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Abstract

The increase in demand for college and career ready students has driven the need for education reform to ensure K–12 schools can support student learning across all content areas and grade levels. A STEM Certification process was established by the Georgia Department of Education as part of an effort to reform public school STEM education. Additionally, an international STEM Certification procedure developed by AdvancED has been implemented in several Georgia schools. As a significant component of STEM certification guidelines, problem based learning has been incorporated to stimulate student interest in science, facilitate self-regulation, and increase pedagogical and content knowledge. As Georgia schools become STEM certified, it is important to understand how certification has influenced achievement in math and science as well as important non-STEM disciplines such as English language arts and social studies. This causal comparative study examined if the STEM certification process altered student achievement in participating schools as compared to schools that have not participated. Student achievement was measured by the median growth percentiles (MGPs) between STEM certified and non-STEM schools in the content areas of English language arts, mathematics, science, and social studies at the fourth and fifth grade levels using a Mann-Whitney *U* test. The study found only the MGPs for fourth grade ELA were significantly higher ($p = .004$) in STEM certified schools. Overall, inconsistent differences in MGPs for ELA, math, science, and social studies were found between STEM certified and non-STEM schools.

Keywords

STEM, problem-based learning, elementary schools, STEM certification

Science knowledge is critical to making sense of our complex world. Science understanding is key to everyday interactions in our lives such as comprehending current events, choosing and using technology, or making informed decisions about our health care. Data from the Bureau of Labor Statistics suggest that employment opportunities in science, technology, engineering, and mathematics (STEM) fields will grow over the next 6 years at a rate almost 1.75 times that of non-STEM fields (Gaddis, 2012). These jobs require workers to be highly innovative and are at the heart of the well-being of the economy of the United States (National Research Council [NRC], 2011).

With increased employment opportunities in STEM fields, educators and policymakers recognize that the higher education system in the United States is not producing enough skilled workers in the area of STEM (Gaddis, 2012; NRC, 2011). Institutions must prepare their students for careers of tomorrow by fostering and perpetuating enthusiasm for STEM disciplines (NRC, 2011; NRC, 2013). Educators, researchers, and administrators are developing STEM education reforms that emphasize common standards, increased rigor, innovative professional development, and greater accountability. STEM education stakeholders do not have a clear understanding of how these reforms are progressing (NRC, 2013). More studies are needed to assess the progress of the reform efforts (NRC, 2011).

STEM schools have shown great promise. Many states have implemented reform efforts that include certification of STEM schools (NRC, 2011; NRC, 2013). A STEM Certification process was established by the Georgia Department of Education (GaDOE) to increase the accountability in public school STEM education (GaDOE, 2015b; STEM Georgia, 2012). The first Georgia STEM-certified school was recognized in 2012 (Walz, 2012). Additionally, an international STEM certification process developed by AdvancED has been implemented in several Georgia schools since 2015 (Denmark, 2015; Farner, 2015).

The Georgia Student Growth Model (GSGM) was introduced in 2013 as a way to determine a student's academic progress relative to academically similar students from across the state in English language arts (ELA), mathematics, science, and social studies (GaDOE, n.d.-b). The GSGM provides an appropriate framework for examining student progress in STEM schools across the curriculum. The problem is little is known about how STEM school certification influences elementary students' achievement in the context of the GSGM.

While a solid understanding of STEM disciplines is important for later student employment, there are indications that integrating STEM learning throughout the curriculum can increase achievement in non-STEM subjects (Honey, Pearson, & Schweingruber, 2014). A better understanding of the early results of current Georgia schools who receive either the GaDOE STEM Certification or the AdvancED STEM Certification will guide administrators and teachers in school reform and improvement efforts to prepare students to be college and career ready in a globally competitive society.

Literature Review

Problem-Based Learning (PBL)

Within the GaDOE, STEM education is defined as a rigorous curriculum that integrates subjects (e.g., math and science) as opposed to teaching them separately in isolation (Honey et al., 2014). Teachers plan and work collaboratively as a team to deliver instruction that is driven by innovation, real-world problem solving, exploration, and student-centered development of creative ideas and solutions. PBL techniques were applied to deliver this type of instruction in Georgia STEM schools. PBL begins with the assumption that learning is an active, integrated, and constructive process influenced by social and contextual factors (Barrows, 1996; Gijselaers, 1996). Students use prior knowledge of a topic to help solve complex problems and gain new knowledge.

In a study of PBL in science classrooms, Ferreira and Trudel (2012) noted improved attitudes toward science and increases in metacognitive framework and self-regulated learning. Students particularly enjoyed the design and implementation stages of the PBL process. While problem solving skills and perceptions of the learning environment improved, the study results also indicated difficulties with knowledge transfer related to problem solving steps and actions.

PBL has been found to significantly improve the higher order science and thinking skills of elementary students (Cinar & Bayraktar, 2013). A separate study found that part of the achievement resulting from PBL resulted from situational interest in the problem. Students learned because they were interested in the problem (Gallagher & Gallagher, 2013). The researchers suggested the benefit of PBL goes beyond skill development and student engagement to teachers' perceptions of a discernible increase in achievement from addressing ill-structured problems using self-directed learning and guided instruction. Studies of PBL have consistently shown students in PBL classrooms are more motivated, engaged, and satisfied (Gallagher & Gallagher, 2013). Interest in the problem itself is considered a significant element of achievement.

STEM school guidelines typically stipulate instructional design applicable to real-world problems and careers, teamwork, and the use of interdisciplinary problem solving techniques (Young, House, Wang, Singleton, & Klopfenstein, 2011). The rigor afforded by PBL makes it a popular instructional strategy for many STEM schools (Honey et al., 2014). The GaDOE and AdvancED procedures both included PBL techniques in their STEM certification guidelines (AdvancED, 2016a; GaDOE, 2015b).

Theoretical Framework

Described in the context of cognitive and constructivist learning theories, PBL is a student centered experiential learning strategy that involves small group activities with teachers as facilitators or guides (Barrows, 1996; Gallagher & Gallagher, 2013; Grider, 1993; Gijselaers, 1996). While problems become both the focus and stimulus for learning, knowledge is gained through self-directed learning (Honey et al., 2014). In a study of the impact of PBL on student attitudes toward science, Ferreira and Trudel (2012) described PBL as a constructivist pedagogical technique that allows students to find solutions to a problem together. In PBL, educationally-sound problems "help students learn a set of important concepts, ideas, and techniques" because they provoke group discussion and give students experience solving problems encountered by experts in the field (Gallagher, 1997, p. 338). Open-ended problems that provide meaningfulness and personal motivation connect with the cognitive constructivism theory, which requires learning to be related to personal ideas and experiences.

Social cognitive learning theories require social dialogue and elaboration. This approach fosters collaborative learning and helps to develop learning communities in which students feel comfortable developing new ideas and raising questions about the material (Allen, Duch, & Groh, 1996). Collaborative learning is a research-based best practice shown to improve student achievement and is used in STEM education within Georgia's public schools. Ferreira and Trudel (2012) found science students enjoyed the sense of control afforded in a PBL environment and demonstrated improved attitudes toward science, problem solving skills, and perceptions of the learning environment. The study also supported the contention of previous studies that PBL can increase students' metacognitive structure and self-regulated learning.

STEM Certified Schools

The NRC Committee on Highly Successful Schools or Programs for K–12 STEM Education hosted a workshop to gather information about STEM schools and education intended to guide district, state, and national leaders in developing strategies to reform STEM education (NRC, 2011). It was part of an NRC effort to understand the nature and potential value of an integrated STEM education. STEM focused schools were examined because they are often considered "the most effective route to improving STEM education" (NRC, 2011, p. 6).

A primary difference between STEM schools and traditional schools is a greater focus on integrating STEM topics in the curriculum (Honey et al., 2014). This is accomplished by increasing the time spent teaching STEM topics, improving rigor with more STEM certified teachers, and incorporating student centered PBL activities that emphasize STEM learning. STEM schools are often certified and have emerged in three formats.

The NRC (2011) identified three general types of STEM schools that can potentially meet the goals for U.S. STEM education: selective, inclusive, and career and technical education (CTE) STEM schools. These schools fall into four categories: (a) state residential schools, (b) stand-alone schools, (c) schools-within-a-school, and (d) regional centers with half-day courses. STEM schools are important because they provide a specific focus on STEM disciplines and can serve as an exemplar for districts. Such schools are often targeted toward specific student populations such as gifted students or students from underserved groups (NRC, 2011). Selective STEM schools are typically high schools that seek small numbers of gifted and motivated students with a proven interest in and aptitude for STEM. Inclusive schools are structured around one or more of the STEM disciplines and do not have selective enrollment requirements. STEM-related CTE schools serve primarily high school students who are preparing to work in STEM related careers and are located in regional centers, CTE-focused high schools, programs in comprehensive high schools, and career academies.

The implementation of an inclusive model has led to a successful Texas STEM school initiative (Young et al., 2011). The program was predicated on the premise that students from traditionally underserved communities must develop math and science competencies and that such competencies can be developed. The Texas STEM schools are autonomous schools within schools that do not screen students based on prior academic achievement and at least 50% of the students must be economically disadvantaged and from ethnic/racial minority groups. The curriculum incorporates built in supports to engage students by providing a wide variety of opportunities to work on teams using interdisciplinary problem solving techniques to master STEM content and skills (Honey et al., 2014).

Elementary STEM Reform

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Little information is available regarding STEM school reform efforts and outcomes (NRC, 2011). However, early STEM reform proposals recommended integrating reading and writing into the STEM curriculum (Glynn & Muth, 1994). In this study, it was noted that the ability to understand and explain fundamental scientific concepts is a central component of science literacy. Furthermore, the concept of integrated STEM learning is extended through the proposal of an integrated curriculum to teach all elements of STEM in a coordinated process (Honey et al., 2014).

Many STEM integration initiatives incorporate PBL in some form. Among the challenges of fully teaching STEM are limitations in teacher education, efficacy, and skill in STEM topics. In a study that examined reform in non-STEM schools from a math perspective, it was found that reform is often initiated through changes to curriculum and teaching standards. Rigor is associated with the level of complexity incorporated in STEM topics. Coherence is related to the sequential logic of how a STEM topic is presented in the curriculum. It is considered the most important standard because it has been shown to have a significant impact on student STEM achievement. An examination of 1995 Trends in International Mathematics and Science Study data found students' outcomes were significantly related to curricular coherence and focus. Curricula based on the most rigorous standard of coherence had the greatest predicted achievement. This was particularly significant for students in Grades 3, 4, 7, and 8 (Schimdt, 2011).

In response to the NRC challenge to improve STEM education, a set of educator and student goals and outcomes to reform STEM education by more clearly integrating STEM topics was proposed (Honey et al., 2014). Goals for students seek to increase interest, engagement, and connections by helping students develop STEM literacy, competency, and workforce readiness. PBL approaches are used to encourage active learning through student engagement with real world STEM problems. Educator reform goals center on increasing STEM pedagogical and content knowledge (Schmidt, 2011). The proposed outcomes for students are closely related to the goals. Increased student interest and identification in STEM will improve achievement and competencies, which lead to educational persistence, enrollment in STEM courses, and STEM employment. In order to accomplish these goals, educators must reform their practices by increasing STEM pedagogical and content knowledge. Experiential learning methods such as PBL focus on real-world problems to stimulate student interest in STEM and increase content knowledge (Honey et al., 2014).

Georgia Department of Education STEM Certification

To support STEM reform, Georgia developed several initiatives in the form of STEM goals, institutes, festivals, certifications, and webinars (STEM Georgia, 2012). The GaDOE (2015b) defines a STEM program as one dedicated to the STEM education and curriculum of select students within the school. A STEM program may be a school within a school or a group of teachers and students who are designated as instructors and students within the STEM program, while other students in the school continue in the existing curriculum. Students may participate in the STEM program by whatever selection process the school chooses. GaDOE STEM Certification can be awarded to entire schools that are dedicated to STEM education and curriculum for all students. The criteria that schools or programs must meet in order to support a comprehensive STEM program and become a state-certified STEM school or program is presented in Appendix A. It is important to note that PBL is an explicit requirement for STEM certification.

AdvancED STEM Certification

In addition to becoming STEM certified by the GaDOE, schools or programs within schools may be STEM certified by AdvancEd, a non-profit, non-partisan organization. AdvancED conducts rigorous, on-site external reviews of PreK–12 schools and school systems to ensure that all learners realize their full potential (AdvancED, 2016b). AdvancED's STEM Certification provides a research-based framework for assessing the quality of STEM educational programs. The AdvancED STEM Standard and Indicators are presented in Appendix B and "clearly define the qualities and components vital to creating and sustaining superior, student-centered K–12 STEM teaching and learning programs, as well as clear expectations for student outcomes and mastery of 21st century skills" (AdvancED, 2016c, para. 1). Indicators ST1.2 and ST1.6 describe skills, knowledge, and thinking strategies associated with inquiry-based learning, creative problem solving, and an interdisciplinary problem-based curriculum associated with PBL (Honey et al., 2014).

Assessment in Georgia's Schools

Historically, federal educational accountability policies have focused mostly on language arts and math as a means for school reform while science has been ignored (Honey et al., 2014). With the increased demand for equipping students to be college and career ready, state assessment systems have begun to hold schools accountable for student learning across content areas and grade levels. The Georgia Student Assessment Program requires schools to be accountable for learning in content areas across grades. It includes measurements

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of how well students learn the knowledge and skills outlined by state-adopted language arts, mathematics, science, and social studies content standards (GaDOE, n.d.-a). The GSGM and Georgia Milestones were integrated to implement the assessment program.

Georgia Student Growth Model (GSGM)

In addition to the state accountability tests, the GSGM was first introduced in 2013 as a way to determine a student's academic progress by utilizing student growth percentiles (SGPs), which describe a student's growth relative to academically-similar students from across the state in the four content areas assessed by the state accountability test (Betebenner, 2008; GaDOE, 2015a; GaDOE, n.d.-b). The GSGM does not predict performance; it describes observed student growth. Georgia Criterion-Referenced Competency Test (CRCT) data were used to calculate the 2013 and 2014 GSGM data, followed in 2015 with Georgia Milestones data. A student must have two consecutive years of scores from the CRCT or Georgia Milestones in order to receive a SGP (GaDOE, 2015a; GaDOE, n.d.-b).

SGPs are created for individual students; however, they can also be combined to summarize the growth of a group of students (i.e., classroom, school, or district). One method that Georgia uses to combine SGPs for a group of students is to use the median SGP for a group of students (GaDOE, 2015a). This median SGP is referred to as the median growth percentile (MGP). To determine the MGP, scores for a particular grade level and content area are ordered from least to greatest. The middle value in this ordered list is the MGP. If there is an even number of values in the list, the mean for the middle two values is calculated to determine the median. Since 2013 GSGM data are published for its schools, districts, and the state (GaDOE, n.d.-c). MGPs are included for both end-of-grade and end-of-course assessments. These MGPs may be compared to determine which schools made the most growth in a particular grade level and content area (GaDOE, 2015a).

Georgia Milestones

The Georgia Milestones Assessment System (Georgia Milestones) is a comprehensive summative assessment program spanning grades 3–12 that was first administered in 2015 to replace the CRCT. Students in grades 3–8 take an end-of-grade assessment in each content area, while high school students take an end-of-course assessment for each of the ten courses designated by the State Board of Education (GaDOE, n.d.-a). The items found on the Georgia Milestones assessments are developed with a particular emphasis on cognitive complexity, or

Depth of Knowledge (GaDOE, n.d.-a). Each item on the end-of-grade assessments is intentionally designed to provide a valid measure of student achievement of the state content standards (GaDOE, n.d.-a). The robust assessment program implemented in Georgia supports learning reform efforts, including recent elementary STEM school certification programs.

Research Questions

This causal comparative study examined if being a STEM certified school altered student achievement by comparing MGPs between STEM certified schools and non-STEM schools. The GSGM was based on student performance on the mandated end-of-grade assessments in ELA, mathematics, science, and social studies. The questions and hypotheses in this study equated the MGPs with Georgia and/or AdvancED certified STEM elementary schools and non-STEM certified elementary schools. The study was guided by the following eight research questions:

RQ1: Is there a difference in the median growth percentiles in fourth grade English language arts for STEM certified schools when compared to non-STEM schools?

RQ2: Is there a difference in the median growth percentiles in fourth grade math for STEM certified schools when compared to non-STEM schools?

RQ3: Is there a difference in the median growth percentiles in fourth grade science for STEM certified schools when compared to non-STEM schools?

RQ4: Is there a difference in the median growth percentiles in fourth grade social studies for STEM certified schools when compared to non-STEM schools?

RQ5: Is there a difference in the median growth percentiles in fifth grade English language arts for STEM certified schools when compared to non-STEM schools?

RQ6: Is there a difference in the median growth percentiles in fifth grade math for STEM certified schools when compared to non-STEM schools?

RQ7: Is there a difference in the median growth percentiles in fifth grade science for STEM certified schools when compared to non-STEM schools?

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RQ8: Is there a difference in the median growth percentiles in fifth grade social studies for STEM certified schools when compared to non-STEM schools?

Method

The purpose of this study was to examine whether the Georgia STEM school certification processes influence MGPs and integrated student achievement. In order to examine an influence, the researchers compared MGPs between STEM certified schools and non-STEM schools. The method for this investigation was quantitative. This study was a causal comparative design between STEM and non-STEM MGPs in the content areas of (a) ELA, (b) mathematics, (c) science, and (d) social studies. MGPs for 2016 were obtained for schools in the Metropolitan Regional Educational Service Agency (Metro RESA) region in Georgia from the GaDOE's website (GaDOE, n.d.-c). These aggregated achievement scores were available to the public through the GaDOE website.

A purposive sampling technique was used for this study. Within the Metro RESA, non-STEM and STEM certified schools were identified. Since more of the STEM certified schools are found in the Metro RESA region, this area was selected to maximize the number of certified STEM schools in operation while satisfying the inclusion criteria.

Since the data were not normal for many of the subgroups, the statistical analysis technique used for this investigation was the Mann-Whitney U test, which is a non-parametric test. Additionally, since the sample sizes of non-STEM and STEM certified schools were highly unbalanced, any departure from the assumption of homogeneity of variances weakens conclusive evidence should any two groups have variances that are statistically different (Field, 2013). Homogeneity of variances alleviated this issue and permitted the use of a pooled variance between the non-STEM and STEM certified data. Under the assumption of equality of variances, large differences in the sample sizes between the two groups had a minimal impact upon the statistical analysis associated with the comparison of two groups (Triola, 2010). The Mann-Whitney U test required homogeneity of variances. When the homogeneity assumption did not hold for any set of comparative groups, a random sample was taken from the non-STEM group using SPSS that was equivalent to the number of STEM schools identified for the study. Homogeneity of variances was satisfied for all groups with the exception of Grade 5 ELA. A random sample for non-STEM Grade 5 ELA was generated and shown to be equivalent to the complete non-STEM sample with regard to mean and variance. Analysis confirmed equivalency regarding the mean and variance as well as any assessment of normality between STEM and non-

STEM for all other content areas and grades. Normality was not a concern regardless of the findings of homogeneity of variances when using the Mann-Whitney U statistical test.

Results

The Georgia School Growth Model (GSGM) was developed to describe observed student growth. Student growth percentiles (SGPs) measure individual student growth and when combined into median growth percentiles (MGPs) provide a measure of combined student growth. Table 1 presents the descriptive statistics for MGPs for Grades 4 and 5 for STEM and non-STEM schools in ELA, math, science, and social studies.

Table 1
Descriptive Statistics for MGPs for STEM and Non-STEM Schools by Content Area

Content Area	n	Median	Min.	Max.
Grade 4				
ELA Non-STEM	423	52.00	23.00	85.00
ELA STEM	17	62.50	36.00	83.00
Math Non-STEM	423	51.00	16.00	87.00
Math STEM	17	56.00	34.50	75.00
Science Non-STEM	423	50.00	18.00	82.00
Science STEM	17	56.00	22.00	77.00
Social Studies Non-STEM	423	51.00	10.00	91.50
Social Studies STEM	17	46.00	29.00	81.00
Grade 5				
ELA Non-STEM	428	53.50	20.00	79.00

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ELA STEM	17	56.00	32.00	62.00
Math Non-STEM	428	51.00	13.00	93.00
Math STEM	17	50.00	20.00	69.00
Science Non-STEM	428	49.00	6.00	86.00
Science STEM	17	50.50	27.00	68.00
Social Studies Non-STEM	428	47.50	11.00	89.00
Social Studies STEM	17	44.00	18.00	88.00

The MGPs for Grade 4 ranged from 10.00 to 91.50 across the four content areas. The median for the various Grade 4 schools ranged from 46.00 to 62.50 across the four content areas. All medians fell within the typical (35–65) growth level (Betebenner, 2008). The medians for Grade 4 were higher for STEM certified schools in all areas with the exception of social studies in which the median for the non-STEM schools was higher.

The MGPs for Grade 5 ranged from 6.00 to 93.00 across the four content areas. The median for the various Grade 5 schools ranged from 44.00 to 56.00. All medians fell within the typical (35–65) growth level (Betebenner, 2008). The medians for the Grade 5 STEM certified schools were higher for ELA and science while the medians for the Grade 5 non-STEM schools were higher for math and social studies.

Mann-Whitney U tests were used to compensate for violations of the normality assumption for several data sets. Other considerations making the Mann-Whitney U preferable over its parametric equivalent included the disparity in sample sizes between STEM certified and non-STEM data sets and the use of ranked data (medians). All groups were unbalanced with only 17 schools in the STEM certified schools and more than 400 schools in the non-STEM schools. Analyses of fourth and fifth grade data were conducted to determine if the MGPs for the STEM certified schools were significantly different from the MGPs for the non-STEM schools. Table 2 shows statistics for the Grades 4 and 5 Mann-

Whitney U tests including effect sizes (η2). Eta squared was calculated using the formula $\eta^2 = Z^2/(N-1)$.

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Table 2
Mann-Whitney U Test Statistics for STEM and Non-STEM Schools by Content Area

Content Area	n	Mean Rank	Z	U	p	η2
Grade 4 (N = 440)						
ELA Non-STEM	423	217.02	-2.87	2122.00	.004	.02
ELA STEM	17	307.18				
Math Non-STEM	423	218.27	-1.84	2651.50	.066	.008
Math STEM	17	276.03				
Science Non-STEM	423	220.08	-0.35	3416.00	.727	.0003
Science STEM	17	231.06				
Social Studies Non-STEM	423	220.57	-0.06	3567.00	.956	.000007
Social Studies STEM	17	218.82				
Grade 5 (N = 445)						
ELA Non-STEM	428	221.88	-0.92	3158.50	.356	.002
ELA STEM	17	251.21				
Math Non-STEM	428	222.77	-0.19	3540.50	.851	.00007
Math STEM	17	228.74				

Science Non-STEM	428	222.63	-0.31	3477.50	.758	.0002
Science STEM	17	232.44				
Social Studies Non-STEM	428	223.27	-0.23	3521.00	.822	.0001
Social Studies STEM	17	216.12				

The Mann-Whitney U test evaluates whether the mean ranks for two groups differ significantly from each other (Green & Salkind, 2008). Fourth grade ELA was the only group to show a significant difference in MGPs between the STEM certified schools (Mdn = 62.50) and the non-STEM schools (Mdn = 52), $U = 2122.00$, $p = .004$, 2-tailed, $\eta 2 = .02$. The fourth grade ELA STEM certified schools showed significantly more growth than the fourth grade ELA non-STEM schools. Interestingly, both the fourth and fifth grade social studies groups had a higher mean rank for the non-STEM groups than the STEM groups. All other content areas showed a higher mean rank for the STEM groups. The greatest differences between the STEM and non-STEM groups were in the area of ELA for both and fourth and fifth grades.

After randomly selecting 17 representative samples in an effort to balance the sample sizes and confirm equivalence in the means and variances between the original sample for Grade 5 ELA and representative random sample for Grade 5 ELA, it was determined that homogeneity of variances between the Grade 5 ELA STEM certified schools and the representative sample for Grade 5 ELA non-STEM schools was not met. Mann-Whitney was foreclosed in favor of the median test to compare Grade 5 ELA STEM certified and non-STEM schools. Although the Mann-Whitney test is more sensitive to outliers, the median test considers the number of values above versus below the median. As a result, the median test is robust to outliers and less sensitive to departures from homogeneity of variance. While the median test result was consistent with the Mann-Whitney result for Grade 5 ELA, without an established equivalency between the shapes of the distributions for STEM and non-STEM data, any result pertaining to the equivalency of the medians should not be considered to be highly conclusive statistically speaking.

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Discussion and Conclusions

The purpose of this study was to examine how the Georgia STEM school certification processes influenced MGPs and integrated student achievement across ELA, mathematics, science, and social studies. STEM certified schools integrate STEM topics in the curriculum, which increases the time that students interact with STEM concepts. Integration of STEM topics requires careful planning of PBL activities that require active engagement, collaboration, and higher order thinking from students.

Based on the statistical differences noted between STEM certified and non-STEM schools, the findings of the study provided support for completing a STEM school certification process in order to increase MPGs for fourth grade ELA ($U = 2122.00$, $p = .004$, $\eta 2 = .02$). The results of this study did not provide support for completing a STEM school certification process in order to increase MPGs for other content areas in other grade levels. This revelation is based on inconsistent differences in the MPGs between students enrolled in STEM certified and non-STEM schools across all content and grade levels. While the fourth grade STEM certified school medians were higher for ELA, math, and science, the median for non-STEM schools was higher for social studies. The fifth-grade STEM certified school median was higher than non-STEM schools for ELA and science and lower for math and social studies. Median growth in ELA, math, science, and social studies for STEM schools was not significantly higher than at non-STEM schools except for Grade 4 ELA. This finding was surprising because it was anticipated that growth in these areas would be significantly higher given the extensive literature available on the benefits of problem-based learning on active learning and retention. Findings paralleled the mixed findings of Judson (2014), which explored elementary achievement in mathematics, reading, and language arts between students who transferred from non-STEM schools to either STEM charter schools or STEM magnet schools. Recent studies of student achievement in Texas STEM high schools also reported mixed results (Bicer, Navruz, Capraro, & Capraro, 2014; Oner & Capraro, 2016). Judson, 2014 noted mixed results that pointed to a possible null effect, which is useful information "because value may too quickly be assumed when a school takes on the moniker of STEM" (p. 264).

While the current study examined if the Georgia STEM school certification processes influence MGPs and integrated student achievement across ELA, mathematics, science, and social studies, some limitations are worth noting. First, the study utilized Georgia Milestones MGPs between students enrolled in a

STEM certified school and students who were not enrolled in a STEM certified school. Variations in the types of students such as student GPA, experience with ELA, math, science, and social studies learning, and academic preparation for any course was not available and, therefore, could not be considered in the interpretation of these results. In order to reduce the impact of this limitation and maximize the similarities of the groups and courses, the researchers conducted analyses that compared groups within one of the 16 Regional Educational Service Agencies in Georgia, the Metro RESA. MPGs were not compared across the entire state, as it would bring extraneous variables that would interfere with the results. Second, other factors that may have contributed to differences included less stringent assessment of learning objectives, the teaching skills of the instructors, the consistency of the amount of time and way of implementing STEM across courses and institutions, type of courses, type of institutions, students' motivation, and student attendance. Third, there was a difference in the number of STEM certified schools compared to non-STEM schools. In the Metro RESA, data were available for 17 STEM certified schools while more than 400 schools contributed data for non-STEM schools. The large differences in sample size and violations of the normality assumption led to the use of the non-parametric Mann-Whitney U test. Fourth, Georgia STEM school certification is a relatively new process that has not had time to mature and improve based on long-term assessment feedback. Only first year data were available for some STEM schools, which likely influenced median achievement scores. Despite these limitations, the results of this study provide an important first glimpse into how the STEM school certification processes in Georgia affect achievement across the curriculum as compared to non-STEM certified schools.

The findings showed inconsistent differences between STEM and non-STEM schools. STEM certified schools had higher median scores in ELA, math, and science, and non-STEM schools were higher in social studies. The medians for the Grade 5 STEM certified schools were higher for ELA and science while the medians for the Grade 5 non-STEM schools were higher for math and social studies. In spite of these inconsistencies, the fourth-grade ELA results are promising. The results of this study and future research may aid instructional designers, instructors, and institutions to identify the contributing factors present in STEM certified schools, develop programmatic improvements, and guide educational leaders in deciding how to pursue STEM reform in order to help schools and districts meet their ultimate bottom line: improving student achievement and producing more globally competitive students.

This study provides a first look at early data that will inform future teacher and administrator actions to assess and improve STEM school curricula. PBL

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provided opportunities to enhance meaningful learning and retention of information by the students enrolled in STEM certified schools. In order to truly support the interpretations of these results, more research should be conducted. Future research could consist of exploring factors of each school through qualitative designs. Future quantitative studies might incorporate (a) other variables that affect the achievement of students (e.g., attendance, poverty, gender, second language learners, and other demographic data); (b) additional geographic areas in Georgia; (c) the most current year of data; or (d) multiple years of data. Additional research is needed to validate and extend the findings of this initial study into the STEM certification process.

As the importance of STEM education increases, schools will consider the value of completing a STEM certification program. There is a need to augment the STEM workforce in a technology-driven society, and create initiatives that develop STEM literacy and boost individuals' interest towards STEM-related professions (Proudfoot & Kebritchi, 2017). Non-STEM schools may consider going through the STEM certification process in order to prepare students for a STEM workforce within the United States of America.

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Appendix A
Georgia STEM Certification Criteria Overview

Criteria	To Meet
STEM Vision and Culture	The vision for STEM is clearly defined and a STEM culture has been established within the program and/or school.

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STEM Students	STEM students are identified by a school designed selection process that has been vetted with successful longitudinal evidence.
Non-traditional Student Participation	The non-traditional student participation reflects the diversity of the school in terms of gender, minorities, and economically disadvantaged.
Characteristics of the STEM Curriculum	STEM students are regularly exposed to a unique and explicit curriculum that is different from non-STEM students and there is evidence of its sustainability. The STEM curriculum should support one or more of the GaDOE. STEM focus areas.
Teacher Content Knowledge	STEM teachers are working toward increasing content knowledge in science and math through multiple means.
Teacher Professional Learning	STEM teachers have on-going STEM professional learning and STEM specific strategies relating to the school's identified STEM focus area and there is evidence of implementation in classroom instruction.
Teacher Collaboration	Teachers collaborate at least weekly to plan integrated lessons, share/co-create STEM activities, and plan learning outcomes.
Math and Science Instruction	STEM students participate in math and science enrichment opportunities and are accelerated through differentiation. Students receive daily integrated math and science instruction.
Business/Industry/Community Partnership	Multiple business, community, and post-secondary partnerships are on-going and are involved by directly connecting to in-class instruction, project/problem-based learning, and exposing students to STEM careers.
STEM Competitions, Exhibits and/or STEM Clubs	STEM students participate in STEM competitions and/or exhibits at the school, district, state and/or national level or participate in STEM extracurricular clubs or activities.

Project/Problem-Based Learning	Short and long-term projects/problems are implemented throughout the school year incorporating student-generated ideas that are standards-based, multidisciplinary and real-world.
Math, Science, Technology, and Engineering Integration	Students receive daily math and science instruction that supports a STEM project correlated to current math and science standards. Instruction is multidisciplinary, including mathematics, technology and the science and engineering practices.
STEM Lab(s) Resources	The STEM lab(s) has technology access and resources are used by multiple teachers for collaboration, project work, virtual collaboration, and can be used as exhibition space.
Student Rigor & Relevance and Instructional Quality	Learning occurs at the adaptation level on a regular basis. Classroom instruction is predominantly student centered and students have the competence to think in complex ways and also apply the knowledge and skills they have acquired.
Technology Integration	Technology use is ubiquitous throughout STEM classrooms and students are producers and not just consumers of digital content.

Note. Adapted from “The Georgia STEM Certification Application,” by the Georgia Department of Education, 2015 (http://stem.wpgadoe.org). In the public domain.

Appendix B
AdvancED STEM Standard and Indicators

STANDARD: STEM students have the skills, knowledge, and thinking strategies that prepare them to be innovative, creative, and systematic problem-solvers in STEM fields of study and work.	
STEM LEARNERS	

ST1.1	The STEM school/program supports non-traditional student participation through outreach to groups often underrepresented in STEM program areas.
ST1.2	Students work independently and collaboratively in an inquiry-based learning environment that encourages finding creative solutions to authentic and complex problems.
ST1.3	Students are empowered to personalize and self-direct their STEM learning experiences supported by STEM educators who facilitate their learning.
ST1.4	Students use technology resources to conduct research, demonstrate creative and critical thinking, and communicate and work collaboratively.
ST1.5	Students demonstrate their learning through performance-based assessments and express their conclusions through elaborated explanations of their thinking.
STEM EDUCATORS	
ST1.6	The interdisciplinary problem-based curriculum includes a focus on real world applications.
ST1.7	STEM educators collaborate as an interdisciplinary team to plan, implement, and improve integrated STEM learning experiences.
ST1.8	STEM learning outcomes demonstrate students' STEM literacy necessary for the next level of STEM learning and for post-secondary and workforce readiness.
ST1.9	STEM teachers and leaders participate in a continuous program of STEM-specific professional learning.
STEM EXPERIENCES	
ST1.10	Community, post-secondary, business/industry partners and/or families actively support and are engaged with teachers and students in the STEM program.
ST1.11	Students are supported in their STEM learning through adult-world connections and extended day opportunities

Note. Adapted from "AdvancED STEM Certification: An Overview of the STEM Standard and Indicators," by AdvancED, n.d. (http://www.advanc-ed.org).