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DOES STEM DESIGNATION MATTER?: A Longitudinal Analysis of T-STEM Academies' Performance in Mathematics.

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Abstract

The purpose of this study was to investigate how STEM designation affected high school mathematics performance over the years by studying T-STEM schools. How T-STEM high schools' mathematics performance changed by school type (Texas Public Schools (TPS) versus Charter Schools(CS)), gender, ethnicity, the number of years as a T-STEM designated school, socio-economic status, and at-risk student population was also examined. A total of 40 (N=40) stand-alone T-STEM designated high schools' student level data was examined in this study. The analysis of the first question yielded results implying that T-STEM designation did not make any positively impact students' mathematics performances over the years in T-STEM designated schools. For the second question, it was found that Charter School (CS) type T-STEM schools outperformed TPS type T-STEM schools in almost all grade levels. In addition, the analysis of the second research question revealed that T-STEM academies fell short of meeting the expectations of closing the achievement gap between male and female students, at –risk and non-at-risk students, students with differing socio-economic status, and ethnic groups. Yet there are some differences between CS type T-STEM and TPS type T-STEM schools; CS type T-STEM schools seemed to be doing a better job in closing the achievement gap, especially for the at-risk and economically disadvantaged student groups.

Introduction

The word STEM is popularly used to represent science, technology, engineering, and mathematics (Breiner, Harkness, Johnson, & Koehler, 2012), and in recent years has become a popular subject matter in the field of education. It is believed that countries that choose to invest in STEM education will benefit economically and socially (Schleicher, 2007). Fostering innovation, which mostly originates in STEM-related fields, is imperative for the sustainment and success of economies as we progress in the 21st century (OECD, 2010; Breiner et al., 2012). Therefore, countries today should prioritize STEM education to obtain sustainable economic growth (OECD, 2010). The recently recognized importance of quality STEM education has spawned concerns in some countries, the United States being among them, that traditional curricula and pedagogical methods in STEM related subjects fail to sufficiently engage and nurture students. The United States' concerns are also shared by a number of other industrialized nations such as the United Kingdom and Australia (e.g., Archer et al., 2012; Tytler, Osborne, Williams, Tytler, & Clark, 2008).

Discourse on STEM stemmed from a concern that the United States, a country once considered an indisputable leader in science and technology, was no longer a major competitor in STEM fields as in the past (Raju & Clayson, 2010). Poor performance in the mathematics and science, in which American students consistently rank lower than their counterparts in studies of academic proficiency, also fueled the emerging conversation on STEM (Johnson, 2012). The 2012 Programme for International Student Assessment (PISA) results revealed that the U.S. showed a mean performance, being below the OECD average in both mathematics and science (OECD, 2013). The 2011 Trends in International Mathematics and Science Study (TIMSS) ranked American students slightly higher, but the U.S. still lags behind many countries around the world, particularly in eighth-grade mathematics and science (U.S. Department of Education, 2013).

Consequently, economic and political considerations as well as international policy resulted in a petition for the training of more students in STEM-related fields (Thomas & Williams, 2010). Led by the National Science Foundation, STEM emerged from governmental policy (Breiner et al., 2012) as policy makers and educators began to note that STEM is an important focus for education reform and global competitiveness. The federal government set aside billions of dollars specifically for STEM education in the form of programs like the Race to the Top competition (Breiner et al., 2012; Johnson, 2012).

STEM-Focused Schools and Texas STEM (T-STEM) Initiative

With these concerns in mind, officials and educators wishing to improve STEM education in the U.S. have especially focused on creating specialized STEM schools; The President's Council of Advisors on Science and Technology has set a goal of establishing 1,000 STEM-focused schools over the next decade (Raju & Clayson, 2010). The United States is no stranger to such specialized schools; although the acronym STEM had not been developed, it is documented that, in fact, several STEM focused high schools were established in early 20th century (Thomas & Williams, 2010) and were designed with a science and mathematics focus. Today, specialized STEM schools, many being supported by states, are designed to meet the needs of students who have an interest in STEM-related fields, and to equip these students with specific technical skills essential for the industry workforce (Thomas & Williams, 2010). Specialized STEM schools offer an advanced curriculum (Olszewski-Kubilius, 2010), and provide many more opportunities to learn and engage in STEM fields than do traditional schools (Raju & Clayson, 2010). Specialized STEM schools offer an advanced curriculum (Olszewski-Kubilius, 2010), and provide many more opportunities to learn and engage in STEM fields than do traditional schools (Raju & Clayson, 2010).

Texas launched the Texas STEM (T-STEM) initiative and opened the first T-STEM academies and assistance centers in 2006 (Young, House, Wang, & Singleton, 2011). T-STEM has its origins in a high school reform initiative called Texas High School Project, which was undertaken by various private and governmental organizations (Young et al., 2011). Developed as either whole STEM schools or schools-within-schools, T-STEM academies are small schools that are not allowed to select students based on prior academic performance, and are required to have populations of at least 50% economically disadvantaged students or students from ethnic minority groups (Young et al., 2011). These inclusive STEM schools do not require students to have strong academic achievement backgrounds, but instead provide a support system to engage students in STEM and help them master STEM-related subjects (Young et al., 2011). Desired outcomes of the T-STEM academies include college readiness, 21st century skills, and STEM career-related experiences (Young et al., 2011). In addition to newly established T-STEM academies, existing schools also have the opportunity to become T-STEM academies by completing an application process conducted by Texas Education Agency (TEA). T-STEM academies have to follow strict requirements outlined by a detailed blueprint (Young et al., 2011).

Outcomes for STEM Focused Schools and T-STEM Academies

T-STEM academies were created to improve math and science proficiency and increase opportunities for underrepresented groups of students in these fields (Young et al., 2011). It was predicted that the integration of STEM would help prepare students effectively for the business and industry workforces (Williams, 2011). It was also asserted that the instruction offered in STEM focused schools and programs are more relevant to real world experiences, and in turn will aid in the improvement of student achievement specifically in mathematics and science (Herschbach, 2011). Thus, many researchers believe that STEM integration will result in bettered achievements in the math and sciences. However, there is very little research that documents the successes or failures of students in specialized STEM schools or T-STEM academies; furthermore, the optimum practices and methodology of specialized STEM schools, and their consequences, must be recorded and made public (Subotnik et al., 2009). Existing research conducted on T-STEM academies has demonstrated that T-STEM academy students perform slightly better in mathematics and science than students from matched non-T-STEM schools (Young et al., 2011). However, there is a need for longitudinal analysis of T-STEM designated schools' performances over a longer period of time as they have been in operation for over a decade, with numbers that are only increasing. This study aims to conduct a longitudinal analysis of T-STEM designated schools' to investigate how STEM designation affects schools' high school mathematics performance over the years by studying STEM-designated schools. The following research questions guided the study;

1. How did T-STEM designation affect high schools' performance in Mathematics?
2. How did T-STEM high schools' mathematics performance change by school type (TPS versus Charter Schools), gender, ethnicity, the number of years as T-STEM designated school (Generation), socio-economic status level, and at-risk student population?

Methods

Sample

The sample consisted of student level data from all 40 stand-alone T-STEM designated schools for the first and second research questions. High school students' Mathematics and End of Course Exam (EOC) scores between 2007 and 2013 were used in this study; the scores of 44,549 high school students in grades 9 through 11 were examined. Texas adopted a new state assessment in 2011; The State of Texas Assessments of Academic Readiness (STAAR) replaced the Texas Assessment of Knowledge and Skills (TAKS). Thus, TAKS data between years 2007 and 2011 and STAAR data between 2012 and 2013 were used. The data was obtained from the Texas Education Agency (TEA).

Variables

Independent variable. The number of years as T-STEM designated school, school type (TPS versus Charter type T-STEM schools), gender, ethnicity, economically disadvantaged and at-risk student population were the independent variables for the first and second research questions.

Dependent variable. High school students' mathematics and EOC exam scores for TAKS and STAAR were the primary dependent variables in this study. High school mathematics testing in TAKS focuses on Algebra I, Geometry, and Algebra II, which are assessed in grades 9 to 11. STAAR EOC testing is done separately in Algebra I, Geometry, and Algebra II in 9th, 10th, and 11th grades, respectively.

Analyses

In order to make comparisons across the years, all raw scores were standardized. This process included transforming all raw scores into Z-scores and then converting Z-scores into T-scores having a mean of 50 and a standard deviation of 10. Then, one-way ANOVA was conducted to examine differences among each generation T-STEM schools for each grade level. For the second research question, Independent samples t-test, One-way ANOVA, and Univariate General Linear Model (Two-way ANOVA) were used to discover how T-STEM high schools' mathematics performance change by school type (TPS versus Charter), gender, ethnicity, grade level, disadvantaged, and at-risk student population over the years, and analyze if there is any interaction between these factors and year factor. SPSS 22.0.0 was used to conduct independent samples t-test, one-way ANOVA, and Univariate General Linear Model analyses.

Results

A total of 40 (N=40) stand-alone T-STEM designated schools and 44,549 (N=44,549) high school students in 9th grade (N=23,380, 52.25%), 10th grade (N=13,225, 29%), and 11th grade (N=7,944, 17,8%) were included for the analysis of the first research question. A one-way ANOVA was used to examine the score changes after designation for each grade level. Score changes in 9th grade are shown in Figure 1. Schools designated as T-STEM in 2006-2007 were labeled as Generation-1 schools. Similarly, others were labeled according to designation year as Generation-2 (2007-2008), Generation-3 (2008-2009), Generation-4 (2009-2010), Generation-5 (2010-2011), Generation-6 (2011-2012), and Generation-7 (2012-2013). However, Generation-1 schools were not included in the analysis of the first question as the data was not available prior to 2006-2007 school year. One-way ANOVA results showed that none of the score changes in 9th grade were statistically statistically significant with the exception of Generation-2 T-STEM schools ($F(6,1225)=14.998$, $p=.000$) in 2009 and 2012, Generation-3 schools (F(6,1197)=8.357, *p*=. 000) in 2012, Generation-6 schools (F(6,626)=8.408, *p*=. 000) in 2012 and 2013, and Generation-7 schools (F(6,7181)=12.629, *p*=. 000) in 2013. No statistics were computed for Generation-5 schools due to the absence of valid data. Tukey HSD Post Hoc procedure was conducted for each group that came out significant in one-way ANOVA. All statistically significant changes produced by the analysis were decreases in scores according to previous year. These results showed that T-STEM designation did not cause any statistically significant increases in 9th grade for all generations.

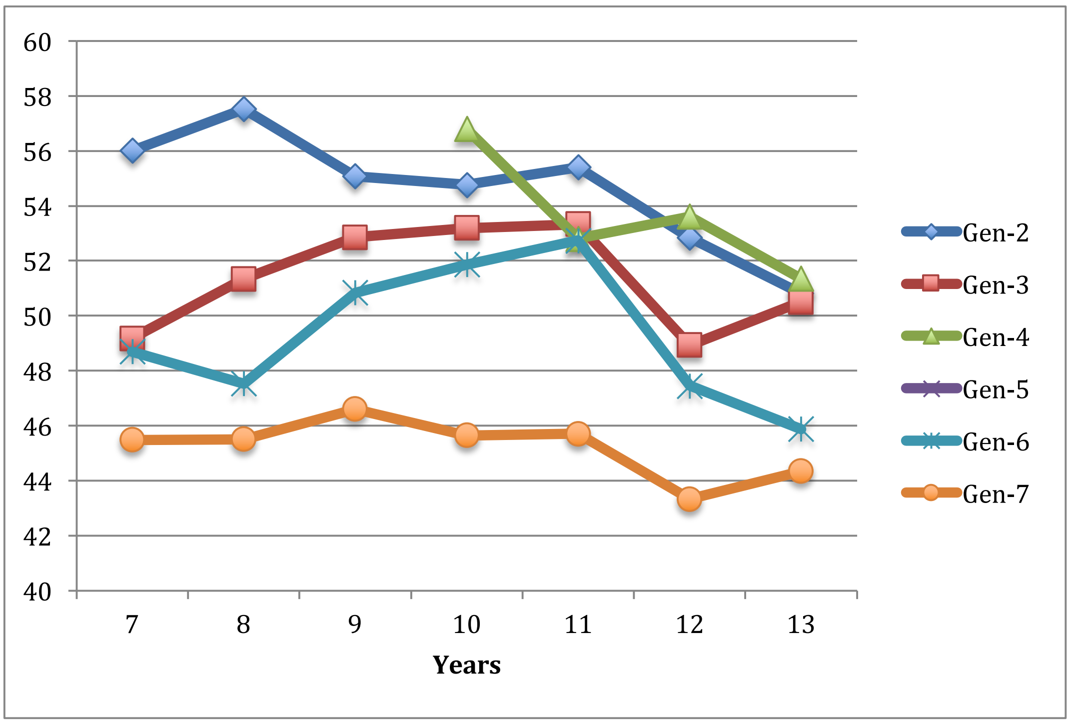


Figure 1. *T-STEM schools' score changes in 9th grade mathematics for each generation; 2007-2013.*

Figure 2 shows mathematics score changes for the 10th grade. One-way ANOVA results revealed statistically significant score changes for Generation-2 (F (5,820)=22.750, *p*=. 000) and Generation-3 schools only (F (5,659)=20.163, *p*=. 000) in both 2009 and 2010. Test data was not available for year 2012. Tukey HSD Post Hoc procedure yielded statistically significant decrease in the first year of designation in 2008-2009 and a significant increase in the following year for generation-2 and generation-3 schools. The same pattern was observed for generation-6 and generation-7 schools as well.

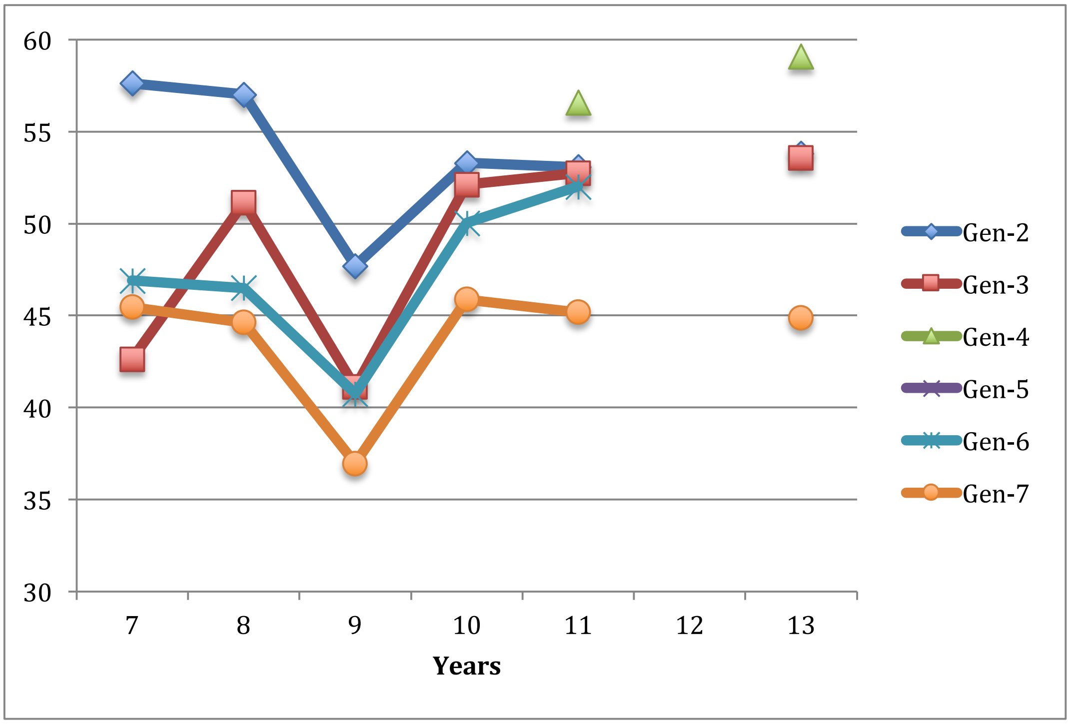


Figure 2. *T-STEM schools' score changes in 10th grade mathematics for each generation;2007-2013*

Figure 3 shows mathematics score changes in 11th grade. The one-way ANOVA results revealed statistically significant score changes for Generation-3 (F (5,223)=7.099, *p*=. 000) in 2009 and Generation-6 schools (F (5,456)=9.771, *p*=. 000) in 2012. Test data was not available for 2013 across all generations. Tukey HSD Post Hoc procedure yielded a statistically significant increase in the first year of designation in 2008-2009 for Generation-3 schools and a significant decrease for Generation-6 schools in 2011-2012. Both generations were in the first year of their T-STEM designations.

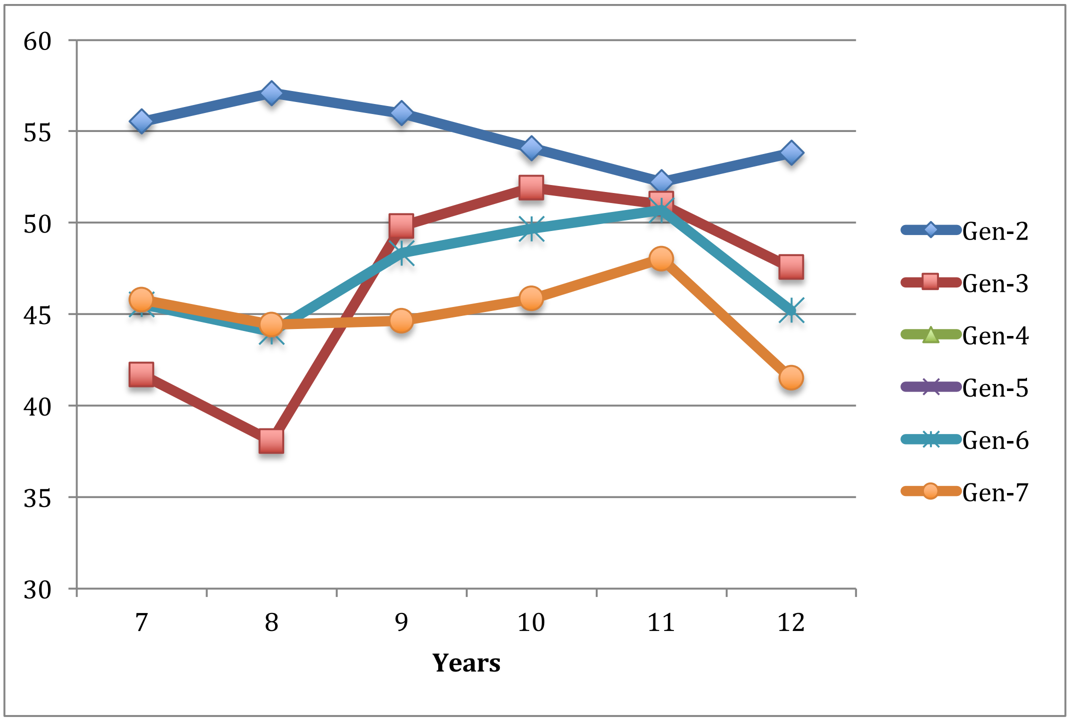


Figure 3. *T-STEM schools' score changes in 11th grade mathematics for each generation;2007-2013.*

Generation 1, 2, and 3 T-STEM designated schools were included for the analysis of the second question. There were a total of 27 stand-alone T-STEM schools designated as T-STEM academies by 2008-2009 school year. Independent samples t-test, one-way ANOVA, and Univariate General Linear Model (GLM) were conducted to discover how T-STEM high schools' mathematics performance change by factors mentioned in the second question between years 2009 and 2013 and analyze whether there is any interaction between these factors.

An independent samples t-test was conducted to discover how T-STEM high schools' mathematics performance change by school type. The analysis showed that students in Charter School (CS) type T-STEM schools scored statistically significantly higher than students in TPS type T-STEM schools in 9^{th} grade in all years between 2009 and 2013 with the exception of 2011. Even though CS students outperformed TPS students in every year in10^{th} grade, none of the differences were statistically significant. The analysis produced statistically significant differences for only in 2009 and

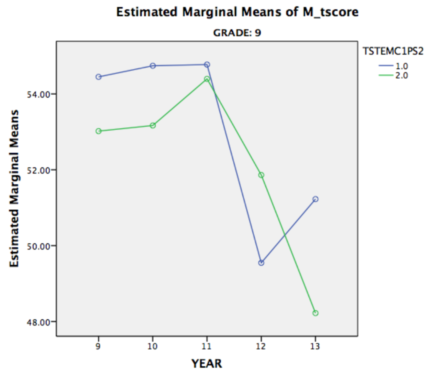
2012 for 11th grade students (See Table 1). No statistics were computed in 2012 for 10th grade and in 2013 for 11th grade as data was not available.

Table 1
Independent Samples t-tests Results of 2009-2013 T-STEM High School Mathematics Performances by School Type

Outcome		Group				95% CI for Mean Difference		
		CS Schools		TPS Schools				
Grade	Year	M	SD	M	SD		t	df
Grade 9	2009	54.45	6.93	53.02	7.85	0.11, 2.75	2.126*	493
	2010	54.74	7.49	53.17	7.15	0.17, 2.98	2.202*	561
	2011	54.77	7.71	54.40	7.05	-0.87, 1.63	0.591	725
	2012	49.55	8.39	51.86	8.69	-4.02, -0.61	-2.672*	412
	2013	51.23	7.92	48.22	8.63	1.23, 4.79	3.319*	437
Grade 10	2009	47.04	11.05	44.89	11.24	-0.59, 4.91	1.544	262
	2010	52.77	8.32	52.70	7.53	-1.51, 1.65	0.089	431
	2011	53.60	8.03	53.29	6.06	-1.18, 1.80	0.409	498
	2012**	.	.	.	.	-	-	-
	2013	54.07	10.36	52.17	11.78	-0.95, 4.73	1.311	304
Grade 11	2009	55.46	5.68	49.46	11.80	2.12, 9.89	3.067*	93
	2010	54.23	6.36	53.41	8.04	-1.10, 2.74	0.843	228
	2011	50.87	9.77	52.03	8.58	-3.19, 0.86	-1.131	341
	2012	53.82	6.46	47.54	4.83	3.19, 9.36	4.04*	92
	2013***	-	-	-	-	-	-	-

* $p < .05$.
** No statistics were computed in 2012 for 10th grade as testing data was not available.
*** No statistics were computed in 2013 for 11th grade as testing data was not available.

A Univariate General Linear Model analysis showed that there was also a statistically significant interaction between the school type and year variables for 9th ($F(4, 2628)=6.112$, $p=.000$)) and 11th grades (($F(3,754)=5.832$, $p=.001$)). The analysis did not yield any significant interaction between these variables in 10th grade. This result suggests that the score difference between CS type T-STEM schools and TPS type T-STEM schools is not the same across all the years between 2009 and 2013(See Figure 4).



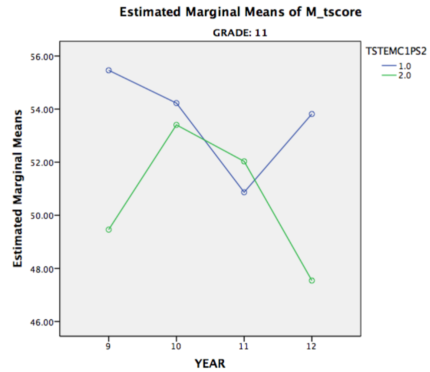


Figure 4. *T-STEM schools' mathematics score changes in 9th and 11th grades respectively by school type (CS:1 vs TPS:2) across the years 2009-2013.*

An independent samples t-test was conducted to examine gender differences among grade levels between 2009 and 2013. The analysis did not produce any statistically significant difference between male and female students in 9th grade. In 10th grade, statistically significant differences were observed in the scores between female students and male students in 2010 (Female (M=51.93, SD=8.11), Male (M=53.74, SD=7.84); t(431)= -2.348, p = 0.019) and 2013 (Female (M=52.35, SD=9.86), Male students (M=55.24, SD=11.55); t(304)= -2.360, p = 0.019). Statistically significant differences were also observed in scores between 11th grade female students and male students in 2009 (Female (M=52.16, SD=9.52), Male (M=56.30, SD=4.19); t(93)= -2.852, p = 0.005) , 2010 (Female (M=52.93, SD=8.10), Male (M=55.17, SD=5.07); t(228)= -2.451, p = 0.015), and 2011 (Female (M=51.52, SD=6.55), Male (M=53.30, SD=6.69); t(341)= -2.298, p = 0.022). No statistics were computed in 2012 for 10th grade and in 2013 for 11th grade as data was not available.

Univariate GLM conducted to investigate the interaction between gender and school type variables for each year between 2009 and 2013 produced statistically significant interactions only in 2011 (F(1,1566)=4.859, *p*=.028)) . This suggests that the score difference between female and male students are not same at school type level. While female students performed better in CS type T-STEM schools, male students' performance was higher in TPS type T-STEM schools in 2011 (See Figure 5).

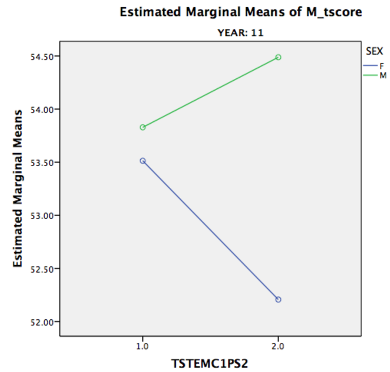


Figure 5. *Gender Differences by school type (CS:1 vs TPS:2) in year 2011.*

A one-way ANOVA was conducted to investigate how T-STEM high schools' mathematics performance changes by ethnicity. The analysis produced statistically significant differences among ethnic groups in all years; 2009 (F(2,831)=10.119, *p*=.000), 2010 (F(2,1168)=6.128, *p*=.002), 2011 (F(2,1324)=5.306, *p*=.005), 2012 (F(2,431)=22.698, *p*=.000), and 2013 (F(2,691)=16.836, *p*=.000) (See Table 2). African American, Hispanic, and White student ethnic groups were included in this analysis. American Indian and Asian categories were excluded due to relatively low student numbers.

Table 2

One-Way Analysis of Variance of T-STEM high schools' mathematics scores change by ethnicity between 2009 and 2013.

		Sum of Squares	df	Mean Square	F	Sig.
2009	Between Groups	1708.059	2	854.029	10.119	.000
	Within Groups	70133.563	831	84.397		
	Total	71841.622	833			
2010	Between Groups	703.369	2	351.684	6.128	.002
	Within Groups	67029.272	1168	57.388		
	Total	67732.641	1170			
2011	Between Groups	680.675	2	340.338	5.306	.005
	Within Groups	91335.158	1424	64.140		
	Total	92015.833	1426			
2012	Between Groups	2851.312	2	1425.656	22.698	.000
	Within Groups	27071.504	431	62.811		
	Total	29922.817	433			
2013	Between Groups	2762.783	2	1381.392	16.836	.000
	Within Groups	56695.225	691	82.048		
	Total	59458.008	693			

Tukey HSD Post Hoc procedure was conducted for each group that came out significant in the one-way ANOVA test. The procedure revealed that there were statistically significant differences ($p<.05$) in 2009 between African American students (M=48.17, SD=11.75) and Hispanic students (M=52.44, SD=8.28), Hispanic students (M=52.44, SD=8.28) and White students (M=50.30, SD=10.50), but not between African American students (M=48.17, SD=11.75) and White student (M=50.30, SD=10.50). Similarly, in 2008, Tukey HSD yielded statistically significant differences ($p<.05$) between African American students (M=50.86, SD=8.62) and Hispanic students (M=53.41, SD=7.30), African American students (M=50.86, SD=8.62) and White students (M=54.46, SD=8.14), but not Hispanic students (M=53.41, SD=7.30) and White students (M=54.46, SD=8.14). The only statistically significant difference appeared between African American students (M=51.45, SD=8.54) and White students (M=54.29, SD=8.67) in 2011. In 2012, Tukey HSD produced statistically significant differences ($p<.05$) between African American students (M=46.41, SD=10.69) and White students (M=56.14, SD=8.53), Hispanic students (M=46.74, SD=7.61) and White students (M=56.14, SD=8.53), but not between African American students (M=46.41, SD=10.69) and Hispanic students (M=46.74, SD=7.61). Similarly, in 2013, Tukey HSD produced statistically significant differences ($p<.05$) between African American students (M=51.86, SD=8.83) and White students (M=56.42, SD=10.37), Hispanic students (M=50.45, SD=8.85) and White students (M=56.42, SD=10.37), but not between African American students (M=51.86, SD=8.83) and Hispanic students (M=50.45, SD=8.85).

A univariate GLM was conducted to examine the interaction between ethnicity and grade level variables for each year between 2009 and 2013. The analysis yielded statistically significant interaction in 2009 ($F(4,825)=3.381$, $p=.009$)) only. This indicates that the score differences among ethnic groups depend on the grade level factor and are not same at grade level variable across the years between 2009 and 2013. As it is shown in figure 6, White and African American students' performance in 11th grade did not follow the same pattern as it did in 9th and 10th grades.

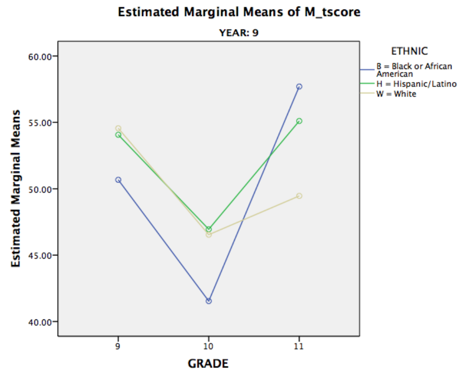


Figure 6. *Plots depicting the interaction between ethnicity and grade level variables for year 2009.*

Another Univariate GLM analysis was also conducted to investigate the interaction between ethnicity and school type variables for each year between 2009 and 2013. The analysis yielded statistically significant interactions only in 2010 (F(2,1165)=5.807, *p*=.003)). This result suggests that the score differences among ethnic groups depend on the school type factor in 2010. Mathematics performances of ethnic student groups are not the same for charter type T-STEM schools and TPS type T-STEM schools in that year. More specifically, all three ethnic groups seem to be performing very close to each other in CS type T-STEM schools, the differences among the performances of these groups seem to be quite different in TPS type T-STEM school setting (See Figure 7).

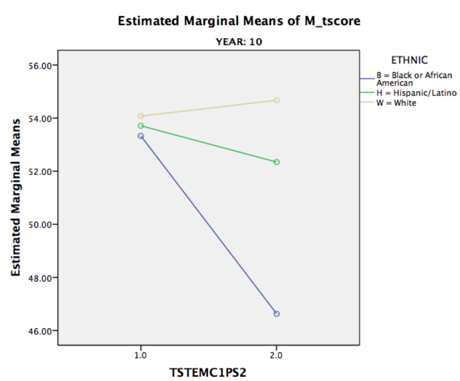


Figure 7. *Plots depicting the interaction between ethnicity and school type (CS:1, TPS:2) variables for 2010.*

A one-way ANOVA was conducted to investigate how T-STEM high schools' mathematics performance differed by designation year. In other words, Generation-1, Generation-2, and Generation-3 schools were compared in years between 2009 and 2013. The analysis yielded statistically significant differences in 2009, 2010, 2011, and 2012, but not in 2013 (See Table 3).

Table 3

One-Way Analysis of Variance of T-STEM high schools' mathematics scores change by T-STEM designation year(generation) between 2009 and 2013.

		Sum of Squares	df	Mean Square	F	Sig.
2009	Between Groups	552.854	2	276.427	3.145	.044
	Within Groups	74807.107	851	87.905		
	Total	75359.961	853			
2010	Between Groups	765.711	2	382.856	6.700	.001
	Within Groups	69884.127	1223	57.142		
	Total	70649.838	1225			
2011	Between Groups	1015.564	2	507.782	7.882	.000
	Within Groups	100949.252	1567	64.422		
	Total	101964.817	1569			
2012	Between Groups	2095.236	2	1047.618	16.213	.000
	Within Groups	32631.147	505	64.616		
	Total	34726.383	507			
2013	Between Groups	115.549	2	57.775	.649	.523
	Within Groups	66014.294	742	88.968		
	Total	66129.844	744			

A Tukey HSD Post Hoc procedure was conducted for each group that came out significant in the one-way ANOVA test. The procedure did not reveal any statistically significant differences (p<. 05) in 2009 among Generation-1, Generation-2, and Generation-3 school students even though the one-way ANOVA procedure had produced significant results. In 2010, the Tukey HSD yielded statistically significant differences (p<. 05) between Generation-1 (M=54.74, SD=7.30) and Generation-3 (M=52.66, SD=8.21), and Generation-2 (M=54.08, SD=7.16) and Generation-3 (M=52.66, SD=8.21). There was no statistically significant difference between Generation-1 and Generation-2. Similarly, in 2011, the procedure yielded statistically significant differences (p<. 05) between Generation-1 (M=54.74, SD=8.64) and Generation-3 (M=52.65, SD=8.43), and Generation-2 (M=53.90, SD=7.29) and Generation-3 (M=52.65, SD=8.43). Again, there was no statistically significant difference between Generation-1 and Generation-2 in 2011. In 2012, Generation-2 (M=53.19, SD=8.08) school students performed significantly better than Generation-1(M=49.65, SD=7.67) and Generation-3(M=48.78, SD=8.22) school students while there was no statistically significant difference between Generation-1 and Generation-3 schools.

A Univariate GLM was conducted to investigate the interaction between generation and school type variables for each year between 2009 and 2013. The analysis yielded statistically significant interactions in 2009 (F(2,848)=7.358, *p*=.001)), 2012(F(2,502)=3.951, *p*=.020)), and 2013(F(2,739)=29.634, *p*=.000)). This result suggests that the score differences among Generation-1, Generation-2, and Generation-3 depend on the school type factor in 2009, 2012, and 2013. Mathematics performances of these student groups are not same for charter type T-STEM schools and TPS type T-STEM schools in the aforementioned years. More specifically, all three groups' performances seem to be different in CS type T-STEM school and PS type T-STEM school settings (See Figure 8).

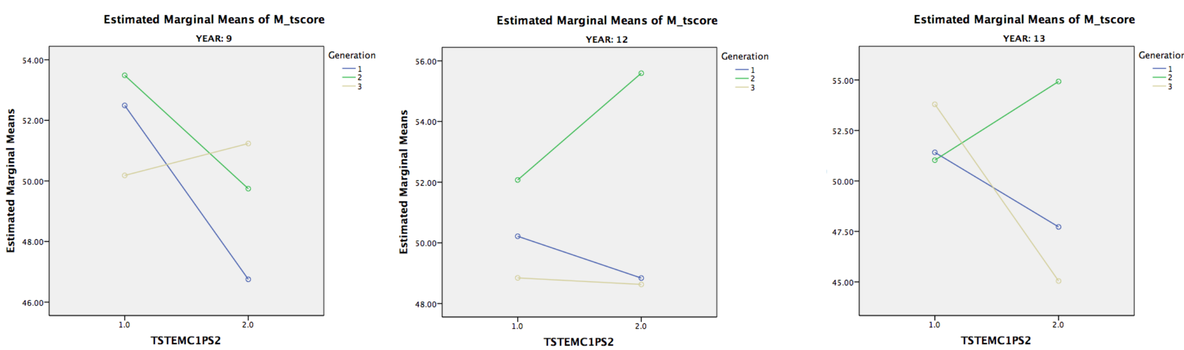


Figure 8. *Plots depicting the interaction between generation and school type (CS:1, TPS:2) variables for 2009, 2012, and 2013.*

An independent samples t-test was conducted to examine how T-STEM high schools' mathematics performance changed by at-risk variable. The analysis showed that the difference in mathematics scores between at-risk students and non-at-risk students was statistically significant in each year between 2009 and 2013 for each grade level at p<.05. As it is shown in Table 4, at-risk student group performed significantly lower than the non-at-risk student group in each category. Univariate GLM was used to determine if there was any interaction between at-risk and grade level variables for each year between 2009 and 2013. The analysis yielded a statistically significant interaction between these two variables in year 2013 (F(1,741)=28.365, *p*=.000)) Figure 9 shows how the score differences among at-risk and non-at-risk student groups depend on the grade level factor for 2013.

Table 4

Independent Samples t-tests Results of 2009-2013 T-STEM High School Mathematics Performances by At-Risk Variable

Outcome		Group				95% CI for Mean Difference		
		Not-At-Risk		At-Risk				
Grade	Year	M	SD	M	SD		t	df
Grade 9	2009	55.42	6.05	49.19	8.61	4.83, 7.63	8.729*	492
	2010	55.21	6.82	49.09	8.75	4.43, 7.80	7.109*	561
	2011	55.68	6.16	50.98	10.47	3.41, 5.99	7.132*	725
	2012	51.28	8.39	47.50	9.39	1.49, 6.07	3.243*	364
	2013	51.34	8.40	47.50	6.57	2.00, 5.67	4.116*	437
Grade 10	2009	47.93	10.18	41.87	10.96	3.11, 9.01	4.04*	260
	2010	54.01	6.81	47.41	10.33	4.78, 8.43	7.109*	431
	2011	54.52	6.74	48.30	9.18	4.50, 7.93	7.129*	498
	2012**	.	.	.	.	-	-	-
	2013	55.51	9.90	42.36	8.27	10.05, 16,26	8.337*	304
Grade 11	2009	56.05	5.67	49.98	9.43	2.88, 9.25	3.779*	93
	2010	54.81	6.10	51.28	8.67	1.47, 5.59	3.378*	228
	2011	53.41	7.20	46.41	11.67	4.96, 9.03	6.756*	341
	2012	54.55	5.98	47.35	5.38	4.57, 9.83	5.428*	92
	2013***	-	-	-	-	-	-	-

* p < .05.
** No statistics were computed in year 2012 for 10th grade as testing data was not available.
*** No statistics were computed in year 2013 for 11th grade as testing data was not available.

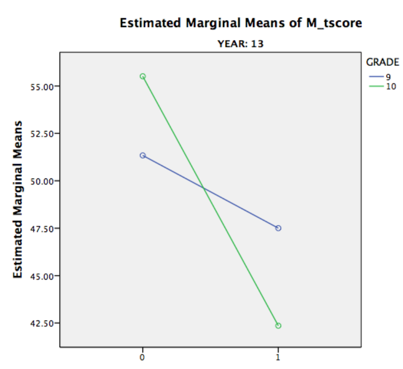


Figure 9. *Plots depicting the interaction between ethnicity and grade level variables for year 2013.*

Another Univariate GLM was conducted to examine the interaction between at-risk and school type variables for each year between 2009 and 2013. The analysis produced a statistically significant interaction between these two variables in 2009 (F(1,847)=11.417, *p*=.001)), 2011 (F(1,1566)=13.471, *p*=.000)), 2012 (F(1,456)=8.706, *p*=.003)), and 2013 (F(1,741)=4.531, *p*=.034)). The score differences between at-risk and non-at-risk students depend on the school type factor and are not same across the years between 2009 and 2013. The score differences between at-risk and non-at-risk students are greater in TPS type T-STEM schools than those in CS type T-STEM schools (See Figure 10).

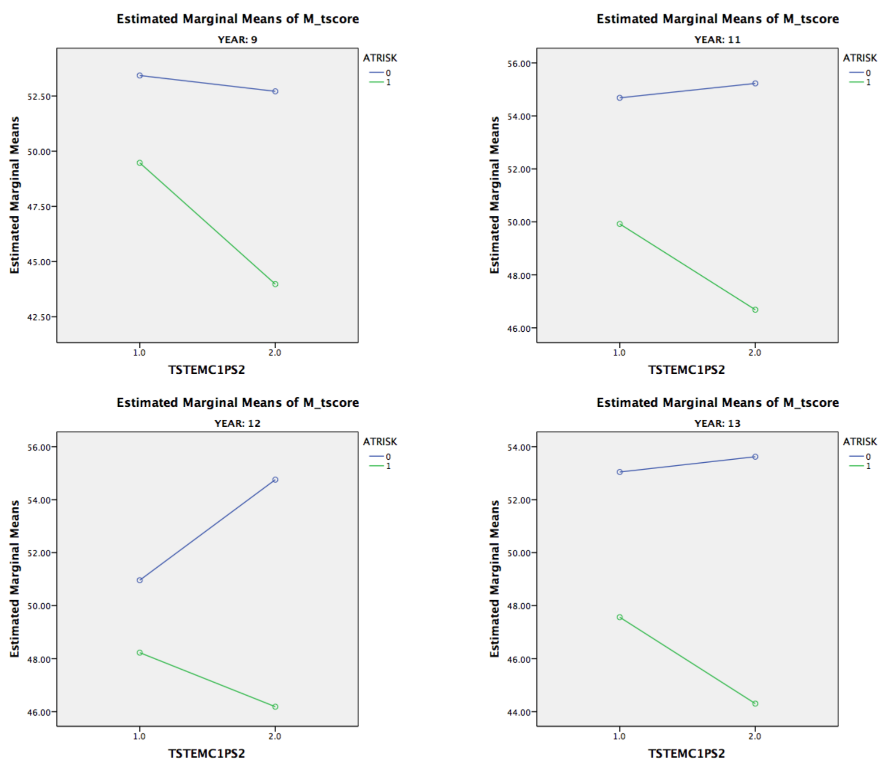


Figure 10. *Plots depicting the interaction between at-risk student population and school type (CS:1, TPS:2) variables for years 2009, 2011, 2012, and 2013.*

An independent samples t-test was conducted to evaluate how T-STEM high schools' mathematics performance changes by students' socio-economic status. In 9th grade, statistically significant differences in scores were observed between economically disadvantaged students (ED) and economically non-disadvantaged students (END) in all years except 2009. ED students include students who, according to the state's guidelines, receive free and reduced lunch. As it is shown Table 5, ED students performed significantly lower than END students in all years except 2009. In 10th grade, statistically significant differences were also observed in scores between END and ED students in 2009 and 2011. In 11th grade, the only statistically significant difference between END and ED student groups was observed in 2010. Even though statistically not significant, 11th grade ED students had a higher mean score than END students in 2009 and 2011 (See Table 5).

Table 5

Independent Samples t-tests Results of 2009-2013 T-STEM High School Mathematics Performances by Socio-Economic Status

Outcome		Group				95% CI for Mean Difference		
		Not Eco. Disadvantaged		Economically Disadvantaged				
		M	SD	M	SD		t	df
Grade 9	2009	54.07	7.70	53.81	7.16	-1.15, 1.65	0.354	493
	2010	55.20	7.52	53.88	7.36	0.03, 2.61	2.012*	561
	2011	55.86	6.93	53.98	7.80	0.75, 3.01	3.275*	725
	2012	53.91	8.71	48.74	8.12	3.38, 6.95	5.695*	364
	2013	52.80	9.18	49.64	7.61	1.46, 4.86	3.655*	437
Grade 10	2009	46.59	11.39	46.39	10.18	-2.44, 2.85	0.155	260
	2010	53.71	9.04	52.39	7.61	-0.39, 3.03	1.518	431
	2011	55.15	7.81	52.52	7.21	1.27, 3.97	3.82*	498
	2012**	.	.	.	.	-	-	-
	2013	57.55	10.57	51.32	10.14	3.83, 8.64	5.108*	304
Grade 11	2009	51.99	11.09	55.19	5.76	-6.79, 0.39	-1.771*	93
	2010	55.08	6.50	53.22	7.17	0.02, 3.70	1.991*	228
	2011	50.24	12.14	51.72	8.06	-3.72, 0.76	-1.3	341
	2012	.	.	.	.	.	.	.
	2013***	-	-	-	-	-	-	-

* $p < .05$. ** No statistics were computed in year 2012 for 10th grade and 11th grade since testing data was not available. *** No statistics were computed in year 2013 for 11th grade since testing data was not available.

A Univariate GLM was conducted to examine the interaction between socio-economic status and school type variables for each year between 2009 and 2013. The analysis yielded a statistically significant interactions between these two variables in 2010 (F(1,1222)=5.105, *p*=.024)), 2012 (F(1,456)=11.421, *p*=.001)), and 2013 (F(1,741)=17.016, *p*=.000)). The score differences between ED and END student groups depend on the school type factor and are not same across the years between 2009 and 2013 (See Figure 11).

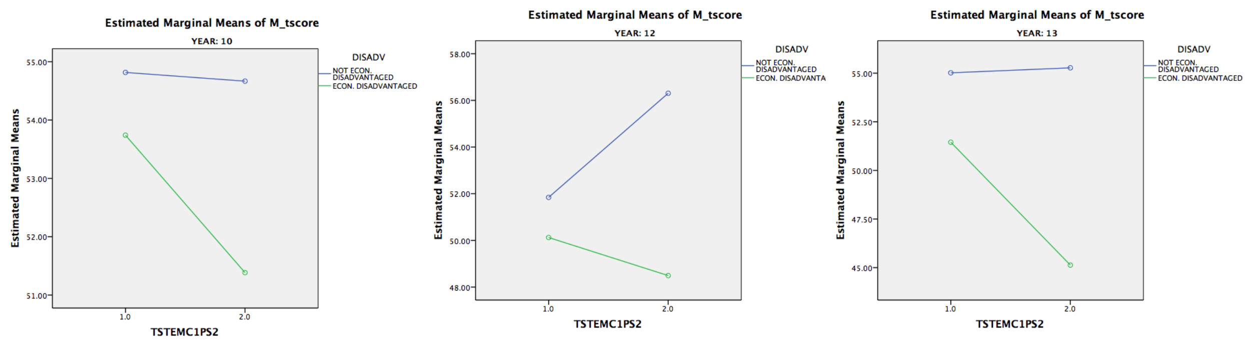


Figure 11. *Plots depicting the interaction between socio-economic status and school type (CS:1, TPS:2) variables for years 2010, 2012, and 2013.*

Discussions and Conclusion

The purpose of this study was to investigate how STEM designation affected high school mathematics performance over the years by studying STEM designated T-STEM schools. How T-STEM high schools' mathematics performance changed by school type (TPS versus Charter Schools), gender, ethnicity, the number of years as a T-STEM designated school (Generation), socio-economic status, and at-risk student population was also examined.

For the first research question, One-way ANOVA was used to examine the score changes after high school's T-STEM designation for each grade level. Generation-1 schools (the schools designated as T-STEM academies in 2006-2007 school year) were not included in the analysis of the first question as the data was not available prior to 2006-2007 school year. The analysis yielded few significant score changes in the years after T-STEM designation, and the changes that did take place were mostly decreases in mathematics scores. These results imply that T-STEM designation did not make any positively impact on students' mathematics performances over the years in T-STEM designated schools. This finding is in accordance with the previous research findings (e.g., Sahin, Oren, Willson, Hubert, & Capraro, 2015) indicating that there was no difference between schools that are designated as T-STEM and traditional public schools without any STEM focus. Young et al.,(2011) and Bicer, Navruz, Capraro, Capraro, Oner, Boedeker, (2015) found that T-STEM students outperformed non-T-

STEM students in 9th grade mathematics. This finding conflicts with aforementioned studies. This might be due to the matching strategies used, sample size differences, or methods used in those studies. This study standardized all years' student scores and compared across the years to comparisons with a greater degree of precision.

How T-STEM high schools' mathematics performance changed by school type (TPS versus Charter Schools), gender, ethnicity, the number of years as a T-STEM designated school (Generation), socio-economic status level, and at-risk student population was examined in the second question. A total of 29 high schools were designated as T-STEM academy by the 2008-2009 school year. Therefore, the first three generations of T-STEM designated schools (schools that opened in the years 2006, 2007, and 2008) were included, and those schools' mathematics performance between years 2009 and 2013 were analyzed for the second question.

The first finding for the second research question is that Charter School (CS) type T-STEM schools outperformed TPS type T-STEM schools in almost all grades even though some of the score differences are not statistically significant. TPS type T-STEM schools had higher scores in two instances; 9th grade in 2012 (significant) and 11th grade in 2011 (not significant). A Univariate General Linear Model (GLM) analysis yielded statistically significant interactions in 9th and 11th grades, which implies that score differences between CS type T-STEM schools and TPS type T-STEM schools are not the same across all the years.

Furthermore, the independent samples t-test analysis yielded significant differences between female and male students in 10th (years 2010 and 2013) and 11th grades (years 2009, 2010, 2011), but not in 9th grade. Males outperformed female students in all years that came out significant. This finding is in accordance with the research in general (e.g.: Niederle & Vesterlund, 2010). where male students usually outperform females in mathematics and science. Univariate GLM produced a significant interaction between school type and year variables in 2011; female students performed better in CS type T-STEM school while male students' performance was higher in TPS type T-STEM schools.

A One-way ANOVA and a Tukey HSD Post Hoc procedure yielded significant differences among ethnic groups. White students outperformed Hispanic and African American students with the exception of the year 2009, in which Hispanic students performed significantly better than White and African American students. These results are in accordance with the research in general that an achievement gap exists between white and minority students. Univariate GLM conducted to examine the interaction between ethnicity and grade level variables also supported this finding that there is an interaction in only 2009. Moreover, another Univariate GLM analysis conducted to investigate the interaction between ethnicity and school type variables also produced significant interaction in only one year (2010), where ethnic groups seem to be performing differently in CS and TPS settings.

The independent samples t-test conducted to examine how T-STEM high schools' mathematics performance changes by the at-risk variable yielded statistically significant differences in each year between 2009 and 2013 for each grade level. At-risk students performed significantly lower than the non-at-risk students in each category. In addition, a Univariate GLM conducted to determine the interaction between at-risk and school type variables produced a statistically significant interaction between these two aforementioned variables in years 2009,2011,2012, and 2013. This implies that the score differences between at-risk and non-at-risk students are greater in TPS type T-STEM schools than those in CS type T-STEM schools. These results suggest that a charter school setting is a better fit for at-risk students.

Another independent samples t-test analysis yielded significant differences between economically disadvantaged (ED) students and economically not disadvantaged (END) students in the 9th (years 2010, 2011, 2012, and 2013), 10th (years 2011 and 2013), and 11th grades (year 2010). ED students were outperformed in all years that were determined to be significant. On a similar note, a Univariate GLM conducted to determine the interaction between socio-economic status and school type variables produced a statistically significant interaction between these two variables in years 2010, 2012, and 2013. Analogous to the findings on at-risk students, these results also suggest that the score differences between ED and END students are greater in TPS type T-STEM schools than those in CS type T-STEM schools. Thus, similarly, the charter school setting seems to better nurture economically disadvantaged students.

A One-way ANOVA conducted to investigate how T-STEM high schools' mathematics performance differs by the T-STEM generation designation year yielded statistically significant results in years 2009, 2010, 2011, and 2012. Generation-1, Generation-2, and Generation-3 schools were included in this analysis, with Generation-1 and Generation-2 schools performing slightly better than Generation-3 schools over the years, implying that early designation might have made a difference. However, this finding conflicts with the findings of the first question; and further research is needed necessary to find out determine the reason(s) that lie behind this difference.

In essence, T-STEM academies were established to increase students' math and science competencies and provide equal opportunities to underrepresented populations (Young et al., 2011). In order to achieve these goals, they were developed as small schools that have clear guidelines on selection blind to prior academic performance, and are required to consist of at least 50% economically disadvantaged students or students from ethnic minority groups (Young et al., 2011). However, the findings of this study, particularly the analysis of the second research question, revealed that T-STEM academies fall short of meeting expectations. The well documented achievement gap between male and female students, at –risk and non-at-risk students, students with differing socio-economic status, and ethnic groups seems to also permeate T-STEM academies. Yet there seems to be some change for the better; CS type T-STEM schools seem to be doing a better job in closing the achievement gap, especially for the at-risk and economically disadvantaged student groups.

Limitations

This study had two limitations. First, not all scores in mathematics between years 2009 and 2013 were available. No statistics were computed in year 2012 for 10th grade in year 2013 for 11th grade since testing data was not available. Eleventh grade scores were not included because STAAR testing was not administered to 11th grade students until the 2013-2014 school year. Also, there was no testing for 10th grade reading, mathematics, and science during 2012, the first year of STAAR testing. The study could have been stronger with the presence of test data for these years.

Second, the STAAR and the TAKS tests were not an exact match for high school grade levels. On the TAKS, mathematics was a mixture of related subjects (e.g., Algebra I, Geometry, and Algebra II) and assessed in grades 9 to 11, whereas the STAAR introduced EOC (End of Course) tests for each of these subjects. STAAR EOC testing is done separately in Algebra I, Geometry, and Algebra II in 9th, 10th, and 11th grades, respectively.

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