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EFFECTS OF SCHOOL CHARACTERISTICS ON STUDENTS' MATHEMATICS PERFORMANCES IN HIGH SCHOOLS: DOES STEM EDUCATION MAKE ANY DIFFERENCE?

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ABSTRACT

The purpose of this study was to determine how different characteristics of Florida public high schools are related to students' performances on the mathematics component of Advanced Placement (AP) exams, End of Course (EOC) exams, The Scholastic Aptitude Test (SAT) and American College Test (ACT) tests. The study also provides a summary of key findings and details about how students perform in STEM schools on the AP pass rates, EOC percentiles, and SAT and ACT test scores comparing to students in non-STEM schools in the State of Florida. The present study included 343 public high schools in the State of Florida. The sample consists of AP, EOC, SAT and ACT mathematics data for those 343 high schools selected among around 800 public high schools in the State. Selection criteria for the schools is based upon availability of required data. Multivariate Analysis of Variance (MANOVA), Cluster Analysis, and Independent Sample T-test Analysis techniques were used to analyze obtained data. Most stunning result of this study is that STEM and Non-STEM high school students' performances on above mentioned assessments are not statistically significantly different. That brings a big question about quality and appropriateness of STEM applications for improving students' understanding of mathematics concepts. Another important finding of the study is that even though student enrollment numbers do not play a role on students' performances, minority rate, economically disadvantaged student rate and student-teacher ratio have statistically significant effects on students' performances in both STEM and Non-STEM schools.

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INTRODUCTION

The quality of students' performance remains at top priority for educators. It is meant for making a difference locally, regionally, nationally and globally. Educators, trainers, and researchers have long been interested in exploring variables contributing effectively for quality of performance of learners. There is a range of factors that effect on the quality of performance of students (Waters and Marzano, 2006). A series of variables are to be considered when to identify the affecting factors towards quality of academic success. Identifying the most contributing variables in quality of academic performance is a very complex and challenging job. The students in public schools belong to a variety of backgrounds depending upon their demography (Farooq *et al.*, 2011). The variables that affect students' quality of academic achievement may be termed as student factors, family factors, school factors and peer factors (Crosnoe *et al.,* 2004). Unfortunately, defining and measuring the quality of education is not a simple issue and the complexity of this process increases due to the changing values of quality attributes associated with the different stakeholders' view point (Blevins, 2009; Parri, 2006).

Role of STEM Education

Teaching and learning in the disciplines of science, technology, engineering, and mathematics in an interdisciplinary manner is called STEM education. In other words, STEM is a curriculum based on the idea of educating students in four specific disciplines Science, Technology, Engineering and Mathematics in an interdisciplinary and applied approach (National Research Council [NRC], 2011). Rather than teach the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications (Hom, 2014). What separates STEM from the traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. It teaches students computational thinking and focuses on the real-world applications of problem solving (Sheldon, 2017). Quality STEM education is critical in K-12 since today's world requires every individual to understand scientific and technological knowledge (Young *et al.,* 2011). By bee (2013) clearly articulates that the overall purpose of STEM education is to further develop a STEM literate society. His definition of "STEM literacy" refers to an individual's:

1. Knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues.
2. Understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry and design;
3. Awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and
4. Willingness to engage in STEM-related issues and with the ideas of science, technology, engineering and mathematics as a constructive, concerned, and reflective citizen." (p.101).

STEM schools are designed to decrease the mathematics and science achievement gaps among various ethnic groups and to increase all K-12 students' mathematics and science scores on both national and international standardized tests (Bicer *et al.,* 2014; Capraro *et al.,* 2013; Capraro *et al.,* 2013). STEM high schools are difficult to define because they do not operate under a single umbrella philosophy or organizational structure (Lynch, Behrend, Burton, and Means, 2013). Although these schools vary significantly in their educational practices, selective and inclusive STEM schools are the two most common STEM schools across the Unites States (NRC, 2011). The curriculum for selective and inclusive STEM schools was designed to improve students' science and mathematics learning by engaging students with hands-on tasks in a collaborative and competitive environment (Gonzalez and Kuenzi, 2012). There are some differences between these two types of STEM schools in terms of their organization. The clearest distinction between selective STEM schools and inclusive STEM schools is the admission criteria. Selective STEM schools admit only students who are talented in and motivated toward STEM related fields while inclusive STEM schools have no selective admission criteria. Because of the difference between admission criteria of the two STEM school types, inclusive STEM schools are considered to serve a broader population (NRC, 2011). Young, House, Wang, and Singleton (2011) noted that "Inclusive STEM schools are predicated on the dual promises that math and science competencies can be developed, and students from traditionally underrepresented populations need access to opportunity to develop these competencies to become full participants in areas of economic growth and prosperity" (p. 2) LaForce, Noble, King, Holt and Century (2014) revealed that inclusive STEM schools have some common characteristics. First, they found that these schools feature problem-based learning, interdisciplinary instruction, student autonomy, and "rigorous learning," which often entails mastery learning and a staff-created curriculum that features real-world applications. These schools also emphasize establishing a positive school culture, developing skills that students can use in their everyday lives and future careers (e.g., technological proficiency, communication, and collaboration), personalized learning (e.g., differentiation of instruction based on ability and relevance to students' lives), and a connection between the school and local community (e.g., partnerships with external educational and business organizations). Thus, LaForce *et al.* (2014) discovered that what makes these schools "STEM" is not necessarily a greater emphasis on STEM subjects. Although that is the case in some inclusive STEM schools, what makes them "STEM" schools is primarily the use of problem-based, interdisciplinary, and personalized learning approaches none of which is unique to this recent STEM movement.

Role of Poverty and Diversity

As the impact of diversity is considered as a factor in student achievement, one cannot ignore the effects of SES and poverty. While individual SES, including generational poverty, is important in examining this issue, school level poverty also should be examined. Schools with a lack of diversity, specifically those with a high concentration of minority students, also display a high concentration of poverty. Frankenberg and Lee (2002), emphasized the important role of poverty on student achievement and the highly correlated relationship between minority status and poverty in schools.

They have stated:

The isolation of Blacks and Latinos has serious ramifications: this isolation is highly correlated with poverty, which is often strongly related to striking inequalities in test scores, graduation rates, courses offered, and college-going rates. Virtually no attention is being paid to this troubling pattern in the current discussion of educational reform even though it is very strongly related to many outcomes the reformers wish to change. (p. 22)

Orfield and Lee (2006) reported that in2001-2002, 43% of all U.S. schools contained less than 10% Black and Latino students. Of these highly concentrated White schools, only 15% had more than half of their students eligible for free/reduced price lunch. Conversely, 88% of schools with high concentrations of minority students had more than half of their students eligible for free/reduced price lunch. Therefore, as students continue to attend neighborhood schools in increasing numbers, students who come from high-poverty neighborhoods will be more likely to attend high-poverty/high-minority schools. The effects of attending high-poverty schools are discussed consistently throughout the literature. Rumberger and Palardy (2005) identified school-level poverty as having more of an effect than racial composition on student performance. A study conducted by Entwisle and Alexander (1992) determined that family SES and school-level segregation were the most significant factors in test-score differences for African American children in mathematics. Therefore, minority students face the triple challenge characterized by individual poverty, school-level poverty, and school-level segregation. Thus, the present study used school data to determine whether the factors such as diversity (minority rate), poverty (economically disadvantaged student rate) and School type (STEM and Non-STEM schools) have effects on students' academic performances on SAT and ACT tests, Advance Placement (AP) and End-of-Course (EOC) exams in participating schools. Specific research questions for this current study are as follows:

1. How do high school students' average mathematics performances on variety of assessments differ by STEM curriculum inclusion?

2. What are the other school characteristics that have or have not effects on students' average mathematics performances on variety of assessments?

METHODS

Overview

Considering the aim of this study, several quantitative data analysis techniques were used to answer research questions (Figure-1). Data were collected from 343 varying sizes of public high schools in the State of Florida selected among around 800 public high schools. School is called as STEM-School if STEM related curriculum is used in education and called Non-STEM-School if it does not indicate any use of STEM curriculum in education. Among the participating schools, 232 were identified as STEM-School and 111 were identified as Non-STEM-School. The student enrollment in participating schools is ranging from 113 to 4712, while the minority rates are ranging from 5% to 99%. Participating schools also have a minimum of 5% and a maximum of 96% of economically disadvantaged students' rate while the student-teacher ratios are ranging between 5 to 32. First independent sample T-Tests were used in order to find out whether there were any achievement differences between STEM and Non-STEM schools. Then, Cluster analysis was used to determine homogeneous and clearly discriminated classes of schools. In order to confirm that clusters are distinct, MANOVA (Multiple Analysis of Variance) was used the determine if there are any significant differences between clusters and 5 dependent variables (SAT scores, ACT scores, AP pass rates, mathematics proficiency levels and End-of-Course exam score percentiles). In the last phase, four MANOVA analysis were run within each cluster in order to investigate differences in mathematics achievement between the levels of variables (School Type, Enrollment, Minority Rate, Student-Teacher Ratio and Disadvantaged Student Rate).

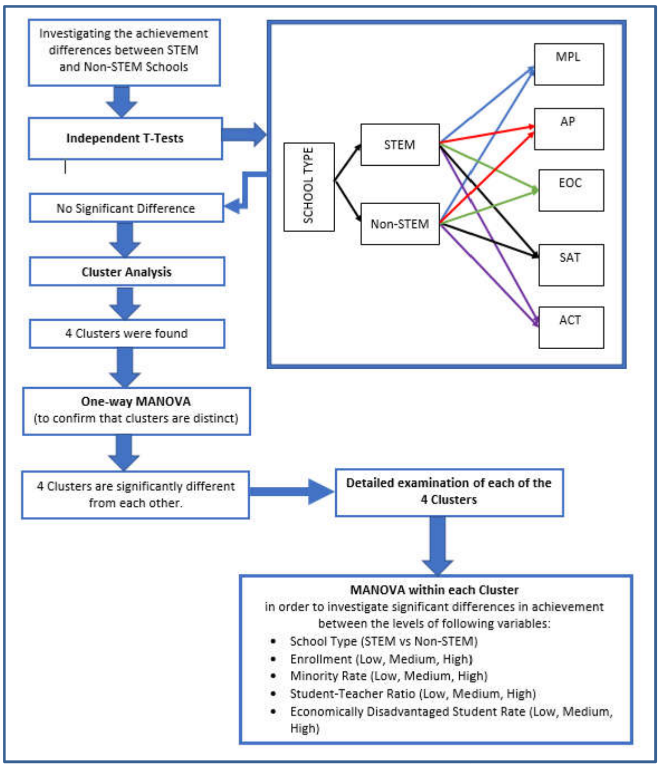

Figure 1. Overview of the Method

Sample

For the purpose of this study around 800 public high schools in Florida were searched to be able to get information on Advance Placement (AP) courses pass rates, End-of-Course Exam percentile scores (EOC), overall Mathematics Performances (MP), SAT scale scores and ACT scale scores. Schools were excluded from the study if there was no information obtained on any of the AP, EOC, MP, SAT or ACT mathematics scores. Schools were also excluded if they have no information on number of enrollments, minority rate, economically disadvantaged student rate, and student-teacher ratio. These exclusions also ensured that the STEM schools have had STEM education curriculum for at least last three years. After all exclusions total of 343 public high schools in the State of Florida were selected for this investigation.

Variables and Scales

In the study, students' average SAT and ACT mathematics test scale scores, AP pass rates, Mathematics Proficiency Levels and End-of-Course exam score percentiles in each participating school were used as an outcome estimate of students' mathematics achievements in each school. Additionally, schools' minority rates, enrollment numbers, disadvantaged student rates, and student-teacher ratios were included to the analysis in order to estimate the effects of each of these characteristics besides STEM education. Further, school type (i.e., STEM or non-STEM) was included in the analysis in order to estimate effects of STEM education on students' mathematics achievement. Variables used in this study are as follows:

School Type: This variable shows the type of the high school and has two levels (STEM and Non-STEM) Schools are called STEM-School if STEM related curriculum is used in education.

Advance Placement (AP) courses pass rates: Many U.S. higher educational institutions grant credits or advanced placement based on high school student's performance on AP® exams. This variable shows percentages of all students who scored a three or higher (3+) on at least one AP exam.

End-of-Course Exam (EOC) percentile scores: This is a percentile score on Florida Standards Assessment and Mathematics End of Course Exams. This measures students' mastery of mathematics exam based on the proportions of students who achieved each proficiency level.

Mathematics Performances (MP): Florida administers the Florida Standards Assessment and Mathematics End of Course Exams to high school students. This variable displays how well the school as a whole performed in mathematics.

SAT scale scores: This variable shows students' average SAT scale score on mathematics section of the test.

ACT scale scores: This variable shows students' average ACT scale score on mathematics section of the test.

Enrollment: This variable shows the total student enrollment in each school.

Minority Rate: This variable shows the minority rate in each school.

Economically Disadvantaged Student Rate: This variable shows the rate of economically disadvantaged students in each school. This variable is measured by the percentage of students at a high school qualifying for free and reduced lunch.

Student-Teacher Ratio: This variable shows the student-teacher ratio in each school.

RESULTS

Independent Sample T-Tests

First, independent sample t-tests were used in order to determine whether there were any differences between independent school types (STEM and Non-STEM) on five continuous dependent variables (AP, MP, EOC, SAT, and ACT). From the five univariate tests that followed (one for each of the dependent variables), no statistically significant differences were found between the mean values of the STEM and Non-STEM schools in terms of mathematics achievement (Table-1).

As it can be seen in the table-1, all 2-tailed significance values are larger than the alpha level of 0.05. Descriptive statistics of STEM and Non-STEM schools for each dependent variable can be seen at table-2 below. From that table it can be obviously seen that although means for STEM schools are slightly higher than the means for Non-STEM schools for each dependent variable, no significant differences revealed between the means. Since no significant differences found in mathematics achievement between STEM and Non-STEM schools in the whole data, cluster analysis was used in the next step in order to investigate whether there is any significant difference between STEM and Non-STEM schools in each of the homogeneous and clearly discriminated classes of schools. The results of the cluster analysis were used to enhance the depth of the analysis by developing more interpretable classes of the high schools.

Cluster Analysis

The use of clustering that presented here is one of the common uses of the technique, the K-means algorithm. From the variety of available cluster models and clustering procedures (e.g., hierarchical, partitioning, density-based, model-based, etc.), K-means algorithm was chosen as it is a relatively simple method

Table 1. Independent Samples Test for mean values of the STEM and Non-STEM schools

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MP_Overall	Equal variances assumed	0.320	0.572	1.280	341	0.201	0.078	0.061	-0.042	0.197
	Equal variances not assumed			1.324	236.418	0.187	0.078	0.059	-0.038	0.193
EOC_Percentile	Equal variances assumed	1.971	0.161	1.494	341	0.136	2.779	1.860	-0.880	6.439
	Equal variances not assumed			1.456	203.160	0.147	2.779	1.909	-0.985	6.544
SAT	Equal variances assumed	0.507	0.477	1.197	341	0.232	4.417	3.691	-2.843	11.677
	Equal variances not assumed			1.206	221.300	0.229	4.417	3.662	-2.799	11.633
ACT	Equal variances assumed	0.125	0.724	0.795	341	0.427	0.173	0.218	-0.255	0.602
	Equal variances not assumed			0.790	213.224	0.431	0.173	0.219	-0.259	0.606
AP_Pass_Rate	Equal variances assumed	0.070	0.791	-0.032	339	0.975	-0.058	1.823	-3.643	3.527
	Equal variances not assumed			-0.031	214.672	0.975	-0.058	1.832	-3.668	3.553

Table 2. Descriptive Statistics of STEM and Non-STEM schools for each dependent variable

	School Type	N	Mean	Std. Deviation	Std. Error Mean
MP_Overall	STEM	232	3.08	.540	.035
	Non-STEM	111	3.01	.491	.047
EOC_Percentile	STEM	232	83.25	15.725	1.032
	Non-STEM	111	80.47	16.921	1.606
SAT	STEM	232	596.94	32.215	2.115
	Non-STEM	111	592.52	31.492	2.989
ACT	STEM	232	25.25	1.877	.123
	Non-STEM	111	25.08	1.912	.182
AP_Pass_Rate	STEM	230	52.60	15.696	1.035
	Non-STEM	111	52.66	15.923	1.511

that at the same time suits the purposes of trying to understand the data. In the K-means clustering, the goal is to group n observations into k clusters. Each cluster has a center computed as the mean of all the instances that belong to it. Then, each observation is assigned to the nearest cluster according to its center. Thus, the algorithm operates in an iterative manner starting from an initial set of cluster centers, assigning each observation to the nearest cluster, and then computing the new cluster centers. This procedure is repeated until a stopping criterion is reached. Then, all variables were converted to z-scores. Normalization is a necessary step because K-means clustering is strongly influenced by the magnitude of the variables. Without normalization, the partitioning of the dataset is driven mainly by the few variables with the highest magnitudes, relegating the others to a secondary role. The conversion of all variables to z-scores overcomes this problem. Therefore, independent variables (AP, MP, EOC, SAT, and ACT) were converted to standard scores (z-scores). Following a careful examination of the clusters, it was hypothesized there would be a 4-cluster partition. Initial four clusters were formed by using a hierarchical cluster analysis (Ward criterion). In order to investigate differences between the four clusters, a Multiple Analysis of Variance (MANOVA) was used with the four clusters variable used as the independent variable and five variables used in developing the clusters (AP, MP, EOC, SAT, and ACT) as the dependent variables. The multivariate test resulted in statistically significant differences between the four clusters. The statistical significance between the mean values of the four clusters was tested by using Tukey's pair-wise comparison test. From the five univariate tests that followed (one for each of the dependent variables), statistically significant differences were found (Table-3) between the mean values of the four clusters and each of the five dependent variables ($p < .001$). After confirming that the developed clusters are significantly different from each other, means and standard deviations for four clusters across the variables were computed to understand the characteristics of each group of schools (clusters) more in depth. Table-4 provides the mean values and standard deviations for each cluster across the variables. Figure-2 also shows the distribution of variables in each the cluster for better visualize the structure of each cluster. Graph presented in figure-2 was produced by using standard scores instead of raw scores in order to see and compare all mean values of the variables in same scale. Another graph shown in figure-3 represents the distributions of mathematics performance variables (AP, EOC, MPL, SAT and ACT) in each cluster. The graph also allows to compare distributions of these variables in each cluster with overall distributions of the variables. Both descriptive and graphical summaries of the clusters were outlined in table-5 below to see the cluster characteristics much more clearly. The one-way multivariate analysis of variance (one-way MANOVA) was used again in the last phase of the study, four MANOVA analysis were run within each cluster in order to investigate differences in mathematics achievement between the levels of variables (School Type, Enrollment, Minority Rate, Student-Teacher Ratio and Disadvantaged Student Rate). More specifically, four separate one-way MANOVA'swere used to understand whether there were any differences in mathematics achievement between the levels of 5 variables (school types, enrollment, minority rate, student-teacher ratio and economically disadvantaged student rate) in each of the four cluster. Table-6 presents the four individual multivariate tests combined in one summary table. There was no statistically significant difference found in cluster-1 between schools' academic performance in mathematics based on a schools' use of STEM curriculum, $F(5, 15) = .119$, $p > .005$; Wilk's $\Lambda = 0.962$. There was no statistically significant difference found in cluster-2 between schools' academic performance in mathematics based on a schools' use of STEM curriculum, $F(5, 109) = .682$, $p > .005$; Wilk's $\Lambda = 0.970$. There was no statistically significant difference found in cluster-3 between schools' academic performance in mathematics based on a schools' use of STEM curriculum, $F(5, 20) = .135$, $p > .005$; Wilk's $\Lambda = 0.967$. There was no statistically significant difference found in cluster-4 between schools' academic performance in mathematics based on a schools' use of STEM curriculum, $F(5, 28) = .154$, $p > .005$; Wilk's $\Lambda = 0.973$. On the other hand, there are significant differences detected between schools' academic performances in mathematics based on total number of enrollments in all four clusters. There are significant differences between schools' academic performances in mathematics based on total student-teacher ratios in clusters 1, 2, and 3. There are significant differences between schools' academic performances in mathematics based on minority rates in clusters 2, 3, and 4. There are significant differences between schools' academic performances in mathematics based on disadvantaged student rates in clusters 1, 2, and 4.

FINDINGS

From the statistical analyses and tables and figures produced according to these analyses, following findings have been reached related to research questions. There was no statistically significant difference found in between schools' academic performances in mathematics based on a schools' use of STEM curriculum. In other words, independent sample t-test conducted at the beginning of this study showed that students' average mathematics performances in STEM schools are not different from those in Non-STEM schools. Upon this finding cluster analysis was done and following findings have been revealed from the analysis.

1. Cluster 1, with 14.07% of the sample, consisted of Florida public high schools with medium-low mathematics performances on AP exams and medium mathematics performance son EOC exams and low mathematics performances on SAT and ACT tests. Cluster 1 type schools were statistically significantly more likely to have low enrollments (μ=899.00), high minority rates (μ=72.58%), high economically disadvantaged student rates (μ=46.21%) and medium student-teacher ratios (μ=18.04). Mathematics performances of students in STEM and Non-STEM schools were not statistically different in Cluster 1 type schools.
2. Cluster 2, with 50.73% of the sample, consisted of Florida public high schools with medium-high mathematics performances on AP and EOC exams and medium mathematics performances on SAT and ACT tests. Cluster 2 type schools were statistically significantly more likely to have medium enrollments (μ=1700.23), medium-low minority rates (μ=45.21%), medium-low economically disadvantaged student rates (μ=27.38%) and medium student-teacher ratios (μ=18.45). Mathematics performances of students in STEM and Non-STEM schools were not statistically different in Cluster 2 type schools.

Table 3. Results of Multivariate Analysis Tukey Post Hoc Tests

Tukey HSD

Dependent Variable	Cluster (I)	Cluster (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
AP Pass Rate	1	2	-8.15*	1.762	0.000	-12.69	-3.60
		3	-18.53*	2.107	0.000	-23.97	-13.09
		4	17.64*	2.076	0.000	12.28	23.00
	2	1	8.15*	1.762	0.000	3.60	12.69
		3	-10.38*	1.638	0.000	-14.61	-6.15
		4	25.78*	1.598	0.000	21.66	29.91
	3	1	18.53*	2.107	0.000	13.09	23.97
		2	10.38*	1.638	0.000	6.15	14.61
		4	36.17*	1.973	0.000	31.07	41.26
	4	1	-17.64*	2.076	0.000	-23.00	-12.28
		2	-25.78*	1.598	0.000	-29.91	-21.66
		3	-36.17*	1.973	0.000	-41.26	-31.07
MP Overall	1	2	-0.11*	0.060	0.000	-0.26	0.05
		3	-.80*	0.071	0.000	-0.98	-0.61
		4	.48*	0.070	0.000	0.30	0.66
	2	1	0.11*	0.060	0.000	-0.05	0.26
		3	-.69*	0.055	0.000	-0.83	-0.54
		4	.58*	0.054	0.000	0.45	0.72
	3	1	.80*	0.071	0.000	0.61	0.98
		2	.69*	0.055	0.000	0.54	0.83
		4	1.27*	0.067	0.000	1.10	1.45
	4	1	-.48*	0.070	0.000	-0.66	-0.30
		2	-.58*	0.054	0.000	-0.72	-0.45
		3	-1.27*	0.067	0.000	-1.45	-1.10
EOC Percentile	1	2	-1.34*	1.780	0.000	-5.93	3.26
		3	-10.13*	2.129	0.000	-15.63	-4.64
		4	26.88*	2.097	0.000	21.46	32.30
	2	1	1.34*	1.780	0.000	-3.26	5.93
		3	-8.80*	1.655	0.000	-13.07	-4.52
		4	28.22*	1.615	0.000	24.05	32.39
	3	1	10.13*	2.129	0.000	4.64	15.63
		2	8.80*	1.655	0.000	4.52	13.07
		4	37.01*	1.993	0.000	31.87	42.16
	4	1	-26.88*	2.097	0.000	-32.30	-21.46
		2	-28.22*	1.615	0.000	-32.39	-24.05
		3	-37.01*	1.993	0.000	-42.16	-31.87
SAT	1	2	-45.60*	2.747	0.000	-52.70	-38.51
		3	-92.74*	3.286	0.000	-101.23	-84.26
		4	-26.30*	3.237	0.000	-34.66	-17.95
	2	1	45.60*	2.747	0.000	38.51	52.70
		3	-47.14*	2.555	0.000	-53.74	-40.54
		4	19.30*	2.492	0.000	12.87	25.74
	3	1	92.74*	3.286	0.000	84.26	101.23
		2	47.14*	2.555	0.000	40.54	53.74
		4	66.44*	3.076	0.000	58.50	74.38
	4	1	26.30*	3.237	0.000	17.95	34.66
		2	-19.30*	2.492	0.000	-25.74	-12.87
		3	-66.44*	3.076	0.000	-74.38	-58.50
ACT	1	2	-2.31*	0.202	0.000	-2.83	-1.78
		3	-4.75*	0.242	0.000	-5.38	-4.13
		4	-1.02*	0.238	0.000	-1.64	-0.41
	2	1	2.31*	0.202	0.000	1.78	2.83
		3	-2.45*	0.188	0.000	-2.93	-1.96
		4	1.28*	0.184	0.000	0.81	1.76
	3	1	4.75*	0.242	0.000	4.13	5.38
		2	2.45*	0.188	0.000	1.96	2.93
		4	3.73*	0.227	0.000	3.14	4.31
	4	1	1.02*	0.238	0.000	0.41	1.64
		2	-1.28*	0.184	0.000	-1.76	-0.81
		3	-3.73*	0.227	0.000	-4.31	-3.14

Based on observed means.The error term is Mean Square(Error) = 1.538.

*. The mean difference is significant at the .05 level.

Table 4. Mean values and Standard deviations for clusters across the variables

	Variables	CLUSTERS Cluster-1		Cluster-2		Cluster-3		Cluster-4		Total	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Demografic Variables	Enrollment	899.00	698.979	1700.23	876.770	1152.52	761.577	1920.03	767.054	1548.33	874.918
	Stdnt/Tchr Ratio	18.04	4.849	18.45	5.675	14.00	7.465	20.32	3.293	18.32	5.705
	Minorty Rate	72.58	25.352	45.21	22.733	19.62	4.999	60.32	18.872	49.34	23.507
	EDS Rate	46.21	23.071	27.38	20.126	19.00	8.495	45.52	15.521	31.90	22.710
Variables used to develop Clusters	AP Pass Rate	48.54	12.483	56.69	9.073	67.07	12.309	30.90	12.266	52.62	15.747
	MP Overall	2.96	0.307	3.06	0.333	3.75	0.556	2.48	0.251	3.06	0.526
	EOC Percentile	84.88	8.432	86.22	8.758	95.02	8.506	58.00	17.856	82.40	16.185
	SAT	578.39	21.234	597.69	13.741	644.83	17.893	552.08	19.686	595.78	31.906
	ACT	24.06	1.611	25.35	1.139	27.79	1.104	23.04	1.304	25.21	1.891

Table 5. Outline of the cluster characteristics

Variables		CLUSTERS Cluster-1 Mean	Cluster-2 Mean	Cluster-3 Mean	Cluster-4 Mean
Demographic Variables	Enrollment	LOW	MEDIUM	LOW	HIGH
	Stdnt/Tchr Ratio	MEDIUM	MEDIUM	LOW	HIGH
	Minority Rate	HIGH	MEDIUM LOW	LOW	HIGH
	EDS Rate	HIGH	MEDIUM LOW	LOW	HIGH
Variables used to develop Clusters	AP Pass Rate	MEDIUM-LOW	MEDIUM HIGH	HIGH	LOW
	MP Overall	MEDIUM-LOW	MEDIUM	HIGH	LOW
	EOC Percentile	MEDIUM	MEDIUM HIGH	HIGH	LOW
	SAT	LOW	MEDIUM	HIGH	LOW
	ACT	LOW	MEDIUM	HIGH	LOW

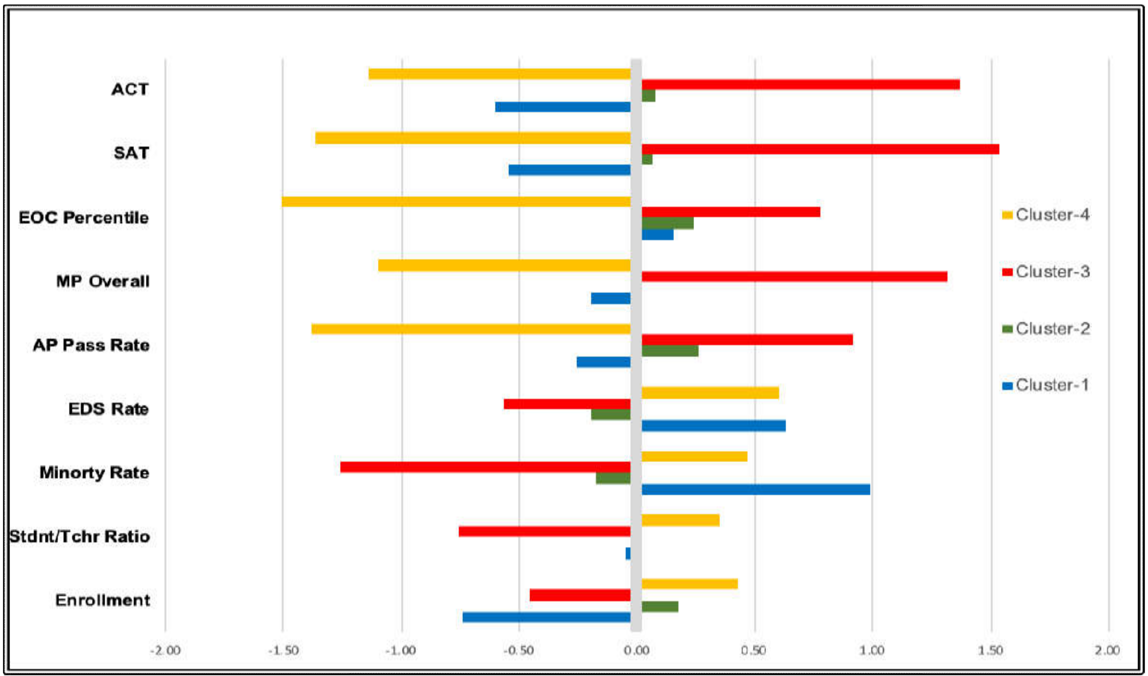

Figure 2. Distributions of variables across clusters

Table 6. Summary results of four multivariate tests across four clusters

Multivariate Tests		Cluster-1		Cluster-2		Cluster-3		Cluster-4	
Effect		F	Sig.	F	Sig.	F	Sig.	F	Sig.
Intercept	Pillai's Trace	5150.940[b]	0.000	37128.558[b]	0.000	101147.741[b]	0.000	13364.091[b]	0.000
	Wilks' Lambda	5150.940[b]	0.000	37128.558[b]	0.000	101147.741[b]	0.000	13364.091[b]	0.000
	Hotelling's Trace	5150.940[b]	0.000	37128.558[b]	0.000	101147.741[b]	0.000	13364.091[b]	0.000
	Roy's Largest Root	5150.940[b]	0.000	37128.558[b]	0.000	101147.741[b]	0.000	13364.091[b]	0.000
STEM	Pillai's Trace	.119[b]	0.986	.682[b]	0.638	.135[b]	0.982	.154[b]	0.977
	Wilks' Lambda	.119[b]	0.986	.682[b]	0.638	.135[b]	0.982	.154[b]	0.977
	Hotelling's Trace	.119[b]	0.986	.682[b]	0.638	.135[b]	0.982	.154[b]	0.977
	Roy's Largest Root	.119[b]	0.986	.682[b]	0.638	.135[b]	0.982	.154[b]	0.977
Enrollment	Pillai's Trace	2.5258416	0.023	4.5988964	0.000	5.1890474	0.000	5.3637042	0.000
	Wilks' Lambda	2.538[b]	0.024	4.676[b]	0.000	8.382[b]	0.000	5.545[b]	0.000
	Hotelling's Trace	2.5333354	0.026	4.750711	0.000	12.487119	0.000	5.7131157	0.000
	Roy's Largest Root	4.396[c]	0.010	7.376[c]	0.000	26.253[c]	0.000	9.173[c]	0.000
Stdnt/Tchr Ratio	Pillai's Trace	2.192398	0.045	3.1839894	0.001	5.6494945	0.000	1.5752588	0.137
	Wilks' Lambda	2.344[b]	0.035	3.230[b]	0.001	6.080[b]	0.000	1.544[b]	0.148
	Hotelling's Trace	2.4725115	0.029	3.27526	0.001	6.4902482	0.000	1.5118872	0.161
	Roy's Largest Root	4.779[c]	0.007	5.298[c]	0.000	11.337[c]	0.000	2.225[c]	0.079
Minority	Pillai's Trace	1.1758426	0.342	5.3426084	0.000	3.6773419	0.001	5.2314195	0.000
	Wilks' Lambda	1.239[b]	0.307	5.367[b]	0.000	3.507[b]	0.002	5.749[b]	0.000
	Hotelling's Trace	1.2884325	0.284	5.3898857	0.000	3.3364932	0.003	6.2599631	0.000
	Roy's Largest Root	2.650[c]	0.063	7.501[c]	0.000	3.974[c]	0.011	11.047[c]	0.000
EDS	Pillai's Trace	2.97562	0.009	10.287716	0.000	1.4197196	0.205	5.0173484	0.000
	Wilks' Lambda	2.861[b]	0.013	10.401[b]	0.000	1.386[b]	0.222	8.613[b]	0.000
	Hotelling's Trace	2.7370515	0.017	10.512551	0.000	1.3486933	0.241	13.249964	0.000
	Roy's Largest Root	4.110[c]	0.014	14.411[c]	0.000	2.126[c]	0.102	27.817[c]	0.000

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

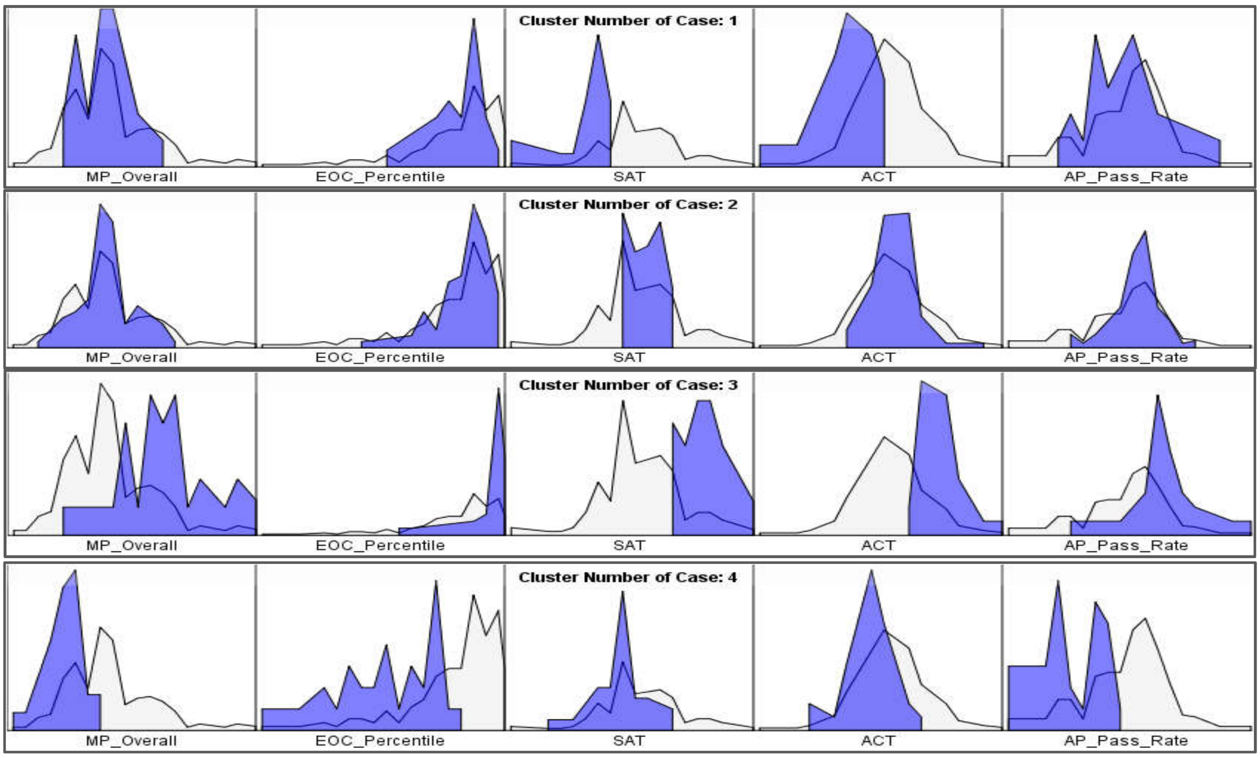

Figure-3. Distributions of mathematics performance variables across clusters

3. Cluster 3, with 17.08% of the sample, consisted of Florida public high schools with high mathematics performances on AP and EOC exams and high mathematics performances on SAT and ACT tests. Cluster 3 type schools were statistically significantly more likely to have low enrollments (μ=1152.52), low minority rates (μ=19.62%), low economically disadvantaged student rates (μ=19.00%) and low student-teacher ratios (μ=14.00). Mathematics performances of students in STEM and Non-STEM schools were not statistically different in Cluster 3 type schools.
4. Cluster 4, with 18.18% of the sample, consisted of Florida public high schools with low mathematics performances on AP and EOC exams and low mathematics performances on SAT and ACT tests. Cluster 3 type schools were statistically significantly more likely to have high enrollments (μ=1920.03), high minority rates (μ=60.32%), high economically disadvantaged student rates (μ=45.52%) and high student-teacher ratios (μ=20.32). Mathematics performances of students in STEM and Non-STEM schools were not statistically different in Cluster 4 type schools.

DISCUSSION AND CONCLUSION

The results from statistical analyses indicated that STEM curriculum in Florida public high schools has no effect on students' mathematics performances on several measures (AP, EOC, MPL, SAT and ACT) used in this study. It could be argued that either Florida public high schools which are claiming that they use STEM curriculum and applications in education are failing to apply STEM enrichment activities in the classrooms to link mathematics to the real-world applications or the exams and tests that are used in schools have no connection to STEM related curriculum in measuring the student' understanding of the mathematical concepts. Although there are considerable number of studies reported positive effects of STEM education in the field of mathematics, there is one study reporting that STEM activities have made no difference to students' performances in mathematics exams. Dr Pallavi Amitava Banerjee (2016), from the University of Exeter's Graduate School of Education, England, used the National Pupil Database, government statistics about each school and pupil, to assess the impact of STEM enrichment schemes on how well students performed in mathematics. By looking at five years of data she found that among the 300 schools who participated there was no impact on mathematics section of the GCSE (The General Certificate of Secondary Education) test results. Additionally, STEM high schools are difficult to define because they do not operate under a single umbrella philosophy or organizational structure (Lynch *et al.,* 2013). Most recent studies, (Bicer *et al.,* 2014; Capraro *et al.,* 2013; Capraro *et al.,* 2013; Lynch, Behrend *et al.,* 2013) identify these schools from the use of nonselective admission policies, a school's self-proclaimed emphasis on the STEM fields, and perhaps a school's affiliation with an organized STEM education initiative. These schools vary significantly in their educational practices. Furthermore, the analysis of data also revealed that students in high schools that have lower minority rates and low economically disadvantaged student rates perform better in mathematics exams and in mathematics sections of the tests such as SAT and ACT. Clayton (2011) has conducted a research study examining whether diversity of a school can predict academic performance on state-mandated tests. She found that the higher-poverty and higher-minority schools displayed lower pass rates at both the standard and advanced pass levels. In the current study, similar results have been revealed. Moreover, results of the present study indicated students in high schools that have lower economically disadvantaged student rates perform better in mathematics exams and in mathematics sections of the tests such as SAT and ACT. Numerous research studies (Clayton, 2011; Orfield and Lee, 2006;Rumberger and Palardy, 2005) reported the repeated finding emphasizing that the portion of a school's students who are live in poverty is by far the greatest predicator of how students will perform academically. Stevenson (2001) conducted a research study investigating the relationship of economically disadvantaged student rates to student outcomes, using SAT scores as the measure of academic performance. As a result of the study it was reported that approximately 60% of the variation in SAT performance across high schools was related to the overall level of student poverty within the schools.

Finally, the analysis of data clearly indicated that total number of enrollments have no significant effect on students' performances in high schools. Several research studies have investigated the relationship between school size and students' academic performances. In most of these studies, no significant relationship was found. Similarly, Crenshaw (2003) sought to answer two questions related to high school size. One was, "What are the relationships among school size, student achievement, teacher attendance, teacher stability, teacher perception of school climate, student attendance, dropout grates, and student perception of school climate?" The other asked, "Does school size influence achievement through the effects of nonacademic factors for teachers and students on school achievement?" The sample for her study included 178 public high schools in South Carolina. Crenshaw discovered that poverty was a significant predictor of both performance outcomes and measures of school climate. Though she did find some connection between school size and student achievement, Crenshaw concluded that: The relationship between socio-economic levels and achievement appeared stronger than the relationship between school size and achievement ratings. Schools that obtained higher achievement ratings tended to be larger, but more importantly the more affluent schools tended to be larger.

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