of those K-12 students pursing math and science as a potential career.

While Ambassadors worked with students, they were able to offer encouragement that lead to an increase in 80% of K-12 students' confidence in their ability to perform well in these math and science courses. In turn, 91% of K-12 students found that STEM Ambassadors made learning easier for them.

Does working with a STEM Ambassador lead to increased understanding of math and science concepts in K-12 students? Along with survey data, test score data obtained from the NWEA was analyzed. An ANOVA analysis was conducted to verify that there was not a statistically significant difference in average test scores at the beginning of the school year (fall) between students with and without a STEM ambassador. Each ANOVA test was conducted with $\alpha = 0.05$ and a null hypothesis (H_0) that the mean test score of those without a STEM Ambassador (μ_1) is equal to the mean test score of those with a STEM Ambassador (μ_2). Tables 1 through 9 are the ANOVA analysis results for each school at the beginning of the school year.

Table 4. ANOVA Analysis for ES1 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	1204.717	1	1204.72	9.265	0.003	3.986
Within Groups	8451.940	65	130.030			
Total	9656.657	66				

Table 5. ANOVA Analysis for ES2 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	226.441	7	226.441	1.221	0.275	4.0427
Within Groups	8898.779	48	185.391			
Total	9125.220					

Table 6. ANOVA Analysis for MS1 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	104.836	1	104.836	1.887	0.177	4.072
Within Groups	2332.800	42	55.543			
Total	2437.636					

Table 7. ANOVA Analysis for MS2 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	58.328	1	58.328	0.232	0.634	4.210
Within Groups	6798.362	27	251.791			
Total	6856.690	28				

Table 8. ANOVA Analysis for MS3 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	343.220	1	343.220	2.047	0.159	4.043
Within Groups	8048.800	48	167.683			
Total	8392.020	49				

Table 9. ANOVA Analysis for MS4 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	4.424	1	4.424	0.080	0.778	4.113
Within Groups	1978.550	36	54.960			
Total	1982.974	37				

Table 10. ANOVA Analysis for MS5 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	2396.909	1	2396.909	34.114	0.005	4.057
Within Groups	3092.341	46	67.225			
Total	5489.25	47				

Table 11. ANOVA Analysis for MS6 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	8262.893	1	8262.893	68.692	0.006	4.210
Within Groups	3397.214	26	130.662			
Total	11660.110	27				

Table 12. ANOVA Analysis for HS1 Math

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	5591.991	1	5591.991	22.959	0.002	4.091
Within Groups	9498.985	39	243.564			
Total	15090.980	40				

Table 13. ANOVA Analysis for ES2 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	483.955	1	483.955	7.865	0.013	4.494
Within Groups	984.545	16	61.534			
Total	1468.500	17				

Table 14. ANOVA Analysis for MS2 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	0.006	1	0.007	0.004	0.995	4.149
Within Groups	4752.229	32	148.507			
Total	4752.235	33				

Table 15. ANOVA Analysis for MS3 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	534.713	1	534.713	4.977	0.032	4.121
Within Groups	3760.584	35	107.445			
Total	4295.297	36				

Table 16. ANOVA Analysis for MS4 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	53.289	1	53.289	1.276	0.266	4.113
Within Groups	1503.579	36	41.766			
Total	1556.868	37				

Table 17. ANOVA Analysis for MS5 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	2257.447	1	2257.447	34.999	0.004	4.067
Within Groups	2773.530	43	64.501			
Total	5030.978	44				

Table 18. ANOVA Analysis for MS6 Science

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	6086.001	1	6086.001	111.674	0.000	4.210
Within Groups	1471.448	27	54.498			
Total	7557.449	28				

In tests where the F value is smaller than the F-critical value, the results fail to reject the null hypothesis, meaning that there was not a statistically significant difference in means with and without a STEM Ambassador. School courses that failed to reject the H_0 in Math were identified with a '✓' in Table 19 below. School courses that rejected the H_0 are indicated with an 'X' below.

Table 19. Selection of School Subjects based on ANOVA Results

Class Type	ES1	ES2	MS1	MS2	MS3	MS4	MS5	MS6	HS1
Math	X	✓	✓	✓	✓	✓	X	X	X
Science		X		✓	X	✓	X	X	

Schools that failed to reject the H_0 in Science were identified as MS2 and MS4. However, MS4 did not have science scores through the winter and spring, so this school was removed from analysis. The schools where students with a STEM Ambassador showed a statistically significant difference in score data at the beginning of the school year were removed from the study (ES1 Math, MS5 Math, MS6 Math, HS1 Math, ES2 Science, MS3 Science, MS5 Science, and MS6 Science). However, a closer look into these specific schools reveal reasons why there is a statistically significant difference in score data. This will be addressed in the following section of this study.

Analysis of test scores throughout the school year was performed, and the results indicate a positive difference in student test scores where students worked with an ambassador in their classroom versus those that did not. These results for halfway through the school year (winter) math and science scores are shown in Figure 1 and Figure 2 below.

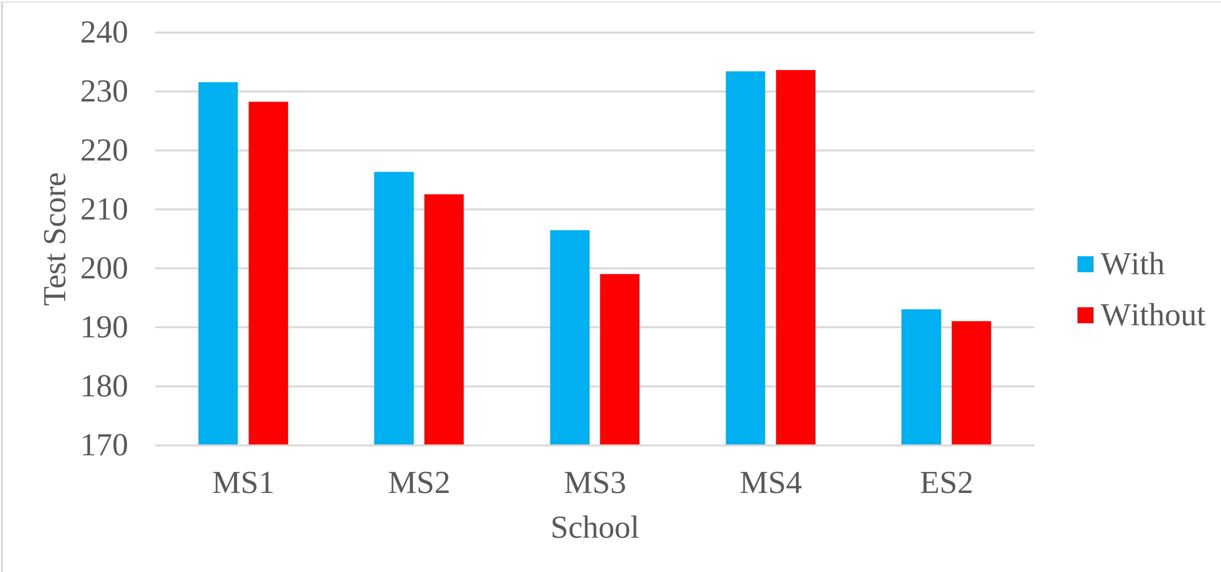

Figure 1. Winter Math Test Scores of Students With a STEM Ambassador vs. Students Without a STEM Ambassador

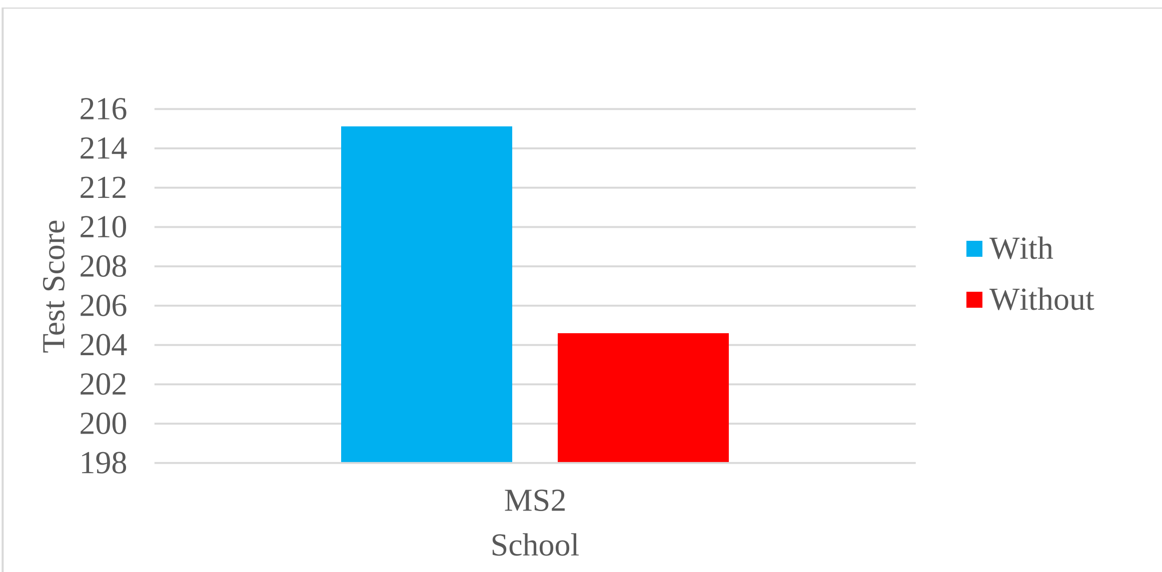

Figure 2. Winter Science Test Scores of Students With a STEM Ambassador vs. Students Without a STEM Ambassador

As indicated in the above figures, students at all schools in both classes with an ambassador earned either the same score or higher in the winter than the students without an ambassador's assistance. Next, an analysis was conducted on students at the end of the school year (spring) to determine if students with a STEM Ambassador continued to show improvement in comparison to the students without a STEM Ambassador in their classroom. The results for spring test scores are shown in Figure 3 and Figure 4 on the following page.

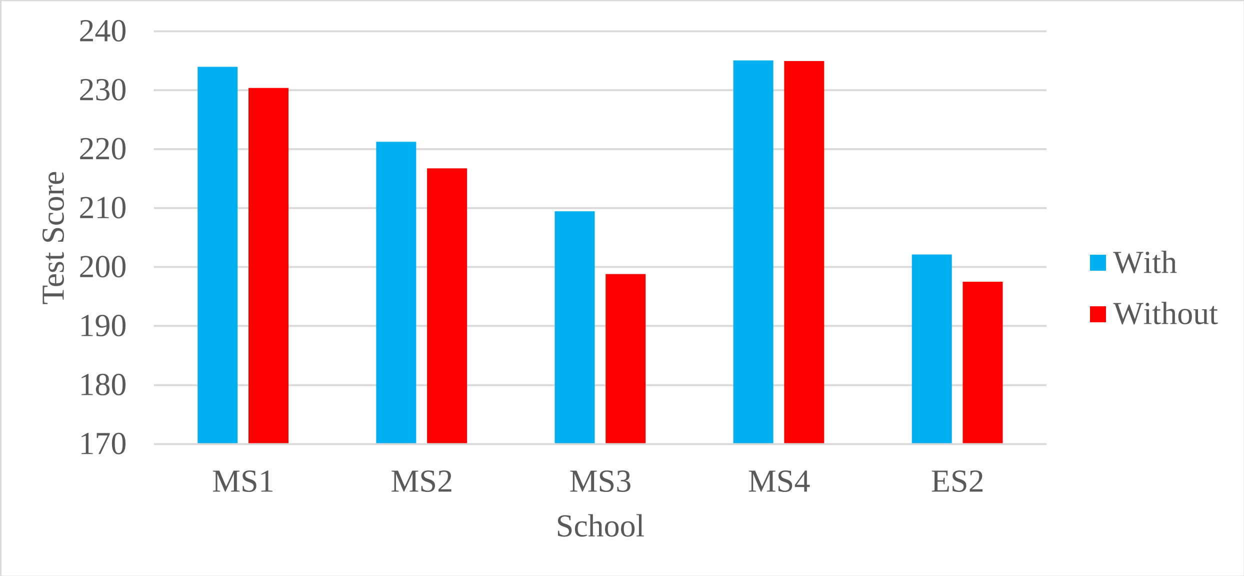

Figure 3. Spring Math Test Scores of Students With a STEM Ambassador vs. Students Without a STEM Ambassador

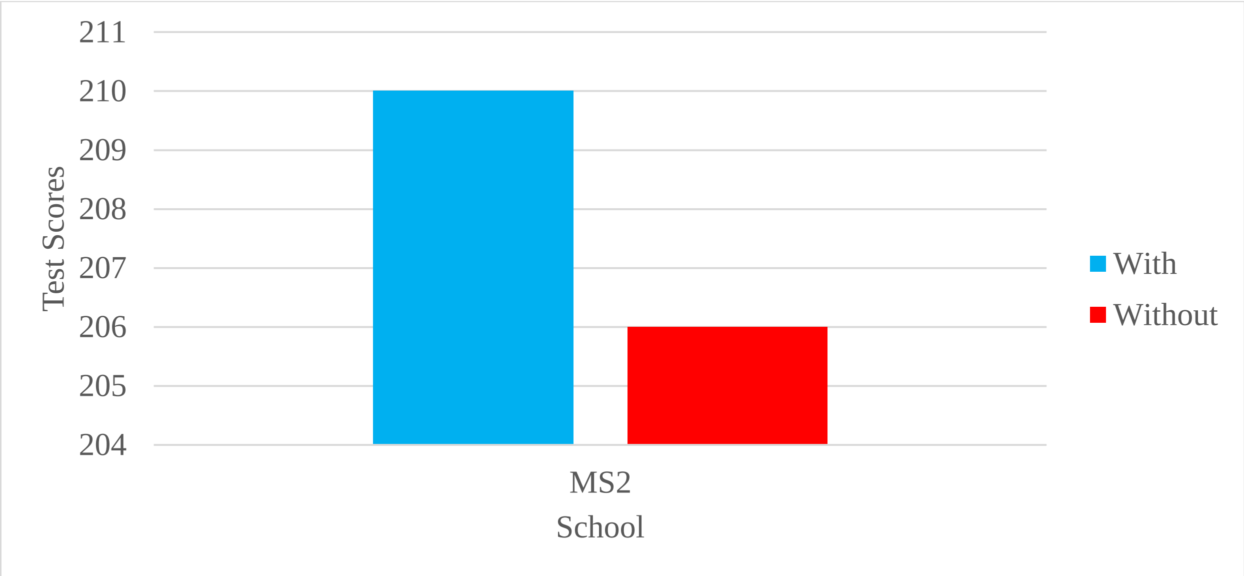

Figure 4. Spring Science Test Scores of Students With a STEM Ambassador vs. Students Without a STEM Ambassador

As indicated in the above figure, students at all schools with an ambassador in their math and/or science classroom earned the same test score or higher score in the spring than the students without an ambassador's assistance. Four out of six schools showed a statistically significant difference in scores between the students with and without STEM Ambassadors; on average, 30% more students in classrooms with a STEM Ambassador had significantly higher achievement than those that did not. While there was not a statistically significant difference in test scores from fall to spring in all cases, there was a generally positive trend in the scores between students with a STEM Ambassador versus the scores of those without a STEM Ambassador.

A composite ANOVA analysis was done of all elementary students' math test scores at the beginning and end of the school year to determine if there was a statistically significant difference between those with and without a STEM Ambassador. Table 20 below shows the output of the ANOVA analysis at the beginning of the year.

Table 20. Fall Composite Elementary School Students ANOVA Output

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	141.251	1	141.251	0.620	0.432	3.896
Within Groups	39176.364	172	227.770			
Total	39317.615	173				

As indicated in Table 20, there was not a statistically significant difference in test scores between the two groups of students at the beginning of the school year. Table 21 below shows the results of the ANOVA analysis conducted between the groups of students with and without a STEM ambassador at the end of the school year.

Table 21. Spring Composite Elementary School Students ANOVA Output

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	4273.888	1	4273.888	19.711	0.914	3.915
Within Groups	2791.242	129	216.831			
Total	32245.130	130				

As indicated in the above table, there is a statistically significant difference in test score data between those students with a STEM Ambassador at the end of the school year, versus those without a STEM Ambassador.

A composite ANOVA test was conducted on all of the middle school students' math test scores at the beginning and end of the school year to determine if there was a statistically significant difference between those with and without a STEM Ambassador. Table 22 below shows the output of this ANOVA test for test scores at the beginning of the school year.

Table 22. Fall Composite Middle School Students ANOVA Output

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	738.841	1	738.841	2.670	0.103	3.870
Within Groups	90768.056	328	276.732			
Total	91506.897	329				

As indicated in Table 22, there was not a statistically significant difference in test scores between the two groups of students at the beginning of the school year. Table 23 below shows the results of the ANOVA analysis conducted between the groups of students with and without a STEM ambassador at the end of the school year.

Table 23. Spring Composite Middle School Students ANOVA Output

Source of Variance	SS	df	MS	F	P-Value	F-crit
Between Groups	9535.635	1	9535.635	23.735	0.165	3.867
Within Groups	145434.123	362	401.751			
Total	154969.758	363				

As shown in the above table, there is a statistically significant difference in test score data between those students with a STEM Ambassador and those without a STEM Ambassador at the end of the school year.

How do STEM Ambassadors provide value to K-12 teachers? Sixteen K-12 teachers between the years 2014 – 2018 that had a STEM Ambassador stationed in their classrooms were given brief, five statement surveys to complete. The five survey statements for each teacher to rate are listed in Table 24 below, as well as the percentage of teachers that agreed with each statement.

Table 24. K-12 Teacher Responses to Survey Statements

Survey Statement	Percent Agree (%)
Having a STEM Ambassador in my classroom made it easier for me to use project-based learning with my students.	94
Having a STEM Ambassador helped me provide additional support to students struggling with math and/or science concepts.	100
The STEM Ambassador was a positive resource for helping me achieve my teaching goals.	94
I would like to have a STEM Ambassador in my class again next year.	98
I would recommend the program to other teachers.	100

As indicated in the above table, STEM Ambassadors are a resource for teachers as well as students. Communication with teachers allows the STEM Ambassador to address teachers' needs, helping the classroom function more efficiently and provide students with the most effectively learning environment. As the program developed, other questions pertaining to their specific ambassador (punctuality, attitude, etc.) were added to their surveys.

How does the STEM Ambassador program impact their own STEM identity and perceptions of leadership and communication abilities? Since conception of the program in 2013, STEM Ambassadors have been required to complete an exit survey at the end of each school year. Forty-one STEM Ambassadors over 2016 – 2018 were surveyed, answering the following questions in Table 25.

Table 25. Ambassador Responses to Survey Statements

Survey Statement	Percent Agree (%)
In this role, I have helped improve academic skills of K-12 students.	85
In this role I was a good role model for K-12 students.	90
I have encouraged K-12 students to consider a STEM major/career.	93
I have made a positive impact on a student/students by being in this role.	95
I think my students plan to pursue a STEM major/career because of my role.	56
The program helped me develop strong leadership skills.	90
This program helped me develop speaking skills.	80
This program gave me real-world skills that I found very useful.	93
I'm more interested in my major because of the program.	71
This program helped me see that I can make an impact in my community.	95
The program helped me develop relationships with adults and students.	93
This program helped me with understand other aspects of STEM.	90
I have learned better communication skills from my involvement in this program.	90
I feel like I gained valuable knowledge and insight from my involvement in this program that I could not get elsewhere.	93

Along with responding to the above questions, STEM Ambassadors themselves addressed the open-ended responses with suggestions regarding all aspects of the program, such as improving efficiency in data recording, suggestions for long-term storage and collection of data, and future research possibilities.

CHAPTER 5:

DISCUSSION

5.1 Interpreting Results

Do STEM Ambassadors influence K-12 students' interest in STEM majors and careers? As indicated in the previous section, STEM Ambassadors do play a significant role in increasing K-12 students' interest in pursuing STEM opportunities post high school. 77% of K-12 students claimed that having a STEM Ambassador in their classroom made learning math and science easier for them, which resulted in 68% of these students more likely to pursue math and science opportunities in college. STEM Ambassadors are able to increase students' interest in math and science by being positive role models in these positions, as well as share real-world examples about the opportunities that exist in STEM positions.

Does working with a STEM Ambassador lead to increased understanding of math and science concepts in K-12 students? While 80% of students claimed that the assistance of a STEM Ambassador made them more confident in their math and/or science skills, 91% of students reported that having a STEM Ambassador in their classroom made learning this material easier for them. Through ANOVA tests, classrooms with and without STEM Ambassadors were identified that began at the same academic level. Throughout the year, performance of these groups of students were compared to one another. At the end of the school year, additional ANOVA tests were conducted to determine if those with an Ambassador were performing at a different level academically. ANOVA tests verified that there was a statistically significant difference in means between groups of students with and without an Ambassador at the end of the school year. In this STEM Ambassador position, undergraduate students are able to bridge the gap between the traditional lecturing method and the active learning method that K-12 students benefit from. Because STEM Ambassadors are generally closer to the age of the K-12 students than the teachers, students often can relate more to the STEM Ambassador. This makes students more likely to respond to STEM Ambassadors influence and teachings.

How does the STEM Ambassador program impact K-12 teachers? According to survey responses, 100% of teachers agreed that having an ambassador in their classroom provided additional support to the students struggling with either math or science courses, while 94% of teachers reported that having an ambassador in their classroom assisted them in being able to reach their teaching goals. Every teacher surveyed would like to have a STEM Ambassador in their classroom in future years. In summarizing these survey responses, it is observed that ambassadors not only help the K-12 students, but the ambassadors provide teachers with valuable assistance inside the classrooms.

How does the STEM Ambassador program impact their own STEM identity and perceptions of leadership and communication abilities? STEM Ambassadors were asked about development of several skills through participation in the program. 90% reported that they were more knowledgeable about various areas of STEM, as well as developed stronger communication and leadership skills. 80% of participating ambassadors claimed they strengthened their public speaking skills through the program. 71% of ambassadors also reported that they were more interested in their own major due to their experience in the program. Teaching K-12 students ensures that ambassadors thoroughly understand the material that is the foundation to their undergraduate degrees in STEM. As they clarify any of their own misunderstandings while they teach others, this solidifies the knowledge in their own field, thus making their major more interesting to themselves.

5.2 Iterative Process to Fully Evolved Model

The STEM Ambassador program has changed in response to increasing demand for support. As the model evolved and the number of students and teachers served expanded, it was crucial to also develop a formal structure around several key areas: program funding, Ambassador recruitment, Ambassador role, training, and program evaluation. These program areas are described in the following sections.

Program Funding: As word of the STEM Ambassador program spread, more schools, organizations, and events requested assistance from the STEM Ambassador program. While originally only serving high school-aged students, through word of mouth and showcase events in the community, teachers working with all ages requested Ambassadors be present in their math and science courses. Originally, program funding was obtained through a Tennessee Department of Education grant. It quickly became apparent that with the dramatic increase in requests for support, a variety sources of funding were needed to ensure program sustainability. The funding model now includes applying for a variety of federal, state, and local grants each year while also securing support from corporate partners, community organizations, and school districts.

Ambassador Recruitment: By 2018, the STEM Ambassador program grew by nearly eight times its original size. Rather than only hiring undergraduate engineering majors, STEM Ambassadors are now recruited from any college STEM major, such as engineering, sciences, information technology, mathematics, and computer science. A formal online application and personal statement are now required for consideration for Ambassador positions. Applicants must also secure letters of recommendation from two faculty members in order to be considered for these roles. Applicants are expected to have a 3.0 GPA in their STEM major and must maintain a minimum of 2.75 GPA to remain in good standing in the program.

Ambassador Role: Ambassadors can take on a variety of different roles. The first is working as a teaching aide. Based on the locations, classrooms, and organizations that are requesting the assistance of an ambassador, STEM Ambassadors are assigned to match their strengths and content knowledge with program needs. For example, if a robotics club at a high school wants the advice or guidance of an Ambassador, a STEM Ambassador majoring in programming or computer engineering may be better geared for that specific group of students than a chemistry major.

Ambassadors that are regularly assigned to participate in a teacher's classroom are expected to report to that location at the same time each assigned day to serve that classroom in the best way possible. Some days, STEM Ambassadors may assist by helping struggling students catch up while the teacher continues through the lesson with the rest of the class. Other days, the ambassador may bring a fun, hands-on activity, such as KNEX or robotics kits, and ask the class to perform a series of challenges related to an area of STEM. As well as leading the class in various STEM activities, Ambassadors can also teach a lesson in place of the teacher during some classes, providing additional content expertise in specific areas where teachers may need support. Ambassadors should be used in a method that is both useful to developing the student's skills and the Ambassadors skills as well. As Ambassadors serve to help the students, they too can strengthen their own understanding and knowledge in STEM concepts. In addition to strengthening their foundations in STEM topics, leadership and networking skills are enhanced by the constant interaction between students, teachers, and other members of the community.

Ambassadors also serve in positions related to extracurricular activities in local schools. Some schools request support for after-school tutoring, where students will stay after school to get help with homework assigned in classes through the day or will simply stay to get further instruction on material covered in the classrooms. Students ask for help regarding their homework assignments, and ambassadors create practice problems similar to the homework problems for the students to work through and model problem solving skills. Ambassadors offer guidance and help through solving the problems, asking leading questions to help the students work through the problems on their own. Ambassadors do not give students the answer to a problem, but rather help them determine the correct method and successfully apply it to solve a specific type of problem. In these after-school programs, ambassadors also create fun, engaging games pertaining to the math and science material covered in students' courses. These after-school programs are a relaxed learning environment for students wanting extra practice or exposure in STEM material.

Community organizations also request the assistance of STEM Ambassadors. Leaders of robotics clubs, math leagues, youth organizations (such as Boys and Girls Clubs and Girls, Inc.), career fairs, and STEM expos often request that ambassadors come to facilitate STEM demonstrations or lead STEM activities with the students. STEM Ambassadors can come equipped with pre-planned activities and challenges to engage K-12 students in STEM concepts. Career fairs call on ambassadors to bring STEM pamphlets and information sheets pertaining to various STEM majors and careers. Ambassadors can share opportunities in STEM fields with young students to get them interested at an early age. Ambassadors not only serve as facilitators in STEM activities, but they also can share resources and knowledge pertaining to all of the different post-secondary STEM opportunities.

As the program continued to grow and the number of Ambassadors needed increased, coordinating teacher class schedules and on-call events became an increasingly time-consuming and tedious task and monitoring Ambassador performance became increasingly challenging. A lead ambassador position was developed address this issue. The ambassador in this position has several different responsibilities, such as collecting ambassador schedules, collecting teacher schedules, keeping track of all on-call events, as well as totaling collective ambassador hours worked and number of K-12 students impacted by ambassador outreach. The lead ambassador is also in charge of keeping in contact with teachers being served (via a monthly check-in email) to handle any issues with their assigned ambassador (attendance, involvement, etc.). At the beginning of the semester for the undergraduate college students, their work availability is collected and stored in a spreadsheet while awaiting the teacher schedules for various schools throughout the school system. After both the teacher and Ambassador availability is determined, Ambassadors are assigned to their class, club, or on-call position for the semester.

Training: Since the STEM Ambassadors work with minors in mentoring relationships, each undergraduate student is required to undergo a background check with the University of Memphis. Each ambassador must also attend and complete a training required by the University of Memphis that instructs them on how to interact with minors. Ambassadors must also complete separate background check, fingerprinting, or training requirements of all school districts and organizations they will serve.

A mandatory training program was also developed to support Ambassadors in pedagogy, communication, leadership, and other relevant skills required for success in the program. As Ambassadors often lead STEM learning experiences with K-12 students, it is crucial that they not only have a solid understanding of the STEM content they are teaching, but that they are also well prepared to deliver the content effectively. Ambassadors must attend one-hour monthly trainings and extended training sessions and workshops between semesters. Individual and small group training sessions are also provided to new ambassadors as part of the on-boarding process. Training sessions are also used to address any comments or concerns expressed by teachers or leaders of community organizations served by the program.

Program Evaluation: Evaluation is done by different groups affected by the STEM Ambassador program. Ambassadors must complete an exit survey at the end of each year they serve in the program, evaluating the program as a whole, assessing the impact they had throughout the year at their different assignments, as well as providing feedback on the teachers and workers they served with throughout the year. Ambassadors that are assigned to a specific school are evaluated by their assigned teacher every month, and the teacher reports on their punctuality, attentiveness, and work with the K-12 students. When test score data is received, similar to data produced by the NWEA in this research, evaluation of the impact of STEM Ambassadors on student performance can be evaluated.

CHAPTER 6:

CONCLUSIONS

6.1 Summarize Findings

The STEM Ambassador program yields positive results with students, teachers, and the Ambassadors themselves. K-12 students with a STEM Ambassador in their class perform better on math and science standardized tests, as well as show an increase in interest in STEM topics and opportunities. Not only do students perform better on these tests than their matched peers without an ambassador, but they continue to perform better throughout the school year. Even though the demand for STEM jobs is growing faster than any other occupations, the number of students entering in STEM field is alarmingly low. STEM Ambassadors have proven to increase K-12 students' interest in pursuing STEM opportunities after high school. Establishing a STEM Ambassador Program at any university where the surrounding K-12 audience is struggling will benefit all parties involved.

K-12 teachers with STEM Ambassadors in their classroom are able to do more hands-on activities with students, as well as get additional academic help for struggling students. STEM Ambassadors are able to bring new ideas, as well as new technology, to the classrooms that teachers may not have access to or be comfortable with implementing. With a STEM Ambassador in their classroom, teachers are able to share their workload, such as having a STEM Ambassador facilitate activities or teach a lesson. 100% of teachers that had a STEM Ambassador in their classroom would like to have one in the future, which indicates that the ambassadors are a valuable resource to teachers.

STEM Ambassadors broaden their individual knowledge of STEM fields and work on skills that are beneficial to their future careers. Communication and leadership skills are essential to have in the workforce and being in this program helps develop those skills for future use. In fact, anecdotal information also indicates that engagement in the STEM Ambassador program is a distinguishing factor that results in both internship and permanent job offers for the Ambassadors versus their peers. As STEM Ambassadors tutor students in STEM classes, they strengthen their fundamental understanding of these subjects, establishing a solid foundation for tougher STEM courses they complete in college.

6.2 Best Practice Results

While developing a STEM Ambassador program, the best practice model below should be considered.

- Establishing Clear Goals: Establishing clear goals for what the partnering institutions want to achieve with the program should be established at the outset to ensure successful implementation. The mission of the program should be defined to ensure proper selection of the undergraduate students as STEM Ambassadors. Defining the roles and responsibilities of the STEM Ambassadors should be done at the outset so that undergraduate students interested in these positions know exactly what will be expected of them.
- Selection of STEM Ambassador: When selecting an undergraduate student for employment in the STEM Ambassador program, their academic performance and social skills should be considered. The ambassadors serve as representatives of the university, and they need to be effective when sent into the school system. Strong performance in their area of study, as well as adequate people skills, allows them to be effective mentors and resources in the K-12 community. Students must also be very self-motivated and responsible since this is not a ‘typical’ job with direct supervisor oversight, and

Ambassadors must be capable of maintaining schedules and adapting to on-site needs independently.

- Ambassador Training: Since STEM Ambassadors work with minors, they must complete a background check and structured orientation through the school system they work with. In addition, training sessions should be held for ambassadors to become familiar with activities they may encounter throughout the school year and learn about relevant pedagogy, communication, and leadership practices. During training, ambassadors should also discuss resources they may have to access during the school year for K-12 students or teachers about opportunities in STEM.
- Appointing a Lead STEM Ambassador: As the program increases in size, it is critical to have a lead ambassador. This individual needs to have strong leadership and organizational skills. Generally, the lead ambassador organizes program meetings and facilitates training sessions. This position is also essential for coordinating schedules, spreading event information, and documenting program impact.
- Documenting Impact: In order to secure funding through grants and corporate sponsors, it is critical to document and share impact of the program. All ambassador hours worked at schools or organizations should be tracked on a running document, such as excel. All details of an event, such as location, duration, and type, number of students impacted, age of students and school or organization served should be recorded. This ensures that program directors can 'tell the story' of how STEM Ambassadors have supported the community.
- Communication: As the program grows, communication becomes more critical. The lead position, as well as the faculty advisor, should be able to reach any STEM Ambassador

via email or phone during normal work hours. Establishing a platform, such as a web platform (Basecamp is used for the current project), is necessary to spread information on upcoming events, training, or time reporting.

CHAPTER 7:

RECOMMENDATIONS FOR FUTURE RESEARCH

7.1 Recommendations

Establishing a method of time reporting will save a significant amount of time later on. Currently, the STEM Ambassadors in the program simply state whether or not they can work an event, keep track of their hours, and report their time. The faculty advisor then has to approve their time sheet, assuming the ambassador reported their time honestly. If there is any discrepancy in the number of hours worked, the lead ambassador has to check the number of hours reported with the events the ambassador has worked over the last two weeks, and this can be an exhausting ordeal. A method of clocking in and clocking out should be developed to make sure correct time is reported by each ambassador. Web applications, although they come at cost, are available to support this type of practice.

7.2 Limitations of Research

Only one year of test score data was available to inform this project, since the data had to be collected through the research office with the partnering school district and required grant funding. In addition, surveys were only distributed to K-12 students during the same year, again as part of a specific grant-funded project. Developing and coordinating a consistent data collection process (and an agreement process with partnering districts/organizations) is important for future research and assessment of the program. When this type of process is established, more rigorous research can be used to track impact over time.

7.3 Improve Evaluation

When developing the survey for students, including questions pertaining to race, gender, and other specific demographics allow future research to be more detailed. Future studies could track individual K-12 students to investigate how they perform through elementary, middle, high school, and on to college. If a STEM Ambassador was assigned to their classroom at any point in time, tracking the students' performance and path after high school would allow researchers to investigate if there is a correlation between STEM Ambassadors, students' academic success, and future career choices.

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List of Figures