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T-STEM Academies' Academic Performance Examination by Education Service Centers: A Longitudinal Study

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ABSTRACT

The purpose of the study is to examine the performance of Texas-STEM (T-STEM) academies in different regions to determine whether the academic achievement differs according to Education Service Centers (ESC). The ESCs' goals were to improve the quality of school district programs and to increase student achievement. It was found that there was no statistically significant difference among T-STEM academies' students' mathematics mean scores in different ESCs when demographic variables taken into account. African American students' mathematics mean scores were statistically significantly lower than those of White students in 9th grade; however, Asian students' growth rate was statistically significantly higher than White students' growth rate. Male students' growth rate was statistically significantly higher than female students' growth rate.

Keywords: T-STEM Academies, Education Service Centers, Ethnicity, Gender

Teksas-FeTeMM Okullarının Akademik Performanslarının İlişkili Oldukları Eğitim Servis Merkezlerine göre İncelemesi: Boylamsal bir Çalışma

Bu çalışmanın amacı farklı bölgelerdeki Teksas-FeTeMM (T-FeTeMM) akademilerinde eğitim gören öğrencilerin akademik performanslarının bulundukları bölgedeki Eğitim Servis Merkezlerine (ESM) göre incelemektir. ESM'lerinin hedefleri okulların kalitesini ve bu okullarda eğitim gören öğrencilerin başarısını arttırmaktır. Bu çalışmada, ESM'lerin bulundukları bölgelere göre öğrenci başarılarında farklılık olup olmadığını belirlemek amacıyla T-FeTeMM öğrencilerinin üç yıllık performansları incelenmektedir. Farklı bölgelerde bulunan ESM'lerde yer alan T-FeTeMM akademisi öğrencilerinin matematik skorları arasında demografik değişkenler göz önüne alındığında anlamlı farklılık bulunmamıştır. Dokuzuncu sınıfta Afrika kökenli Amerikalı öğrencilerin skorlarının aritmetik ortalaması Beyaz Amerikalı öğrencilerinkinden istatistiksel olarak daha düşük bulunmuştur. Asya kökenli öğrencilerin matematik gelişim oranları ise Beyaz Amerikalı öğrencilerinkinden daha yüksek bulunmuştur. Erkek öğrencilerin matematik gelişim oranı kızlarınkinden daha yüksek bulunmuştur.

Anahtar Kelimeler: Teksas-FeTeMM Okulları, Eğitim Servis Merkezleri, Etnik köken, Cinsiyet

GENİŞLETİLMİŞ ÖZET

Amerika Birleşik Devletleri'nde (ABD), Eğitim Servis Merkezleri (ESM) öğrenci performansının gelişiminde tüm okullara yardımcı olmak ve okulların daha etkili ve ekonomik olarak verimli şekilde yönetilmesine katkıda bulunmak üzere kurulmuşlardır. Teksas eyaletinde 20 ESM bulunmakta ve bu merkezler yaklaşık 5 milyon öğrenci ile birlikte 660.000 öğretmen ve okul yöneticisine hizmet vermektedir. Bu merkezlerin bütçeleri eyalet ve federal hükümet ödeneklerinden karşılanmaktadır (Texas System of Education Service Center, 2013). ESM'lerin ana görevi öğrencilerin fen ve matematik başarısına katkıda bulunmak (Texas System of Education Service Center, 2011) ve bu hedefe yönelik kurulan Fen Teknoloji Mühendislik ve Matematik (FeTeMM) akademilerinin sayısını arttırmaktır.

Teksas eyaletinde kurulan FeTeMM akademilerine kısaca T-FeTeMM denmektedir. T-FeTeMM akademileri Teksas eyaletinde öğrenci başarısının arttırılması için bu alanlarda bütünleştirilmiş bir müfredat uygulamaktadır. T-FeTeMM okullarının amacı sadece başarının arttırılması ile sınırlı değil aynı zamanda öğrencilerin FeTeMM alanlarında kariyer sahibi olmaları için desteklenmesini ve bu alanlarda üniversite eğitimine hazırlanmalarını sağlamaktır (Pantic, 2007; Young et al., 2011). Bu amaçların gerçekleştirilebilmesi için ise öğretmenlerin hizmet içi eğitimlerine özel bir önem verilmektedir (Educate Texas, 2013). Bu hizmet içi eğitimler ile öğrencilerin yirmi birinci yüzyıl becerilerini kazanmaları amaçlanmaktadır (Young et al., 2011).

Bu çalışmada T-FeTeMM akademilerinde öğretim gören öğrencilerin akademik sınav performanslarının bulundukları ESM'lere göre değişip değişmediği demografik bilgileri göz önüne alınarak araştırılmaktadır. Çalışmanın örneklemini 26 farklı T-FeTeMM akademisinde öğrenim gören toplam 4,018 lise öğrencisi oluşturmaktadır. Bu 26 farklı akademi Teksas'taki 11 farklı bölgede yer almaktadır. Çalışmanın verileri, öğrencilerin üç yıl boyunca her yıl düzenli olarak yapılan Texas Assessment of Knowledge and Skills (TAKS) matematik testinden aldıkları puanlardan oluşmaktadır. İlk ölçüm 2009 yılında öğrenciler 9. sınıf, diğer iki ölçüm ise 2010 ve 2011 yıllarında öğrenciler 10. ve 11. sınıf seviyesinde iken yapılmıştır. Bu çalışma boylamsal bir çalışma olduğundan dolayı, veri sırasıyla aynı öğrenciler 9., 10. ve 11. sınıflarda takip edilerek elde edilmiştir. Örneklemin % 49'nu kız öğrenciler, % 51'ni ise erkek öğrenciler oluşturmaktadır. Etnik yapı olarak, örneklemin % 63'u Latin Amerika kökenli, % 17'si Afrika kökenli Amerikalı, % 4'ü Asya kökenli ve geriye kalan % 16'sı da Beyaz Amerikalı öğrencilerden meydana gelmektedir.

Veriler üç düzeyli hiyerarşik lineer modelle (HLM) ile analiz edilmiştir. Çalışmada öğrencilerin TAKS matematik puanları birinci düzey de; kendilerine ait değişkenler ikinci düzeyde: okullar ise üçüncü düzeyde hiyerarşik bir yapı oluşturmaktadır. Düzey 1: Öğrencilerin üç yıl boyunca aldıkları TAKS matematik puanları birinci düzeyde yer almaktadır. Düzey 2: Cinsiyet değişkeni kızları 1, erkekleri 0 olacak şekilde kodlayarak elde edilmiştir. Etnik yapı değişkeni dört farklı etnik gruptan meydana geldiğinden dolayı, etnik yapı değişkenini HLM ile analiz edebilmek için, üç tane yeni kukla (dummy) değişkeni, Beyaz Amerikalılar referans grubu olacak şekilde, oluşturulmuştur. Sosyoekonomik değişken, dezavantajlı öğrenciler 0, diğer öğrenciler 1 olarak kodlanarak elde edilmiştir. Düzey 3: ESM değişkeni toplam 11 farklı bölgeden oluşmaktadır. Bu değişken onuncu bölge referans grubu olacak şekilde 10 tane kukla değişkenin oluşturulmasıyla çalışmaya dahil edilmiştir.

Etnik yapı açısından Beyaz Amerikalı ile Latin Amerika kökenli ve Beyaz Amerikalı ile Asya kökenli öğrenciler arasında 9. sınıf düzeyinde anlamlı bir fark bulunmamıştır. Fakat 9. sınıf Afrika kökenli Amerikalı öğrencilerin matematik skorlarının aritmetik ortalaması Beyaz Amerikalı öğrencilerin ortalamalarından (p<0,001) 163,96 puan daha düşük olarak bulunmuştur. 9. sınıf düzeyinde cinsiyet bakımından anlamlı fark bulunmamıştır. Öğrencilerin sosyoekonomik düzeyleri dikkate alındığında gruplar arasında anlamlı fark bulunmamıştır. Gelişim oranı açısından Beyaz Amerikalı ile Latin Amerika kökenli ve Beyaz Amerikalı ile Afrika kökenli Amerikalı öğrenciler arasında anlamlı fark bulunmamıştır. Fakat Asya kökenli öğrencilerin yıllar boyunca gelişim oranı Beyaz Amerikalı öğrencilerin gelişim oranından daha fazladır (p=0,007). Sosyoekonomik düzey açısından öğrencilerin gelişim oranlarında anlamlı bir fark gözlemlenmemiştir. Erkek öğrencilerin matematik gelişim oranı kız öğrencilerin matematik gelişim oranından daha yüksek bulunmuştur (p=0,037). Akademilerin başlangıç noktası olarak belirlenen 9. sınıf seviyesinde ve gelişim oranlarında varyans

gözlemlenmediği için okullar arasında ESM'lerine göre fark olup olmadığına dair analiz yapılma gereği kalmamıştır.

ESM'lerinin öğrenci başarısına etkilerini daha kapsamlı bir şekilde anlayabilmek için başka çalışma ve yöntemlere ihtiyaç bulunmaktadır. TAKS skorlarına ilaveten öğrencilerin başka testlerden elde edilen skorlarının ve öğretmenlerin sınıf içi değerlendirmelerinin incelenmesi önerilir. Ayrıca ESM'lerinin hizmet yıllarının ve deneyimlerinin T-FeTeMM akademilerindeki öğrenci başarısına olan etkisinin göz önüne alınması gerekmektedir.

ESM'lerinin ABD'deki etkilerini ortaya çıkarma amacındaki bu araştırma sonunda hizmet içi eğitim gibi FETEMM okullarının ihtiyaçlarını gidermek ve FeTeMM okullarında başarılı bir FETEMM müfredatı uygulanmasına yardımcı olmak için Türkiye'de de eğitim servis merkezlerinin açılması bu çalışmanın önerisi olabilir. Türkiye fen liseleri gibi bir konuda özelleşmiş okullara bu tür hizmetler sağlamamaktadır. Bu çalışmanın uygulaması olarak öğretmenlere verilecek olan hizmet içi eğitimi sağlayacak ve başarılı bir bütünleşik FeTeMM uygulamasına yardımcı olacak eğitim servis merkezlerinin Türkiye'de kurulması sunulmaktadır. Türkiye'de yeni yeni gelişen *Bilim Merkezlerinin* sadece bilimin popülerliğinin arttırılması değil ayni zamanda ESM'lere benzer sorumluluklar almalari ve okullar ile işbirliği içerisinde geliştirilme ve yaygınlaştırılmaları tavsiye edilmektedir. Bu bilim merkezlerinin diğer devlet okullarını öğretmenlerin hizmet içi eğitim bakımından gerekli kaynak ve deneyimli uzmanlar ile hareket ederek desteklemeleri önerilmektedir. Ayrıca bilim merkezleri ile üniversiteler arasında kurulması gereken güçlü işbirliği öğrencilerin FeTeMM performansını arttırmak için iyi bir yöntem olarak düşünülmelidir.

INTRODUCTION

The Texas regional education service centers (ESC)

Education Service Centers (ESC) bridges the gap between mandated state legislature and needs of the local school districts and public charter schools. The motto for the ESCs are "World class educational community preparing a world class workforce" (Texas System of Education Service Centers, 2011, p. 2). The ESCs assist school districts in improving student performance, enable school districts to operate more efficiently and economically, and are responsible for the implementation of initiatives assigned by the Texas state legislature or the Commissioner of Education. There are 20 different ESCs throughout the state of Texas and, they serve more than 4.8 million students, approximately 660,000 administrative and staff members, and over 1,100 school districts (Texas System of Education Service Centers, 2011). They are financially supported by state and federal grant funds, state appropriated funds, and revenue generated by the sale of the ESC services (Texas System of Education Service Centers, 2013).

Each ESC is positioned geographically to address the needs of a diverse state. Texas is composed of a variety of ethnic and economic groups, leading to a diverse population of students, each with different challenges (Texas System of Education Service Centers, 2013). Some ESCs serve primarily urban school districts, whereas others serve rural school districts. The number of school districts per ESC varies from 10 to 100 and the number of students from 40,000 to 1,000,000 (Ausburn, 2010). Each ESC is governed by a board of unpaid directors that is elected by local school members within the region. The ESCs provide support and services that specifically address the local school district and public charter schools' needs (Texas System of Education Service Centers, 2013). The number of services at each ESC varies from 20 to 400 (Texas System of Education Service Centers, 2014). All of the ECSs offer services related to curriculum, leadership, and special programs but vary in what is emphasized. For example, ESCs in urban regions offer services related to homeless education along with other topics relevant to a highly populated area, whereas ESCs located in rural areas focus on services that enable teachers and students to access resources that they lack due to the small population size and remote locations (Ausburn, 2010).

Accountability of each ESC

ESCs are held accountable by local taxpayers, school districts, the Texas Education Administration, and the Texas Legislature. The accountability of each ESC is measured in different ways such as financial audits, student performance, superintendent and charter school director satisfaction, and an accounting of how much money was saved using the offered resources. Students' performance within each area covered by an ESC is measured by their results on a series of Texas state standardized tests. These tests measure elementary and secondary level students' knowledge and skills in core subject areas such as mathematics, science, English language arts, and social studies (Texas System of Education Service Centers, 2013).

ESCs and STEM education

In 1994, the ESC leadership were surveyed to determine what services they felt would be priorities in the years 2000-2019. These leaders believed that topics such as staying on the cutting edge of new trends, innovations, and successful programs in order to better serve school districts were important priorities. Besides these topics, providing professional development related to current trends in order to provide leadership to schools and expertise in mathematics, language arts, science, and social studies was another priority. The ultimate goal of the ESCs was to assist the educational community and thus to improve student achievement (Texas System of Education Service Centers, 2011). To achieve that goal, ESCs in Texas aimed to enlarge the number of districts/campuses/charters to meet the state No Child Left Behind (NCLB) standards, which require improving students' performance in mathematics and science as well as in other subjects (Texas System of Education Service Centers, 2011). However, evaluating *cutting edge* programs and innovations and communicating these findings were lower on the list of priorities (Blackwell, 1995). In addition, despite the developing understanding of STEM education as the construction of integrated knowledge through collaborative efforts of students and teachers (Corlu, 2014; Corlu, Capraro, & Capraro, 2014; Committee on Integrated STEM Education, 2014), the integration of technology or engineering into mathematics and science subjects or building a community of practice among STEM teachers was not amongst the list of priorities of the strategic plan of Texas System of Education Service Centers for 2010-2015. In fact, only very few of the ESCs emphasized the integrated nature of STEM education in their programs.

T-STEM academies

Science, Technology, Engineering, and Mathematics schools in the state of Texas are called Texas-STEM (T-STEM) academies. T-STEM academies are schools which were established to provide STEM integrated curriculum to enhance overall success in the state and country. The goal of the T-STEM academies are: 1) to increase students' achievement in STEM subjects (Avery, Chambliss, Pruiett, & Stotts, 2010), 2) to develop students' interest in STEM disciplines and careers as well as promote college readiness (Pantic, 2007; Young et al., 2011), 3) to support teachers through professional development (Educate Texas, 2013), and 4) to develop students' 21st century skills (Young et al., 2011). T-STEM academies, along with professional development centers and other educator networks, work collaboratively to increase the quality of instruction and students' academic performance in STEM subjects at middle and high schools. They are designated by the Texas Education Agency, and as of the 2013-14 educational year, there are 65 T-STEM academies. T-STEM academies are also classified in two categories, T-STEM high schools and T-STEM middle and high schools. Twenty-four of the 59 T-STEM schools serve only students in grades 9 through 12, and the remainder of the T-STEM academies serve students in grades 6 through 12. These academies are well equipped with laboratories that enable teachers to incorporate innovative instructional methods into their science and mathematics classrooms.

Diversity and STEM education in Texas

Having students from different ethnic backgrounds is common across STEM schools across the country. In Texas, every T-STEM academy has an obligation to serve at least 50% minority groups (including African American and Hispanic students) at the school level (Young et al., 2011). However, the type of STEM schools (selective or inclusive/open-admission) generally indicate the demographic background of students. For instance, selective STEM schools can be expected to be mostly populated by high socio-economic status (SES), White, and Asian students (Rogers-Chapman, 2013) while inclusive (open-admission) STEM schools are more popular among students from underrepresented groups.

The effect of demographic background on STEM degree attainment has been a topic of debate in research. For example, in the state of Florida, even though 21.5% of female students obtained post-secondary education degrees, only 9.6% of them were in the STEM related subjects (Tyson, Lee, Borman, & Hanson, 2007). In contrast, this number was 21.3% for male students. The story is different for Asian students; 32.7% out of the 44.5% of Asian students who obtained undergraduate degrees in STEM disciplines, whereas the percentages were 12.8% for White, 12.3% for African American, and 14.8% for Hispanic students (Tyson et al., 2007). Tai, Sadler, and Mintzes (2006) found that demographic background such as ethnicity and parental educational level, as well as educational background, were predictors for college science performance. In addition, although female students took high level mathematics and science courses, they were less likely than male students to obtain STEM degrees (Tyson et al., 2007). Therefore, students' demographic backgrounds are relevant in STEM education research, including post-secondary STEM degree attainment and success.

Purpose of the study

Studies related to relationships between regional ESCs and students' academic performances were sparse. Our objective in this study was to examine the effects of services provided by ESCs in terms of mathematics outcome scores of students in T-STEM academies.

Our overarching research question is: Do Education Service Centers differ in how they affect T-STEM academies' mathematics achievement over a number of years by gender, ethnicity, and SES? We will address this overarching research question by answering the following three sub questions:

1. *Do T-STEM academy students perform differently in mathematics over time?*
2. *Does T-STEM academy students' mathematics achievement differ by the Education Service Centers they are affiliated with?*

3. Does T-STEM academy students' mathematics achievement differ by the Education Service Centers when gender, ethnicity, and SES factors are controlled?

METHOD

Sample

The sample consisted of 4,018 high school students attending 26 T-STEM academies from 11 ESCs in Texas. The data included Texas Assessment of Knowledge and Skills (TAKS) mathematics scale scores. The first measurement for the 9th graders took place in 2009, and the other two measurements occurred in 2010 and 2011. We obtained the same students' scores subsequently for each high school grade (9th, 10th, and 11th). In our sample, we included the high school students who had at least one TAKS mathematics score in three subsequent years, 2009-2011.

In our sample, 49% were female students. In terms of ethnicity, 63% were Hispanic, 17% were African American, 4% were Asian, and the remaining 16% were White. Also, 61% of the sample was economically disadvantaged who were specified in terms of their eligibility for free or reduced lunch.

Data Analysis

The data included students' demographic variables, gender, ethnicity, socioeconomic status, three year of mathematics TAKS test scores, school names, school identification number, and region number where the school was located.

When data structures are nested, hierarchical linear modeling (HLM) can be used (Woltman, Feldstain, MacKay, & Rocchi, 2012). When researchers have nested structures, the participants tend to be more homogeneous in a cluster than participants who would be simple randomly sampled. Homogenous observations in a cluster violates the assumption of independence of the observations, which is one of the important assumptions in conventional statistical models (Osborne, 2000). Applying conventional statistical models to clustered data can produce biased results (Hox, 2002). HLM accommodates this problem (biased results in conventional statistical models) by taking into account the homogeneity of the observations. Therefore, in this study three-level hierarchical linear modeling was used to analyze the data because our data included three level structures. We used HLM software version 7 to run the longitudinal analysis. Restricted maximum likelihood was used as an estimation method to generate robust standard error estimates. Three subsequent measurements were nested under the 4,018 high school students, and the students were nested under 26 schools.

The first model was conducted as a three-level unconditional model using only the variables of *time* and *mathematics scores* (see Appendix 1 for our first model). The three-level unconditional model was used to determine if students or schools varied in terms of their starting scores and slopes (growth rate). After applying the unconditional model, a new model with level 2 variables, which were dummy coded, namely, ethnicity, gender, and socioeconomic status was tested (see Appendix 2 for our second model). This second model provided us with information on whether or not there were some explained variations coming from level 3 when we control the level 2 variables, specifically whether or not there are statistically significant variations among the 26 schools from the 11 ESCs.

Variables

All independent variables used in the analysis were created by using dummy coding (coded with a numerical value of 0 or 1).

Level 1. The multivariate format of TAKS mathematics scores for three subsequent years was restructured as the *math* variable in the univariate format in order to be analyzed in the HLM program. In order to indicate which mathematics score was coming from which year, a new variable, *time* was created. The *time* variable included three levels. Level 0 represented the measurement when students were in 9th grade; level 1 represented the 10th grade measurement, and level 2 represented the 11th grade measurement.

Level 2. Females were coded with a numerical value of 1, and males were coded with 0 in one variable called *female*. Since we had four different ethnicities in our sample, we used White students as the reference group, and three other new dummy coded variables were created to represent other ethnicities. In the variable *H*, representing Hispanic student scores were coded as 1, others as 0; in the variable *AA*, representing African American student scores were coded as 1, others as 0; and similarly

AS, representing Asian student scores included 1 for Asian student scores and 0 for others. For the variable *DIS*, representing socio-economic status, socioeconomically disadvantaged students were coded as 0 and others as 1.
Level 3. ESCs were coded similarly by using region 10 as the reference group. Because we have a total of 11 ESCs in our sample, dummy coding created for 10 new variables: R1, R2, R4, R5, R6, R7, R10, R11, R17, R19, and R20.

RESULTS

Table 1 displays the descriptive statistics for three subsequent TAKS mathematics scores for 2009, 2010, and 2011.

Table 1. Descriptive Statistics For Three Subsequent TAKS Mathematics Scores

	N	Minimum	Maximum	Mean	Standard Deviations
M9	3744	1063	2955	2105.79	415.99
M10	2403	1288	2786	2204.56	230.07
M11	2050	1316	2839	2285.21	216.29

Mean trend in Table 1 showed that students' mathematics mean scores increased over time while their standard deviations decreased. Estimates for the mean intercept and slope for the students from unconditional model are shown in Table 2.

Table 2. Model 1 Final Estimation of Fixed Effects (With Robust Standard Errors)

Fixed Effect	Coefficient	Standard Error	t-ratio	Approximate *d.f.*	*p*-value
For INTRCPT1, π_0					
For INTRCPT2, β_{00}					
INTRCPT3, γ_{000}	2195.33	27.14	80.88	25	<0.001
For TIME slope, π_1					
For INTRCPT2, β_{10}					
INTRCPT3, γ_{100}	28.93	11.99	2.41	25	0.024

A statistically significant intercept, 2,195.33 points was estimated. This indicated that students' mean mathematics scores when they were in the 9th grade was 2,195.33 points. The statistically significant slope, 28.93, indicated that there was a linear growth between measurements.

Table 3. Model 1 Final Estimation of Level-1 And Level-2 Variance Components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1, r_0	366.25	134136.36	2477	15885.50	<0.001
TIME slope, r_1	137.64	18944.49	2477	5864.72	<0.001
level-1, e	129.93	16882.30			

Table 3 demonstrates that there was a statistically significant variation between students' mathematics scores when they are in the 9th grade, and this variance was estimated as 134,136.36 points. Also, there was a statistically significant variation between students' slopes (18,944.49 points). These statically significant variances' estimates indicated that students did not have the equal starting scores in grade 9 or growth rate over the three years.

Table 4. Model 1 Final Estimation of Level-3 Variance Components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1/INTRCPT2, u_{00}	124.70	15549.78	23	647.45	<0.001
TIME/INTRCPT2, u_{10}	51.01	2601.60	23	388.73	<0.001

Similarly, Table 4 depicts the variance components in level 3. Based on the results, we interpreted that there was statistically significant variation among schools' starting scores (i.e., 9th grade) and their growths. However, these results came from an unconditional model, so these results should be examined when level 2 variables were controlled. Model 2 estimates for the level 2 variables are shown in Table 5.

Table 5. Model 2 Final Estimation Of Fixed Effects (With Robust Standard Errors)

Fixed Effect	Coefficient	Standard Error	*t*-ratio	Approximate *d.f.*	*p*-value
For INTRCPT1, π_0					
For INTRCPT2, β_{00}					
INTRCPT3, γ_{000}	2163.24	14.00	154.59	25	<0.001
For H, β_{01}					
INTRCPT3, γ_{010}	-5.92	33.33	-0.18	25	0.860
For AA, β_{02}					
INTRCPT3, γ_{020}	-163.96	41.22	-3.98	25	<0.001
For AS, β_{03}					
INTRCPT3, γ_{030}	-15.48	30.08	-0.52	25	0.611
For DIS, β_{04}					
INTRCPT3, γ_{040}	37.88	52.73	0.72	25	0.479
For FEMALE, β_{05}					
INTRCPT3, γ_{050}	12.11	14.87	0.81	25	0.423
For TIME slope, π_1					
For INTRCPT2, β_{10}					
INTRCPT3, γ_{100}	55.67	7.07	7.87	25	<0.001
For H, β_{11}					
INTRCPT3, γ_{110}	-6.09	13.78	-0.44	25	0.662
For AA, β_{12}					
INTRCPT3, γ_{120}	-0.40	26.74	-0.02	25	0.988
For AS, β_{13}					
INTRCPT3, γ_{130}	33.07	11.22	2.95	25	0.007
For DIS, β_{14}					
INTRCPT3, γ_{140}	-13.28	23.18	-0.57	25	0.572
For FEMALE, β_{15}					
INTRCPT3, γ_{150}	-15.22	6.91	-2.20	25	0.037

In terms of ethnicities, there were no statistically significant differences between White and Hispanic and between White and Asian students when they were in grade 9. However, African American students' mathematics scores were 163.96points ($p < 0.001$) lower than White students' scores on average when they were in 9th grade. There was no statistically significant difference between male and female students ($p = 0.423$) when they were in grade 9. In terms of socioeconomic status, there was no statistically significant difference between socioeconomically disadvantaged and advantaged students in the 9th grade ($p = 0.479$), either.

In terms of growth over the three years, there were no statistically significant differences between White and Hispanic and between White and African American students. However, Asian students' growth rate was statistically significantly higher than White students' ($\gamma_{130} = 33.07$, $p = 0.007$). There was no statistically significant difference between socioeconomically disadvantaged and advantaged students in terms of their growth rate ($p = 0.572$). Male students' growth rate was statistically significantly higher than female students' ($\gamma_{150} = 15.22$, $p = 0.037$).

In order to examine the level three variables (i.e., ESCs) and to understand whether mean student scores of academies in these ESCs were statistically significant from each other, we needed to look at variance components in level 3. If there was no statistically significant variation between school means, then there was no reason to run a model that included level 3 variables in addition to level 2 variables. Table 6 shows the variance components of level 3 based on the Model 2 that controls the level 2 variables. Based on Model 2, when we controlled the level 2 variables, there was no variance among schools in terms of their mean intercepts (u_{00}=1,296.90; $p = 0.106$) and their mean slopes (u_{10}=3.19; $p > 0.050$). Thus, there was no reason to find whether there was a statistically significant difference between ESCs' intercepts and slopes because there was no variation between school starting means and their slopes.

Table 6. Model 2 Final Estimation Of Level-3 Variance Components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1/INTRCPT2, u_{00}	36.01	1296.90	1	2.55	0.106
TIME/INTRCPT2, u_{10}	1.79	3.19	1	0.10	>.500

Based on Model 2, when we controlled the level 2 variables, there was no variance among schools in terms of their mean intercepts (1,296.90 points; $p= 0.106$) and their mean slopes (3.19; $p>0.500$). Thus, there was no reason to find whether there was a statistically significant difference between ESCs' intercepts and slopes because there was no variation between school starting means and their slopes.

DISCUSSION and CONCLUSION

According to our analysis of the HLM results, there was a statistically significant difference among T-STEM academies in different ESCs if the demographic variables were not taken into account. The demographics of schools are important independent variables and could have affected the dependent variable; therefore, we analyzed the effect of demographic variables. When we analyzed the effect of demographic variables, the results showed that there was not a statistically significant difference among students' mathematics mean scores who were in T-STEM academies in different ESCs. Even though there was not a statistically significant difference among T-STEM academies in different ESCs, some student demographics showed statistically significant difference, which indicated parallel results with our previous findings (Navruz, Erdogan, Bicer, Capraro, & Capraro, 2014). However, each ESC offers different types of support depending on the needs of their local students, teachers, administration, and other stakeholders. There were no significant differences in the students' mathematical achievement based on the ESC serving them when ethnicity and SES were taken into account. Therefore, this lack of significant differences could indicate that the specialized services offered by the different ESCs are meeting the needs of the diverse student population across the state of Texas (Bicer, Navruz, Capraro, & Capraro, 2014).

To further explore the impact of ESCs on their unique student populations' mathematical achievement, future studies must be performed. Besides the TAKS scores, indicators of student achievement such as college readiness and the results of various new Texas standardized tests (State of Texas Assessments of Academic Readiness, STAAR) could be analyzed. Also, the number of years that ESCs served could be considered, and we could analyze whether there is a statistically significant difference between T-STEM academies' students' academic achievement in ESCs in terms of their service years. Since the services provided by the ESCs could impact student achievement at the T-STEM academies, studies explicitly exploring the relationships between ESCs differing services and student achievement should be conducted.

Besides the contribution of ESCs in the U.S., launching services such as ESCs in other countries could be helpful. Turkey is one of those countries that does not offer a similar service specific for specialized science schools (e.g., *fen liseleri*, Turkish STEM schools). The implication from this study is to establish education service centers in Turkey to address the needs of STEM schools such as professional development of their teachers and to aid STEM schools in successful STEM integration. For other schools in Turkey, it is recommended that science centers are assigned with similar responsibilities rather than limiting their potential to increase the accessibility to scientific demonstrations. It is recommended for these science centers to be equipped with resources and expert human resources to support public schools in terms of professional development of teachers, as well. A strong collaboration between science centers and universities can be considered as a method in ensuring an increase in student performance in STEM subjects.

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APPENDIX 1

Model 1: Unconditional Model

Level-1 Model

$\mathrm{MATH}_{ijk} = \pi_{0jk} + \pi_{1jk}*(TIME_{ijk}) + e_{ijk}$

Level-2 Model

$\pi_{0jk} = \beta_{00k} + r_{0jk}$
$\pi_{1jk} = \beta_{10k} + r_{1jk}$

Level-3 Model

$\beta_{00k} = \gamma_{000} + u_{00k}$
$\beta_{10k} = \gamma_{100} + u_{10k}$

Mixed Model

$MATH_{ijk} = \gamma_{000} + \gamma_{100}*TIME_{ijk} + r_{0jk} + r_{1jk}*TIME_{ijk} + u_{00k} + u_{10k}*TIME_{ijk} + e_{ijk}$

APPENDIX 2

Model 2

Level-1 Model

$\mathrm{MATH}_{ijk} = \pi_{0jk} + \pi_{1jk}*(TIME_{ijk}) + e_{ijk}$

Level-2 Model

$\pi_{0jk} = \beta_{00k} + \beta_{01k}*(H_{jk}) + \beta_{02k}*(AA_{jk}) + \beta_{03k}*(AS_{jk}) + \beta_{04k}*(DIS_{jk}) + \beta_{05k}*(FEMALE_{jk}) + r_{0jk}$

$\pi_{1jk} = \beta_{10k} + \beta_{11k}*(H_{jk}) + \beta_{12k}*(AA_{jk}) + \beta_{13k}*(AS_{jk}) + \beta_{14k}*(DIS_{jk}) + \beta_{15k}*(FEMALE_{jk}) + r_{1jk}$

Level-3 Model

$\beta_{00k} = \gamma_{000} + u_{00k}$
$\beta_{01k} = \gamma_{010} + u_{01k}$
$\beta_{02k} = \gamma_{020} + u_{02k}$
$\beta_{03k} = \gamma_{030} + u_{03k}$
$\beta_{04k} = \gamma_{040} + u_{04k}$
$\beta_{05k} = \gamma_{050} + u_{05k}$
$\beta_{10k} = \gamma_{100} + u_{10k}$
$\beta_{11k} = \gamma_{110} + u_{11k}$
$\beta_{12k} = \gamma_{120} + u_{12k}$
$\beta_{13k} = \gamma_{130} + u_{13k}$
$\beta_{14k} = \gamma_{140} + u_{14k}$
$\beta_{15k} = \gamma_{150} + u_{15k}$

Mixed Model

$$MATH_{ijk} = \gamma_{000} + \gamma_{010}*\mathrm{H}_{jk} + \gamma_{020}*\mathrm{AA}_{jk} + \gamma_{030}*\mathrm{AS}_{jk} + \gamma_{040}*\mathrm{DIS}_{jk} + \gamma_{050}*\mathrm{FEMALE}_{jk} + \gamma_{100}*TIME_{ijk} + \gamma_{110}*TIME_{ijk}*\mathrm{H}_{jk} + \gamma_{120}*TIME_{ijk}*\mathrm{AA}_{jk} + \gamma_{130}*TIME_{ijk}*\mathrm{AS}_{jk} + \gamma_{140}*TIME_{ijk}*\mathrm{DIS}_{jk} + \gamma_{150}*TIME_{ijk}*\mathrm{FEMALE}_{jk} + r_{0jk} + r_{1jk}*TIME_{ijk} + u_{00k} + u_{01k}*\mathrm{H}_{jk} + u_{02k}*\mathrm{AA}_{jk} + u_{03k}*\mathrm{AS}_{jk} + u_{04k}*\mathrm{DIS}_{jk} + u_{05k}*\mathrm{FEMALE}_{jk} + u_{10k}*TIME_{ijk} + u_{11k}*TIME_{ijk}*\mathrm{H}_{jk} + u_{12k}*TIME_{ijk}*\mathrm{AA}_{jk} + u_{13k}*TIME_{ijk}*\mathrm{AS}_{jk} + u_{14k}*TIME_{ijk}*\mathrm{DIS}_{jk} + u_{15k}*TIME_{ijk}*\mathrm{FEMALE}_{jk} + e_{ijk}$$