ACADEMIC OUTCOMES OF STUDENTS IN STEM-ACCREDITED SCHOOLS

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Abstract

Schools across the globe are looking to include quality Science, Technology, Engineering, and Mathematics (STEM) education in their schools. This research examined a collection of data over the effect on test scores in schools that implement STEM. This study also analyzed interviews with teachers and their thoughts on STEM and STEM professional development. Although many studies have discussed the positive effects of STEM in schools, there are few studies that explored how STEM schools influence test scores. There are difficulties with conducting this study because there are limited numbers of STEM schools. Even though many schools implement STEM, few schools are STEM accredited or have not been accredited for a prolonged period. The problem to be investigated is the comparison of United States assessment scores in STEM schools vs. Traditional schools (non-STEM). This study also examined STEM state test scores over a prolonged period. Finally, this study also sought to explore some of the factors that may have contributed to the inconsistent test scores in STEM schools across the United States by reviewing data on test scores in Ohio and North Carolina and interviewing educators who work in STEM schools. The findings of this research can serve as a guide to educators and administrators who are considering implementing STEM in their schools and how it can negatively affect or positively affect their school test scores.

Key Words: STEM, test scores, teacher education, STEM integration, professional development, state assessments

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Chapter I

Introduction

Science, Technology, Engineering, and Mathematics (STEM) integration is becoming popular in schools across the globe. Teaching through the engineering design process requires students to apply their knowledge by completing a real-world problem through hands-on learning and inquiry. Teachers expect students to think like a scientist while using the knowledge they have learned through their curriculum/standards. Students learn by doing and are encouraged to develop new understandings. STEM integration has been shown to benefit students of all academic achievement levels. Hockett (2009) examined

> all major curriculum recommendations for gifted learners and found five principles of agreement: uses a conceptual approach within a discipline; pursues advanced levels of understanding; asks students to use process and materials that approximate those of a practicing professional in the domain; and emphasizes problems, products, and performances that are true-to-life with transformational outcomes, and the curriculum needs to be flexible enough to allow self-directed learning fueled by student interest (p. 3).

All these curriculum recommendations for gifted students also followed the STEM pedagogy, which was explained and studied by Leung (2019). Whether students are gifted or not, STEM integration tends to allow students to learn through their own experiences, which in return should benefit them for the remainder of their educational career. Multiple studies show that STEM provides students with ample opportunities to grow and learn, while also transforming their learning process to become lifelong learners (Gnagey & Lavertu, 2016; Han & Capraro, 2015; Margot & Kettler, 2019).

Despite the assumed benefits of schools focused on STEM integration, overarching questions for this study were:

1) How does STEM School designation relate to state assessment scores in science, math, and reading across the United States?
2) What are the factors that may contribute to the data collected on state assessments in STEM schools?
3) How does professional development for teachers, or the lack thereof, relate to student achievement in STEM schools?

The problem investigated in this study was the comparison of state test scores in STEM schools over time as well as state test scores in STEM schools versus Traditional schools (non-STEM). The purpose of this study was to identify how STEM school designation related to state proficiency scores in math, science, and reading. This study also explored factors that may have altered the results of student performance on state assessments.

Research Questions

1) To what extent do scores on state assessments vary among students in traditional schools when compared to those in STEM-designated schools?
2) To what extent is teacher preparedness in STEM pedagogy associated with student achievement on state assessments?

Hypothesis

1) No differences in state test scores for Math, Science, and Reading exist among STEM-designated and Non-STEM designated schools in the United States across Grades 3-12.

2) No differences in student achievement as measured by the state tests exist across levels of teacher preparedness in STEM-designated schools.

A multitude of studies has extolled the benefits of STEM integration in K-12 schools (Capraro, 2015; Margot & Kettler, 2019; Saw, 2019). STEM integration has been embraced as an authentic approach to prepare students in the areas of STEM within a developmentally appropriate context. If taught properly, every STEM design/lesson should relate to a specific standard and provide students with a hands-on approach that extends their learning (Jamil et al., 2018). If taught incorrectly, STEM may be viewed as a waste of instructional time. Many researchers have gathered data on state test scores (Gnagey & Lavertu, 2016; Kogo-Masila, 2017; Saw, 2019; Timms et al., 2019). These data were beneficial because they provided an insight on the impact STEM had on a student's test score over time; however, many researchers have not compared the test scores of STEM schools over time or have not explored the possible factors behind the results of state test scores.

The participants in the study met the following requirements: attended a STEM accredited school in either middle or high school, and participated in state tests. The independent variable of this study is the type of school – STEM-designated or traditional programs. The dependent variables included the academic outcome in STEM accredited schools as measured by test scores from the state assessment. These students varied in academic ability as well as ethnicity and age. The ages were from 10-18 years old.

The assumptions made in this study were that all students participated in the state assessment to the best of their ability. It was also assumed that students in STEM and traditional schools were taught math, science, and reading.

One limitation of this study was that a vast majority of STEM schools have not been STEM accredited for a prolonged amount of time. This limited the amount of data that were available. Tracking the data over time and recognizing trends in STEM schools could alter the results. Socioeconomic status and parental involvement or lack thereof could have also altered the data.

Current Study

The current study sought to analyze multiple data sets on student achievement in STEM schools in comparison to traditional schools. This study also explored the possible factors that may contribute to the results of the test scores in STEM schools versus Traditional schools. The study analyzed interviews of multiple teachers across the United States to determine how the teachers felt about STEM in their schools and why it was beneficial to students. This study provided information that allowed educators and administrators to determine if STEM integration was beneficial or harmful (to state tests) to administer in their schools.

Administrators may be able to use this information to explore the effects of teacher preparedness in STEM and its association with state test scores. If schools can identify a problem and recognize that there is a trend, changes can be made to improve test scores. If schools are not able to identify the problem with state test scores, the prospects of STEM expanding integration could be diminished.

Chapter II

Review of Literature

The review of literature discusses the learning and achievements in STEM schools across the nation. Specifically identifying the importance of STEM integration and the benefits it provides for students of all academic abilities. Teacher views on STEM integration is also discussed, also looking at the benefits and limitations it possesses. The discussion of literature provides educators, administrators, parents, and students with information on STEM integration in schools and what it can provide a school.

Learning and Achievements

Many researchers discussed the benefits of integrating STEM in schools K-12. Gnagey and Lavertu (2016) explored the benefits of STEM schools and stated,

> These schools feature problem-based learning, interdisciplinary instruction, student autonomy, and "rigorous learning," which often entails mastery learning and a staff-created curriculum that features real-world applications. These schools also emphasize establishing a positive school culture, developing skills that students can use in their everyday lives and future careers, personalized learning, and a connection between the school and local community (p. 3).

Other researchers stated, "Teachers believe STEM education is inherently motivating to students. The complex, open-ended design of STEM challenges also leads to student increases in academic achievement" (Margot & Kettler, 2019, p. 4). Researchers and teachers can identify the many benefits of STEM integration; however, a common trend in many studies is that STEM provides an engaging approach to learning.

Researchers showed that providing students with interesting lessons results in engagement, therefore resulting in academic achievement (Saw, 2019, p. 10). Students were more motivated to understand the curriculum in order to complete a task when they are engaged in the lesson. Honey et al. (2014) discussed research that indicated STEM provided an interesting approach to learning and that students were benefiting from this integration. This study discussed the infusion of STEM in a middle school that documented outcomes related to interest. This study consisted of surveys over the students' attitudes toward mathematics and technology before and after the intervention. The study compared the interest level of students who participated in the study (STEM integration) versus students who completed a typical math lesson. The study targeted sixth and seventh grade girls, primarily to identify if STEM integration would increase their likelihood of entering a career that requires STEM skills. Although the study targeted the futuristic outcome of STEM in girls, it still discussed the interest level STEM provides. The outcome of the study by Honey (2014) stated,

> Turning to out-of-school programs, in an unpublished evaluation of the Techbridge program, 367 girls (44 percent of the total number of girls) who had participated in the program from 2000 to 2007 completed surveys. Nearly 90 percent of the respondents reported that Techbridge had increased their interest in STEM; asked to identify what got them the most interested in STEM, 72 percent cited hands-on projects and 16 percent said it was field trips (p. 36).

While this study targeted young girls, it also discussed that the interest level in these science and engineering has increased. Another study examined the teachers' views on STEM and how STEM has benefited their classrooms. Just as it was discussed in previous research, the teachers in this study also found that STEM brought student enjoyment. Margot and Kettler

(2019) conducted a study on teachers' perceptions of STEM integration and education. The participants included teachers across the world, teaching Grades K-12. In their study, Margot and Kettler (2019) revealed that "teachers feel the persistence and interest gained by students are very valuable as the work on STEM challenges and that students eventually begin to feel motivated and empowered by their ability to solve complex problems" (p. 14). They also noted that "they also felt students were genuinely interested in STEM problems. Teachers note an overwhelmingly positive response from students during STEM education. Moreover, teachers felt this increase in student's enjoyment and engagement was the main reason for integrating STEM into their curriculum" (p. 14). Although STEM provides interest in academics, there are also some concerns with STEM.

There are many reasons researchers have highly recommended STEM be implemented in schools. However, the implementation of STEM also brings concern. Researchers have discussed the problem with STEM as being that it does not correlate with state tests. Although STEM provided interesting and engaging lessons, it required students to think of multiple answers to solve a problem. The students could understand the concept that problems can be solved multiple ways, yet they were expected to answer state test questions where only one answer is allowed. While completing a problem-based learning (PBL) segment, students were expected to use the entire curriculum that is taught to solve the problem. Researchers have explored the problems with STEM in relation to state tests. Most state tests focus on content-area specific concepts and procedures because there is no "widely accepted definition of integrative thinking." Honey et al. (2014) noted,

> Most studies of STEM learning consider each discipline singly and do not measure students' ability to make connections across disciplines of their proficiency with skills

> such as collaboration or general problem solving. In addition, learning is often assessed using standardized tests, which may not effectively measure the full range of learning and reasoning outcomes supported by integrated experiences (p. 67).

Honey et al. (2014) reported that the state tests were not correlating with the STEM discipline (p. 67). Although STEM has created an engaging and meaningful educational experience, it does not mean much when it is not being tested appropriately.

The National Academies Press (2011) examined the effective approaches to integrating STEM in Grades K-12. One of the primary topics in this text investigated the problems with testing STEM schools accurately. In the text, it noted, “It is challenging to identify the schools and programs that are most successful in the STEM disciplines because success is defined in many ways and can occur in many different types of schools and settings, with many different populations of students” (p. 15). Due to the inaccuracy of data in STEM schools, it was difficult to determine if STEM schools were successful based on state-mandated tests. There are many ways to assess the success of STEM implementation; however, it may be different based on what is considered successful. There are few studies however that collected data on STEM accredited schools.

A study conducted by Kogo-Masila (2019) consisted of the researcher collecting data in a STEM accredited program and compared those state test scores to students that attended the traditional program. This researcher looked specifically at the state scores in the subjects of science, math, and reading. Although this researcher was able to collect data and provide valuable information for future research, it also came with some limitations. In the study conducted by Kogo-Masila (2019), there were certain criteria for students to attend the STEM program. The students had to maintain a Level 3 (out of 5) on the end-of-grade (EOG) exams.

Students had to successfully complete Math 1 prior to entering ninth grade, score a Level 3,4, or 5 on the reading and math EOGs in Grade 7 and 8, and scored 75% or higher on nationally normed tests for students not enrolled in the district. To continue in the STEM program, students had to also maintain an overall grade average of 80% on the final average of the eight courses taken each year. These students were required to meet the behavior requirement of not having three or more school suspensions. Students who did not maintain these criteria were expelled from the STEM program (p. 43). Because of the criteria required to attend the STEM school, data may have looked different in comparison to a public STEM school where no criteria were required to attend. It would be beneficial for additional researchers to collect data on these schools to see if their achievement improved on state tests rather than stay the same or fall below the traditional school scores.

Gnagey and Lavertu (2016), similar to Kogo-Masila (2019), investigated STEM state test scores; however, unlike Kogo-Masila, they conducted a longitudinal study of the same STEM school over a period to see if student's test scores varied over time. While useful for future research and for this current study, it too had limitations. The STEM schools studied by Gnagey and Lavertu (2016) were selective, and admission decisions were based on their competitive exams and previous academic achievement. The schools in the study sought to cultivate and strengthen existing STEM talent and interest.

In the study conducted by Kogo-Masila (2019), students had to attain eligibility in the STEM program. Again, there were certain criteria that students had to have to be included in this study. If there was more diversity in the students that had data collected on them, it may have a different result. As stated earlier, Hockett (2009) described STEM to benefit students of all diversity and academic abilities. Students who tend to have a lower academic ability have more opportunities to show growth than a student who already achieved at a higher level.

Teacher Education in STEM

Margot and Kettler (2019) conducted a study on the teacher's perception of STEM. They surveyed teachers on student enjoyment, student struggles, the value of STEM, pedagogical challenges, curriculum challenges, and assessments, time, and knowledge. This study included 14 schools across the world, with a total of 3,232 teachers interviewed. The participants included teachers in all Grades K-12. These teachers expressed the benefits of STEM integration as being engaging and is inherently motivating to students. The participants also communicated the many concerns within STEM. One of the primary concerns is the teachers' lack of knowledge in STEM.

"Student learning is limited when teachers' knowledge and understanding is deficient" (McMullin & Reveve, 2014). Teachers who have limited knowledge and comfort with STEM may feel they are unable to contribute to classroom learning during STEM activities. The teachers also explained their inability of being able to combine the STEM pedagogical approach with the content concepts. Even after attending multiple professional development courses, teachers were still uncomfortable integrating STEM in their classrooms (Margot & Kettler, 2019). Teachers showed resistance to integrating STEM with the fear of not following their content concepts. STEM also required teachers to shift away from teacher-led instruction and to focus on student-led instruction. All these limitations can cause a disruption with how explicitly the standards are taught.

It was also mentioned that teachers were uncomfortable with integrating STEM in their lessons. They discussed that grade-level standards were not flexible, which prevented STEM integration. Most teachers feared teaching STEM because they were also required to teach students to the state tests, which STEM integration did not allow. Although teachers were aware of the benefits of STEM, they still feared the lack of preparation as well as the lack of administrative support. “Teachers believe that they had a lack of subject matter knowledge concerning STEM content. Pre-service and in-service training was seen as inadequate in preparing teachers to implement STEM” (p. 12).

Even with training, teachers did not feel that they were adequately prepared to teach STEM while also preparing students to achieve well on state tests. For teachers to feel adequately prepared, they believed that frequently available learning opportunities would produce a successful STEM integration. Extant research on achievement in STEM schools has been inconclusive. Few studies were able to determine the possible factors behind decreased state test scores in STEM schools. Multiple researchers conducted surveys on teachers and their views on STEM (Gonzalez-Gomez, Yllana, 2020; Jamil, Linder & Stegelin, 2018; Margot & Kettler, 2019). However, with STEM being a newly implemented way of teaching, their views varied after years of professional development, as well as experience in STEM integration. Studies conducted by Margot and Kettler (2019) as well as Jamil, Linder, and Stegelin (2018), investigated the teachers’ view on STEM and the problems that it brought to their schools. Many of the teachers felt ill-prepared in STEM as well as a lack of support from administration. Unfortunately, there was a lack of research on teachers who had been trained in STEM for multiple years.

Yildirim and Turk (2018) also conducted a study on the teachers’ opinions on STEM integration. The study group consisted of 28 teachers who were asked a variety of questions over STEM integration and what they felt was important when teaching STEM. The researchers asked the 28 teachers, “Do you feel sufficient about STEM education?” One teacher said they felt sufficient, seven teachers felt partially sufficient, and 20 teachers felt insufficient. Teachers were also asked, “What are the problems that can be encountered during STEM education?” Nineteen teachers said lack of time under the teacher-oriented problem category, while 13 teachers said material deficiencies under the physical problem category.

Although there were some limitations, such as the number of teachers studied, the research suggested that most teachers do not feel confident in their knowledge over STEM. Most of their opinions had to do with factors that were not under their control, such as the lack of time, lack of resources, curriculum appropriacy, and excessive student numbers. Teachers also felt like they were not adequately prepared to teach STEM. Yildirum and Turk (2018) also stated that multiple research has been conducted over this topic and most results show the same.

Jamil et al. (2018) conducted a study over early childhood teacher beliefs about Science, Technology, Engineering, Art, and Mathematics (STEAM) education after professional development. They studied a total of 60 participants who attended a professional development conference on STEAM education practices. At the end of the professional development, the attending teachers completed a survey that asked for items regarding their beliefs about STEAM teaching and information on their personal and professional demographics. After reviewing all 60 surveys, Jamil et al. (2018) found that there was a tension between “covering specific learning standards and planning more integrated learning activities that approached learning in a more contextualized manner” (p. 7). There seemed to be a misconception throughout the study that STEM integration consists of add-on activities that exist separately from a standards-based curriculum. The teachers believed that STEM tasks did not correlate with the standards, but that they allowed students to enjoy learning. The teachers also communicated their lack of materials, resources, support from administration, as well as time restrictions to be able to implement STEM into their classrooms.

Chapter III

Methodology

This chapter describes the methodology and research design used to conduct the study that analyzed multiple data sets to identify trends found in state test scores in STEM accredited schools versus traditional schools. This study also analyzed and reviewed multiple interviews, questionnaires, and surveys provided to teachers across America. Since this study analyzed multiple data sets, it was considered a meta-analysis. A meta-analysis is a method for systematically combining qualitative and quantitative studies from several selected studies to develop a conclusion. This study looked at both quantitative and qualitative data to identify trends found in STEM accredited schools and their state test scores.

Participants - Student Academic Achievement

There were two data sets observed in this research. In data set 1, collected by Kogo-Masila (2017), the participants were selected using a concurrent mixed-methods approach sampling. Since Kogo-Masila looked at quantitative and qualitative components of the research, this type of sampling made it possible to triangulate the results from the separate quantitative and qualitative components of research. However, this study was looking only at the quantitative components of the study. This sampling method was chosen so that researchers were able to cross-validate within a single study. The site where data was collected was at a high school in North Carolina. The high school implemented a STEM program and was located in a suburban neighborhood with a less dense population in comparison to the surrounding city. This same high school also had a traditional program where STEM was not implemented. This school was the only magnet STEM school in the school district with mixed student demographics. The selected school had 1,712 students. There are 351 students in the STEM program and 1,361 students in the traditional program. The participants had a diverse racial makeup of 15.7% Hispanic, 21.9% African-American, 55.7% White, and 6.7% of other ethnicities. Eighty percent of the teachers who work at the school selected were highly qualified teachers with 12 of the teachers being National Board-Certified teachers.

In data set 2, conducted by Gnagey and Lavertu (2016), the participants consisted of 1,022 students in 5 different STEM high schools across Ohio. Two of the schools consisted of Independent STEM schools, meaning that these schools were private schools and not a part of the district school system. Three of the schools consisted of District STEM schools, which means they were a part of the district school system in Ohio. Since all participants are tested in both eighth grade and tenth grade, the study focused on the estimation of 2-year STEM integration. All data were collected by the Ohio Department of Education from the 2012-2013 tenth grade cohort. This study looked at the state standardized test scores in STEM subjects (math and science) and non-STEM subjects (reading and social studies).

Participants - Teacher Education

In the data collected by Margot and Kettler (2019), the participants included teachers around the globe teaching grades pre-k through twelfth grade. For the purposes of this study, we looked specifically at the interviews conducted by teachers in America. It included 18 studies with a total of 2,015 teachers. These teachers had different levels of experience, and work in different regions of the country with different socioeconomics and diversity in their schools.

Research Methods - Student Academic Achievement

In data set 1, Kogo-Masila (2017) used a mixed methods approach by collecting, analyzing, and integrating quantitative and qualitative research in a single study. For the purpose of this study, only the quantitative data were analyzed and reviewed. The quantitative data collection included: STEM program demographics, traditional program demographics, STEM program requirements, standardized test scores, GPA for STEM and traditional program students, and the graduation rate for STEM and traditional program students.

In data set 2, Gnagey and Lavertu (2016) used an empirical strategy which consisted of "estimating student growth models comparing the achievement of students who attended one of the six STEM schools with students who attended traditional public schools in the feeder districts." (p. 7). The empirical method focused on conducting an investigation that relies on systematic observation and experimentation rather than theoretical speculation.

Research Methods - Teacher Education

Margot and Kettler (2019) thoroughly researched articles using Academic Search Complete, ERIC, Ebscohost, and PsychINFO. Google Scholar was also used to check to relevant articles that had been found. Each article had to fit five different criteria. These five criteria included: study published between 2000 and 2017 in English, study published in a scholarly journal, study participants included preK-12 teachers, study is empirical (qualitative, quantitative, mixed methods, or meta-analyses), and extracted data aligns with current study's focus and research questions. After the screening, 29 articles were chosen. Those 29 articles were then examined using a rubric that included seven criteria. This criterion included: Objectives and purposes, review of literature, theoretical frameworks, participants, methods, results/conclusions, and significance. All these criteria were measured to see if they met the standards of quality reporting.

Data Analysis Procedures - Student Academic Achievement

In data set 1, Kogo-Masila (2019), used an independent samples *t*-test to assess whether the means of the STEM program and the traditional program were statistically different from each other using the state (North Carolina) test data. In this study, the independent variable consisted of the STEM and traditional programs (school type), while the dependent variable consisted of student's achievement indicated by the state standardized test. Data that were obtained from state tests were downloaded into the Statistical Packages for the Social Sciences (SPSS). This study also includes an unpaired *t*-test to identify the group differences for the scores in Math 1, Biology, and English II.

In data set 2, Gnagey and Lavertu (2016), created a time trend analysis from ordinary least squares regression (OLS). The researchers estimated linear time trends in STEM school performance for each of the four subjects. For each time trend variable takes the value of zero in the year in which the school's first cohort entered tenth grade and increases by one in each subsequent year.

Data Analysis Procedures - Teacher education

Margot and Kettler (2019) used a thematic analysis for their research. This analysis involved reading through a data set and identifying themes and patterns in the data. This data analysis procedure allowed the researchers to generate new insights and concepts derived from data. The researchers went through six phases of thematic analysis. Margot and Kettler (2019) described these phases stating,

> The first phase involved becoming familiar with the data, the second phase was where initial codes were generated, the third phase involved an initial search for themes by collating the codes, the fourth phase required that each theme was checked or reviewed to ensure the coded extracts work in relation, the fifth phase was when the themes were defined and named, and the sixth phase was producing the report from the themes by relating them back to the research questions (p. 4).

Chapter IV

Results

The primary goal of this study was to review multiple data sets to find themes within the data to assess the impact of STEM integration on state assessments, specifically in math, science, and reading. This chapter describes the findings of the two data sets discussed by previous researchers. In data set 1, Kogo-Masila (2017), the study included a mixed methods approach analyzing state test data in North Carolina; however, the researcher specifically examined only the quantitative data that were collected. This included the STEM and traditional student archival achievement data, specifically looking at the EOC scores. This study examined the ACT, EOC scores from Biology, Math 1, and English II, and GPA. For the purposes of this study, only the state scores in Biology, Math 1, and English II were observed. The scores of all participating students were collected and analyzed by Kogo-Masila (2017). The students could score from 1 (being the lowest) to 5 (being the highest). This was conducted using an independent *t*-test to compare the means between both programs (STEM and traditional). Table 2 also included group differences for the scores in each of the subject areas. Tables 2a and 2b included the ANOVA results for the difference between the EOC scores in STEM schools and Traditional schools. There were no outliers in the data, which was assessed by inspection of a boxplot by Kogo-Masila (2017). The descriptive statistics (Table 1), and differences for the scores (Table 2) are summarized below.

Table 1

Descriptive Statistics on EOC Scores

Subject	**Program**	***N***	***M***	***SD***	***SE***
Math	STEM	65	3.184	0.882	0.109
	Traditional	65	3.015	0.909	0.113
Biology	STEM	65	4.276	0.839	0.104
	Traditional	65	4.000	0.884	0.110
English	STEM	65	3.692	0.967	0.120
	Traditional	65	3.861	0.609	0.076

Table 2

Group Differences for the Scores

Math	STEM	65	3.185	0.882	0.109
	Traditional	65	3.015	0.909	0.113
	Increase or Decrease	**65**	**0.169**	**0.896**	**0.111**
Biology	STEM	65	4.277	0.839	0.104
	Traditional	65	4.000	0.884	0.109
	Increase or Decrease	**65**	**0.277**	**0.861**	**0.107**
English	STEM	65	3.692	0.967	0.119
	Traditional	65	3.862	0.609	0.076
	Increase or Decrease	**65**	**-0.169**	**0.788**	**0.098**

Table 2a

ANOVA for Difference among Math, Bio, and Eng Scores in Traditional Schools

	SS	*df*	*MS*	*F*	*P*
Between	36.931	2	18.465	27.974	0.000
Within	126.738	192	0.660		
Total	163.668	194			

Table 2b

ANOVA for Difference among Math, Biology, and English Scores in STEM Schools

	SS	df	MS	F	P
Between	38.840	2	19.420	24.111	< 0.001
Within	154.646	192	0.805		
Total	193.487	194			

There were 65 STEM students and 65 traditional students. Referring to Table 1, the traditional students had a higher mean score in English (*M*=3.86) than the STEM students who had a mean score of (*M*=3.69) in English. The STEM students had a higher mean score in Math (*M*=3.18), and Biology (*M*=4.28) than the traditional students who had mean scores of (*M*=3.02), in Math and (*M*=4.00) in Biology. Table 2 provides data over the group differences of the EOC scores. Table 2a and 2b show the ANOVA results for differences among Math, Biology, and English in STEM schools. In math, the STEM school had a statistical significance of 0.169. By conventional criteria, this difference was considered to be not statistically significant. In Biology, the STEM school had a statistical significance of 0.277. By conventional criteria, this difference was considered to be not quite statistically significant. In English, the STEM school had a statistical significance of -0.169. By conventional criteria, this difference was considered to be not statistically significant.

In data set 2, Gnagey and Lavertu (2016) examined five inclusive STEM schools in Ohio. These data were collected using their state standardized test scores, specifically looking at the student's scores in Math, Science, Reading, and Social Studies. This study observed and analyzed how the students' test scores changed in STEM schools over a two-year period. Gnagey and Lavertu (2016) noted "to examine whether the negative results that we unearthed are attributable to these schools' growing pains, we estimated linear time trends in STEM school performance for each of the four subjects" (p. 11). Table 2 presents the estimated STEM school and time trend effects from ordinary least square regressions. Each column presents the effects from a single regression disaggregated by school. Bolded coefficients are significant at the following levels for a two-tailed test: $p* < .05$ ^ and $p < .10$.

Table 3

Estimates of STEM School Trends Over Time

School	N	Math	Science	Reading	Social Stud.
A Indep. STEM	306	0.02	-0.04	**0.15***	**0.15^**
A x Time Trend	306	0.01	0.01	**-0.05***	**-0.07***
B Indep. STEM	142	-0.03	0.10	0.04	-0.11
B x Time Trend	142	0.06	0.05	-0.03	0.03
C District STEM	256	**-0.30***	**-0.18***	**-0.28***	**-0.39***
C x Time Trend	256	0.07	-0.07	-0.01	**0.13***
D District STEM	130	0.01	-0.07	0.02	**-0.17***
D x Time Trend	130	-0.06	-0.04	**-0.11^**	-0.01
E District STEM	188	0.00	0.06	-0.15	**-0.18***
E x Time Trend	188	-0.10	0.05	0.14	-0.12

Note. This table presents estimated science, technology, engineering, and mathematics (STEM) school and time trend effects from ordinary least squares regressions. Each column presents the effects from a single regression disaggregated by school. Bolded coefficients are significant at the following levels for a two-tailed test: * $p < .05$. ^ $p < .10$.

There was a total of 1,022 students in five different STEM schools. Two schools (schools A and B) were Independent STEM schools and three schools (C, D, and E) were District STEM schools. Table 2 presents the results for the time trend analysis. After assessing, the STEM subjects (math and science), showed there were no statistically significant trends. In the non-STEM subjects (reading and social studies), there was a negative trend in reading at Independent STEM school A and negative trends in social studies in Independent STEM school A and

District STEM school E. The only positive trend observed is at District STEM school C in social studies, however, the scores remained low to the comparison groups.

Table 4 (see Appendix A) included a summary of included empirical articles that were collected, analyzed, and created by Margot & Kettler (2019). The columns included the author, the participants, the methodology, and the findings from each article. Table 4 provides information on teachers' perception of STEM and the impacts of professional development in STEM. This table includes 13 different articles with approximately 2,000 teachers interviewed. For this study, only the articles that included teachers in the United States were used. Data collected from the teacher interviews in the United States associated with the data collected on student achievement in schools located in the United States.

The results from Table 4 show a similar trend throughout. Each article that surveyed, interviewed, and questioned teachers over STEM discussed the benefits of integrating STEM. The articles that discussed STEM professional development opportunities allowed teachers to feel more comfortable with integrating/teaching STEM to their students. Some barriers were also described by teachers, such as: lack of education/ teacher knowledge, securing supplies, time constraints, and state-mandated requirements.

Chapter V

Discussion

This chapter presents a summary over the findings in the study. The reasoning of this study was to identify trends in the data to help further research in STEM integration and the effect teacher preparedness has on state tests. After looking at 2 data sets conducted in North Carolina and Ohio, it was concluded by both researchers that STEM integration shows to have a negative effect on test scores in non-STEM subject areas (reading and social studies) in comparison to traditional schools. However, STEM-designated schools did not show to have a statistically significant difference in STEM subjects (science and math) in comparison to traditional schools. As discussed in the literature, these researchers had some limitations. Both researchers only collected data on students that followed a certain criterion. Specifically, students had to perform at a certain “level” to attend the STEM accredited schools. STEM accreditation is becoming sought after across the United States. It would benefit readers to identify the effects STEM has on students of all academic abilities, including students who struggle with the traditional learning environment.

As discussed earlier, the research that was conducted by Saw (2019) and Gnagey and Lavertu (2016) included participants who met certain criteria before being admitted into the STEM-accredited schools. Additional research in public STEM schools where no criteria are required, would resonate with more educators, administrators are parents that are looking to either work for a STEM accredited school or for someone who is debating on sending their child to a STEM school. This study also only analyzed two data sets. More research is recommended to be conducted in STEM programs across the United States so that it is easier to identify a trend among state test scores in multiple STEM schools with diversity. Although the reasoning behind decreased test scores (specifically in non-STEM subject areas) isn't verified by the data, it is discussed by teachers and their perception of STEM.

After analyzing Margot and Kettler's research, it is evident that teacher education, and the lack thereof, is a possible explanation of why students in STEM schools may not be performing as effectively as expected. A common denominator in those multiple interviews discussed the lack of education the teachers have in STEM. The teachers that did attend a professional development (PD) in STEM integration benefited from the knowledge they were taught. The PD made teachers feel more confident and knowledgeable in STEM.

In Table 4, an article produced by Nadelson and Seifer (2013), explained that teachers who attended a PD on STEM expressed that their comfort level with STEM significantly increased even after one PD. Table 4 also included a study by Al Salami (2017) where they interviewed teachers before PD's in STEM and after their PD's in STEM. These teachers had PD opportunities throughout an entire year. They explained that even though they felt more confident in teaching STEM, there were still multiple outside factors that provided barriers. After analyzing the articles provided by Margot and Kettler (2019), a common trend appears. Teachers are lacking in multiple areas. Some of which are out of their control. They are either lacking in PD opportunities, lacking administrative/state support, lacking resources, or lacking enthusiasm. All these limitations could possibly contribute to how students are receiving STEM education. The more knowledgeable a teacher is in STEM integration; the more likely students will receive proper STEM education.

There are many articles that provided the qualitative data on teacher thoughts and beliefs, however, a future study where both state test scores in STEM schools and surveying the teachers in the same school may be beneficial. For example, if a STEM accredited middle school is scoring high on their state tests but a STEM middle school in the neighboring district is not scoring well on state tests, it would be beneficial to interview the teachers at both schools to identify trends in their knowledge with STEM. If this was conducted in multiple STEM schools across the United States, it could provide readers with a more accurate insight on the impact teacher knowledge has on state tests in STEM-designated schools. There may be no correlation between the two or there may be a strong correlation between the two. Regardless, the information would be beneficial and would allow future researchers to add on to the existing research.

After looking at the data collected by Kogo-Masila (2019) and Gnagey and Lavertu (2016), it could be concluded that traditional students were scoring higher in reading and social studies versus STEM accredited schools. This could also be a connection with what teachers are mentioning in their interview stating that they are not comfortable with integrating all subject areas. Teachers in traditional schools tend to focus more predominately on reading while also teaching to the test. STEM-designated schools are intended to not only focus on science and math but also integrate all subject areas. If teachers are not comfortable with this method, it could be a possibility that many STEM teachers are focusing solely on science and math practices. A few teachers mentioned in their interview that state test scores seemed to overpower the benefits that STEM had to offer. If teachers had more flexibility within STEM integration, multiple professional development opportunities, and administrative support, it is a possibility that the state assessment data could alter. The National Academies Press (2011) expresses that administrators should “support student learning with expert teachers, advanced curricula, sophisticated laboratory equipment, and apprenticeships with scientists.” For administrations to implement these recommendations, it will require support from across the school, additional funds where needed, and teachers who have experience and education in STEM.

The study conducted by Gnagey and Lavertu (2016) was in schools across Ohio, with different demographics and a different attendance rate. The researchers mentioned that the attendance rate was significantly lower in the public schools, which means many student scores in public schools were not factored into the study. The attendance rate could have caused an inaccurate comparison between the two schools. The study included private STEM schools as well as public STEM schools. The demographics in these schools were significantly different which can also play a role in how the data was portrayed. Although there are many factors that could have altered their data, throughout the 6 schools, STEM was showing a negative effect on student achievement over a period. It was discussed in the literature review that over time a STEM school should improve after practice and experience (The National Academies Press, 2011); however, the data collected from Gnagey and Lavertu (2016) showed otherwise. If data was collected on the teachers' beliefs and views in STEM integration during the time that the academic data was collected, some trends may have been present, and a possible explanation may have occurred. However, since there is no data or research collected on the staff, a conclusion as to why the test scores in the STEM programs in Ohio are not improving over time is precluded.

Based on Kogo-Masila's (2019) data, the STEM program was performing less adequately than the traditional program in non-STEM subject areas. Specifically, STEM schools were scoring higher on science and math on state tests in comparison to non-STEM schools but were not achieving in other subject areas. However, there are some limitations to this study. This study was done in a STEM program that was in the same school as its traditional program. The school the research was conducted at was once a traditional-only school (non-STEM) and then created a program. Most of the teachers were pulled from the traditional school to teach in the STEM program. Although it is not stated in the research, these teachers may have held the same values as they did while teaching in the traditional program. It is possible that teachers were thrown into the STEM program without the proper training and may continue to teach similarly to how they taught in a traditional school. Again, it would have been beneficial for data to be collected in a STEM accredited school and have included interviews/surveys with those particular teachers in the schools. This study explored data collected in two states, Ohio and North Carolina, and also analyzed teacher interviews with teachers all over the United States. The STEM schools that had data collected on them (Ohio and North Carolina) more than likely did not include teacher interviews. Although this study can identify trends in lack of professional development in STEM, it doesn't accurately correlate with the state test data that was collected. This is a limitation to the study and could be improved in future research.

There was limited research on STEM integration in primary grades and the effects it has on students throughout their educational careers. STEM implementation is supposed to prepare students to become successful learners all the way through high school and then any additional education. More research should be conducted on STEM in relation to state tests starting in grades as early as 3rd grade. It would also benefit to conduct research on the accuracy of state tests, which determine a student as successful or not. As discussed by the National Academies Press (2011), expert teachers, as well as additional funds and administrative support, are needed to deem a STEM school as "successful". This can result in problems across the country if schools are not able to meet these criteria. Even if schools were able to meet these criteria, it still does not provide the data to prove that STEM schools would excel on state tests. To determine why state scores are decreasing in STEM schools across the United States, additional studies will need to be conducted. Although some studies provided data on schools across the state, very few studies compare multiple schools within the state. By comparing multiple schools within the state and interviewing their staff/teachers the study will be able to provide additional information needed to determine if a STEM is deemed “successful”.

Chapter VI

Conclusion

After analyzing and reviewing data sets on student achievement in STEM and traditional schools, more research is needed to make conclusions. There are many gaps in research as well as many outside factors that can alter the results of state test scores in STEM schools. However, data provided by Kogo-Masila (2019) and Gnagey and Lavertu (2016) showed that state tests do not prove to improve state test scores in STEM-designated schools in comparison to traditional schools. Non-STEM subjects (reading and social studies) are showing a decline in test scores in STEM schools, which make up most of the state test. More research needs to be conducted on teacher preparedness in STEM and how the inconsistency (in the way STEM is taught) across STEM schools could be a possible factor in the success/failure on state tests. Although more research does need to be conducted, there is a common trend in data sets, and that is STEM integration causes students to perform less effectively on state tests in reading in comparison to traditional schools, however, there is no statistical difference between state test scores in math and science in STEM-designated and Traditional schools. With the benefits that STEM integration tends to offer, it may be beneficial for more research to be conducted to identify the reasons behind the effects STEM integration has on state assessments. The interviews conducted by Margot and Kettler (2019) provide valuable insight on other possible factors that may contribute to the data on state test scores in STEM-designated schools. The teachers in the interviews not only mentioned the lack of PD, but they also discussed the outside factors that provide barriers in integrating STEM. Those other outside factors included: lack of administrative support, lack of supplies, and the pressure of state tests scores. Future researchers may want to explore the other factors that may contribute to the decline of state test scores in STEM schools. This study allows educators, parents, teachers, and students to understand the effects STEM integration has on student performance on state tests. This study also gives possible factors that may contribute to the reasoning behind the state test scores in STEM schools. Future researchers can use this study to build on and explore more possible factors to the reasoning behind state test scores. Although more research should be conducted, this study may provide a start to a much deeper analysis on the connection between state test scores in STEM schools and teacher education in STEM.

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APPENDICES

Appendix A: Table 4

Table 4

Summary of included empirical articles

Author(s) Year	Participants	Methodology	Findings
Al Salami et al. (2017)	42 middle and high school teachers in USA	Pretest-posttest surveys administered with PD and teaching a STEM unit. 29 of the teachers also answered 2 open-ended questions about successes and challenges with implementation of STEM.	No overall significant change from pretest to posttest in attitudes toward STEM. Qualitative findings of the challenges and barriers teachers felt are as follows: (1) students' background knowledge and skills, (2) students' buy-in, (3) securing supplies/ expenses, (4) students' group, (5) using fellows, (6) time constraints, (7) meeting mandated requirements, and (8) cross-content collaboration.
Asghar et al. (2012)	25 teachers at a STEM workshop in the USA	Interviews, focus groups, and observational data were analyzed using the constant comparative method.	Major themes found (1) initial perceptions, (2) perceptions after PD, (3) integrating STEM content and pedagogy, (4) problems with model problems, and (5) barriers to implementation
Bruce-Davis et al. (2014	Students, teachers, and administrators at 6 STEM high schools in the USA	Data from individual and focus group interviews were analyzed to identify recurring patterns through an inductive and deductive coding process.	Three themes emerged (1) a common vision of a challenging and engaging learning environment, (2) a focus on applying curricular and instructional strategies and practices to real-world problems, and (3) an appreciation for academic and affective support

Dare et al. (2014)	48 9th grade physical science teachers in the USA	Mixed methods methodology using observations, interviews and surveys	Teachers focused on soft skill integration (teamwork and communication) instead of engineering content. Teachers felt student engagement and enjoyment were important considerations for STEM.
Goodpaster et al. (2012	6 rural STEM teachers in the USA	Phenomenographical study using interviews regarding their perceptions of benefits and challenges.	Community interactions, professional development, and rural school structures emerged as three key factors. Participants felt each of these factors had both positive and negative implications.
Herro and Quigley (2017)	21 middle school math and science teachers in the USA	Descriptive case study of teachers participating in a year-long STEAM PD using observations, written reflections, focus group interviews, and teacher created artifacts	Teachers increased their understanding of STEAM to teach content and perceived the PD as effective in changing their practices. They felt collaboration and integrated technology were important considerations to effect successful STEAM implementation
Holstein and Keene (2013)	3 high school teachers implementing new STEM curriculum in the USA	Observations and interviews examining teachers' conceptions related to their implementation of STEM materials were coded using Productive Pedagogies framework.	Common conceptions that influenced teacher implementation were (1) negative beliefs about student abilities, (2) lack of subject matter knowledge, and (3) non-traditional beliefs about teaching that led to use of pedagogical techniques similar to those of the curriculum creators.
Hsu et al. (2011)	192 elementary teachers in the USA	DET survey results were examined using nonparametric tests (Mann-Whitney and Kruskal-Wallis)	Participants felt design, engineering, and technology (DET) is important, but felt unfamiliar with the content. Teacher motivations to teach DET differed based on their ethnic backgrounds.

Lesseig et al. (2016)	34 grade 6–8 teachers in the USA	Case study of observations, field notes, artifacts, and video during implementation of STEM design challenges.	Teachers valued STEM practices and learner motivation/engagement. Challenges associated with pedagogy, curriculum, and school structures were identified.
Nadelson et al. (2013)	33 elementary teachers in the USA	Demographics, confidence for teaching STEM survey, and a survey of efficacy for teaching STEM were analyzed for correlations pre and post PD.	Significant and consistent increases in pre- to post PD of teacher confidence, efficacy, and perceptions of STEM. Also, increased links between STEM curriculum and instruction to learning standards were made.
Nadelson and Seifert (2013)	377 K-12 teachers in the USA	Several STEM teaching surveys were administered pre and post STEM institute then descriptive statistics and correlations were found.	Participants had an average level of comfort teaching STEM before the institute, which increased significantly after the institute. Some teacher characteristics, perceptions, and practices were related to one another.
Nadelson et al. (2012)	230 grade 4–9 teachers in the USA.	Pre- and post- survey results of various STEM implementation factors were analyzed using descriptive statistics and correlations.	Participants' perceptions and conceptions of STEM achieved substantial gains after the STEM institute. Perceptions of efficacy for teaching STEM was found related to comfort with teaching STEM, pedagogical discontentment with teaching STEM and inquiry implementation.
Stohlmann et al. (2012)	4 middle school STEM teachers in the USA	Field notes, observations, and interviews, collected over school year, were analyzed using constant comparative method.	Content and pedagogical knowledge were found to contribute to positive self-efficacy. Teacher felt these supports are needed for successful STEM education: (1) partner with university or nearby school, (2) attend PD.