

Leading STEM Opportunity: A National Comparison of Public and Private High School Principals' Support for STEM Education

Dr. Emmanuel Nwagwu¹, Fiyin Owoseje²

¹Texas Southern University College of Education, Houston Texas, 77004

²Texas Southern University College of Education, Houston Texas, 77004

Abstract: *School principals shape the organizational conditions through which students encounter science, technology, engineering, and mathematics (STEM) opportunities. This study examined school-level supports for mathematics and science reported in the first follow-up of the High School Longitudinal Study of 2009 (HSLs:09), a nationally representative longitudinal study sponsored by the National Center for Education Statistics. The analysis focused on nine dichotomous indicators organized into three domains: after-school support, mentorship and enrichment, and teacher professional development. Descriptive percentages were used to characterize the prevalence of these supports, and logistic regression models examined differences between public and private school settings. Across school types, mentorship and enrichment activities were more common than several after-school and teacher-development supports. Public schools reported higher levels of partnership with college or university summer programs, sponsorship of mathematics or science after-school programs, use of guest speakers, dissemination of information about STEM opportunities, and professional development intended to increase student interest in mathematics and science. Private schools reported higher levels of mathematics or science fairs, workshops, or competitions and STEM-relevant field trips. The findings demonstrate meaningful differences in the ways public and private high schools organize opportunities intended to strengthen students' engagement with mathematics and science. Because the HSLs:09 first follow-up represents a 2009 ninth-grade cohort observed in 2012, the results should be interpreted as historical evidence about school practices rather than as estimates of current national practice. The study highlights the continuing importance of principal leadership, organizational capacity, and professional learning in building coherent STEM-support systems.*

Keywords: STEM education; principal leadership; instructional leadership; high schools; public schools; private schools; HSLs:09

1. Introduction

Expanding access to high-quality science, technology, engineering, and mathematics (STEM) learning remains an important educational priority. Although much of the STEM literature has focused on curriculum, teaching, student participation, and postsecondary pathways, school leadership is also consequential because principals influence priorities, professional learning, partnerships, scheduling, enrichment opportunities, and the conditions under which teachers implement instructional initiatives.

Recent scholarship has sharpened this leadership focus. Geiger et al. (2023) conceptualized principals' STEM leadership capability as a multidimensional capacity involving STEM knowledge and practices, contextual understanding, dispositions, tools, and critical orientation. A systematic review by Talib et al. (2025) similarly identified leadership management, professional development, STEM-focused school culture, and assessment as recurring dimensions of principals' roles in STEM implementation. Beswick et al. (2026) further showed that principals may hold positive dispositions toward STEM while possessing uneven STEM-specific leadership content knowledge. Together, this work reinforces an earlier insight in school-improvement research: principals matter not simply because they endorse reform, but because they help create the organizational capacity needed to sustain it (Bryk et al., 2010).

Public and private high schools provide distinct organizational contexts for examining STEM-support

practices. Differences in governance, resources, accountability structures, staffing, partnerships, and curricular flexibility may shape the types of opportunities schools provide. Yet national comparative evidence describing concrete principal- or school-level supports for STEM has been limited.

The present study revisits nationally collected HSLs:09 first-follow-up administrator data to describe mathematics- and science-related supports and compare reported practices in public and private high schools. The value of the analysis is historical and comparative: it provides a national benchmark for understanding how schools organized STEM-support activities during the 2011–2012 academic year and creates a basis for comparison with more recent research on STEM leadership.

2. Purpose and Research Questions

The purpose of this study was to identify specific school programs and practices used to support student interest and participation in mathematics and science and to determine whether reported support patterns differed between public and private high school settings. The study addressed two research questions:

- 1) What types of STEM-related support were reported by high schools in the HSLs:09 first follow-up?
- 2) How did reported STEM-support practices differ between public and private high schools?

3. Review of Related Literature

Principal Leadership and STEM Capacity

Principals influence instructional improvement through the organizational conditions they establish, the expectations they communicate, and the resources and professional learning they support. Bryk et al. (2010) identified school leadership as a central component of organizational improvement. In STEM-specific contexts, contemporary research extends this logic by emphasizing principals' capability to understand STEM practices, develop supportive cultures, mobilize resources, and enable teacher learning (Geiger et al., 2023; Talib et al., 2025). Beswick et al. (2026) argues that STEM leadership also requires leadership content knowledge sufficient to make informed decisions about STEM teaching and learning.

Student Enrichment, Mentoring, and STEM Opportunity

STEM engagement can be supported through experiences beyond conventional classroom instruction, including mentoring, competitions, field experiences, guest speakers, partnerships, and career exposure. Earlier work found that mentoring can contribute to students' perceptions of academic support in STEM (Kendricks et al., 2013), while research on STEM pathways has long emphasized the importance of educational experiences that make students aware of STEM options and trajectories (Nicholls et al., 2010). These opportunities are particularly relevant to school leadership because many require coordination, external partnerships, scheduling, funding, or administrative approval.

Teacher Professional Learning

Teacher learning is another mechanism through which principals can influence STEM opportunity. Professional development can strengthen instructional practice when it is sustained, focused, and connected to classroom implementation. STEM leadership scholarship increasingly treats teacher development as part of a broader school capacity-building function rather than as a stand-alone event (Talib et al., 2025). Thus, requirements or supports for professional learning in mathematics and science provide one indicator of how schools attempt to build instructional capacity.

4. Method

Data Source and Design

Data were drawn from the first follow-up of the High School Longitudinal Study of 2009 (HSLs:09), conducted in spring 2012 by the National Center for Education Statistics (NCES). HSLs:09 began with a nationally representative cohort of fall 2009 ninth graders and followed students over time. The first-follow-up school administrator questionnaire collected information about school characteristics, programs, policies, staffing, and activities intended to increase student interest and achievement in mathematics and science. Because NCES states that the first-follow-up data were designed around the original 2009 ninth-grade cohort and were not freshened to form a new cross-sectional sample of

all 2012 eleventh graders, the present findings should be interpreted within the longitudinal HSLs:09 design.

Population Estimates and Weighting

The original analysis reported weighted public- and private-school totals of 14,651 and 4,565, respectively (weighted $N = 19,216$). These values should not be interpreted as the literal number of principals or schools surveyed. NCES documentation reports that 939 base-year schools were eligible for continued participation in the first follow-up and 904 agreed to participate. Accordingly, the counts reproduced in this article are presented as weighted population estimates from the original analysis. Future replication should report the exact school-level analytic sample, weight variable, variance-estimation procedure, and treatment of missing data.

Measures

Nine yes/no indicators were grouped into three domains. After-school support included mathematics/science fairs, workshops, or competitions; partnerships with colleges or universities offering mathematics/science summer programs; and sponsorship of mathematics/science after-school programs. Mentorship and enrichment included pairing students with mentors; bringing in guest speakers; taking students on mathematics- or science-relevant field trips; and informing students about contests, websites, blogs, or other programs. Teacher support included required professional development on how students learn mathematics/science and required professional development intended to increase student interest in mathematics/science.

Analysis

Descriptive percentages summarized each support indicator overall and by school control. Three logistic regression models were then used to examine associations between the support indicators and school control (public versus private), with private schools serving as the reference category. Positive coefficients and odds ratios greater than 1.00 indicate that a support practice was more strongly associated with public-school status; negative coefficients and odds ratios below 1.00 indicate stronger association with private-school status. Because the source manuscript reports weighted estimates but does not document design-based standard errors or replicate-weight procedures, inferential results should be interpreted cautiously.

5. Results

The descriptive results show that STEM-support practices were unevenly distributed across the nine indicators. Mentorship and enrichment activities were generally more prevalent than several after-school and teacher-development supports. The most frequently reported activity was taking students on mathematics- or science-relevant field trips (65.3%), followed by informing students about contests, websites, blogs, or other programs (58.0%) and bringing in guest speakers (56.0%). The least frequently reported activities were mathematics/science fairs, workshops, or competitions (33.5%), pairing students with mentors (35.2%), and required professional development intended to increase student interest in mathematics/science (37.0%).

Table 1: Overall Weighted Percentages for STEM-Support Practices (Weighted N = 19,216)

Domain	Support practice	Yes (%)	No (%)
After-school	Math/science fairs, workshops, competitions	33.5	66.5
After-school	College/university math/science summer partnership	40.2	59.8
After-school	Math/science after-school program	42.1	57.9
Mentorship/enrichment	Pairs students with math/science mentors	35.2	64.8
Mentorship/enrichment	Guest speakers in math/science	56.0	44.0
Mentorship/enrichment	Math/science-relevant field trips	65.3	34.7
Mentorship/enrichment	Information on contests/websites/blogs/programs	58.0	42.0
Teacher support	PD on how students learn math/science	51.8	48.2
Teacher support	PD to increase interest in math/science	37.0	63.0

Public and private schools differed most visibly in several after-school and enrichment practices. Public schools more frequently reported college/university summer-program partnerships (42.5% vs. 32.9%) and mathematics/science after-school programs (48.3% vs. 22.4%). Private schools more frequently reported fairs, workshops, or competitions

(38.4% vs. 32.0%) and mathematics/science-relevant field trips (74.1% vs. 62.6%). Public schools also reported higher percentages for guest speakers, dissemination of STEM opportunity information, and both teacher professional-development indicators.

Table 2: Weighted Percentage Reporting Each STEM-Support Practice by School Control

Support practice	Private Yes (%)	Public Yes (%)
Math/science fairs/workshops/competitions	38.4	32.0
College/university math/science summer partnership	32.9	42.5
Math/science after-school program	22.4	48.3
Pairs students with math/science mentors	33.0	35.9
Guest speakers in math/science	50.7	57.7
Math/science-relevant field trips	74.1	62.6
Information on contests/websites/blogs/programs	49.8	60.5
PD on how students learn math/science	43.3	54.4
PD to increase interest in math/science	23.4	41.3

The logistic regression results were consistent with the descriptive contrasts for most indicators. Seven of the nine reported coefficients were statistically significant at $p < .001$. Public-school status was positively associated with college/university summer partnerships, after-school mathematics/science programs, guest speakers, information about STEM opportunities, and professional development

intended to increase student interest. Private-school status was more strongly associated with fairs/workshops/competitions and STEM-relevant field trips. Pairing students with mentors and professional development on how students learn mathematics/science were not statistically significant in the reported models.

Table 3: Logistic Regression Associations Between STEM-Support Practices and Public-School Status

Domain	Support practice	B	Odds ratio	p
After-school	Fairs/workshops/competitions	-0.453	0.636	< .001
After-school	College/university summer partnership	0.332	1.39	< .001
After-school	Math/science after-school program	1.160	3.19	< .001
Mentorship	Pairs students with mentors	0.019	1.01	.612
Mentorship	Guest speakers	0.420	1.53	< .001
Mentorship	Relevant field trips	-0.824	0.439	< .001
Mentorship	Contests/websites/blogs/programs	0.538	1.71	< .001
Teacher support	PD: how students learn math/science	0.084	1.08	.092
Teacher support	PD: increase student interest	0.791	2.21	< .001

Note. Private schools are the reference category. Values reproduce the coefficients reported in the source manuscript. The source did not provide standard errors, confidence intervals, or full survey-design specifications; therefore, inferential interpretation should remain cautious.

6. Discussion

The study provides a national historical portrait of how schools serving the HSLS:09 cohort organized opportunities intended to promote mathematics and science engagement. The central pattern is not that one school sector uniformly supported STEM more strongly than the other. Rather,

public and private schools differed in the forms of support they reported.

Public schools were substantially more likely to report sponsoring mathematics or science after-school programs. The reported odds ratio of 3.19 represents the largest public-school association among the nine indicators. Public schools were also more likely to report college/university summer partnerships, guest speakers, dissemination of STEM opportunity information, and professional development aimed at increasing student interest. These practices may reflect differences in scale, external partnerships, funding structures, accountability systems, or organizational routines, but the HSLS indicators analyzed here do not

directly test those explanations. Accordingly, causal explanations based on Title I funding, school size, or administrative autonomy should not be inferred from these results alone.

Private schools showed stronger associations with fairs, workshops, or competitions and with mathematics- or science-relevant field trips. These activities may be easier to organize under some school conditions, but the present analysis cannot determine why the sector differences occurred. The appropriate conclusion is descriptive: the sectors displayed different patterns in the kinds of STEM opportunities reported.

A second important finding is the uneven prevalence of supports across domains. Several potentially consequential practices were reported by fewer than half of schools, including formal mentoring, after-school mathematics/science programming, summer-program partnerships, and professional development aimed at increasing student interest. Contemporary STEM-leadership research makes these historical patterns especially relevant because it emphasizes that effective STEM leadership involves coordinated organizational capacity, not isolated activities (Geiger et al., 2023; Talib et al., 2025).

The teacher-development findings also deserve attention. Just over half of schools reported requiring professional development on how students learn mathematics/science, while only 37% reported professional development aimed at increasing student interest. Current scholarship on principals' STEM leadership capability suggests that leaders themselves need STEM-specific knowledge and practices to make informed decisions about teacher learning and schoolwide STEM culture (Beswick et al., 2026). Thus, professional learning for teachers and STEM leadership development for principals should be viewed as complementary capacity-building strategies.

7. Implications for Leadership and Practice

The findings support a systems-oriented approach to STEM leadership. Rather than relying on a single activity, high schools can consider how after-school programming, mentoring and career exposure, external partnerships, field experiences, and teacher professional learning fit together as a coherent opportunity structure. Principals are positioned to coordinate these elements through scheduling, resource allocation, partnership development, staff learning, and communication of instructional priorities. The results also suggest that public and private schools may have complementary strengths worth studying rather than treating school control as a proxy for overall quality.

8. Limitations

Several limitations are important. First, the data are historical. The first follow-up was conducted in 2012, so the

results do not describe current national STEM-support practices.

Second, HSLS:09 is a longitudinal cohort study. NCES cautions that first-follow-up data were not freshened to create a cross-sectional 2012 eleventh-grade cohort. Claims should therefore remain tied to schools serving the original HSLS:09 cohort.

Third, the source analysis reports weighted totals of 19,216 schools but does not document the unweighted analytic sample, specific weight used, survey-strata or PSU adjustments, replicate weights, missing-data treatment, or design-based standard errors. A publication submission should ideally reproduce the analysis from the original HSLS:09 data and report those specifications.

Fourth, the indicators are dichotomous and capture whether an activity was reported, not its intensity, quality, duration, student participation, or effectiveness. Finally, observed public/private differences are associational and should not be interpreted as causal effects of school sector.

9. Recommendations for Future Research

Future research should replicate these comparisons with contemporary national data and incorporate measures of program intensity, access, participation, and quality. Studies should also examine whether principal STEM leadership capability, professional learning, school resources, student composition, and community partnerships explain variation in STEM-support practices. Linking school-level supports to longitudinal student outcomes—such as advanced mathematics/science course-taking, STEM identity, postsecondary STEM enrollment, degree completion, and workforce entry—would extend the descriptive contribution of the present study.

10. Conclusion

This study demonstrates that schools serving the HSLS:09 cohort used multiple strategies to support mathematics and science engagement, but the prevalence and form of those strategies varied by school control. Public schools reported stronger use of several after-school, partnership, information, and teacher-development supports, whereas private schools reported greater use of fairs or competitions and STEM-relevant field trips. The findings do not establish that either sector provided superior STEM leadership. Instead, they reveal different organizational patterns and reinforce the importance of examining the concrete practices through which principals and schools create STEM opportunities. As contemporary research continues to define the knowledge and capabilities required for STEM leadership, national data on actual school practices remain essential for connecting leadership theory to the opportunities students experience.

Table 4: Reference Update and Use in the Revised Manuscript

Source	Focus	Action	Role in revision
Bryk et al. (2010)	School improvement / leadership	Retained	Foundational evidence on organizational leadership and school improvement.
Geiger et al. (2023)	Principal STEM leadership capability	Added	Provides a contemporary model of capabilities required for effective STEM leadership.
Talib et al. (2025)	Principal roles in STEM	Added	Systematic review of principal leadership, PD, STEM culture, and implementation.
Beswick et al. (2026)	STEM leadership content knowledge	Added	Updates the paper with recent empirical evidence on principals' STEM-specific leadership knowledge.
NCES HSLs:09 documentation	Dataset/design	Added/updated	Corrects the first-follow-up date, longitudinal design, administrator questionnaire scope, and interpretation of school counts.
Kendricks et al. (2013)	STEM mentoring	Retained	Supports the discussion of mentoring as a STEM-support strategy.
Nicholls et al. (2010)	STEM pathways	Retained	Supports the importance of experiences and awareness in STEM trajectories.
Older tangential sources	Various	Reduced	Removed or deemphasized where claims were speculative, dated, or not directly supported by the present analysis.

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