MEMORANDUM January 11, 2019

TO: Board Members

FROM: Dr. Grenita Lathan
Interim Superintendent of Schools

SUBJECT: **TEACHER INCENTIVE FUND STEM GRANT: PROGRAM EVALUATIONS**

CONTACT: Carla Stevens, 713-556-6700

The fourth cohort of the Teacher Incentive Fund federal grant competition ("TIF4") included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education (science, technology, engineering, and mathematics). In September 2012, HISD was awarded a TIF4 grant for $15.9 million over five years. The TIF4 project schools were among the HISD schools serving grades K–8 with the highest student economic disadvantage and the most risk factors for chronic absenteeism.

Attached are the three program evaluation reports associated with the TIF4 grant. A human capital approach to strengthening STEM education addressed the TIF4 project schools' need for high-quality supports for student learning, and the systemic challenges to teacher retention, development, and recruitment in hard-to-staff subjects. The first report in this series provided a descriptive overview of the grant-funded activities and interventions unique to the TIF4 project schools, setting the context for a meaningful discussion of programmatic impact.

The second report in the series addressed student outcomes for State of Texas Assessments of Academic Readiness (STAAR) Mathematics (grades three through eight) and STAAR Science (grades five and eight), during the grant period of 2012–2013 to 2016–2017. The TIF4 programming produced substantive, statistically significant results for science and for secondary mathematics. Key findings include:

- **STAAR Science, Grades 5 and 8.** Over the grant period, the cumulative impact of the TIF4 program on Grade 5 Science was an increase in student achievement of about a fifth of a standard deviation (0.20 SD). The impact on Grade 8 Science was about a quarter of a standard deviation (0.24 SD). Both estimates are statistically significant, although the evidence in eighth-grade science is less compelling. With a fifth of a standard deviation of improvement, a student initially at the 50th percentile would improve to the 58th percentile.
- **STAAR Math, Grade 6.** The point estimates suggest a cumulative impact over the grant period of about a fifth of a standard deviation (0.21 SD). These estimates were not considered statistically significant at conventional levels.
- **STAAR Math, Grades 7 and 8.** Over the grant period, the cumulative impact of the TIF4 program on Grade 7 Math was about half of a standard deviation of student achievement (0.49 SD). The impact on Grade 8 was about four-tenths of a standard deviation (0.39 SD). Both estimates were statistically significant at conventional levels. A half-standard-deviation increase would improve the achievement of a student at the 25th percentile to the 43rd percentile, or a student at the 50th percentile would then grow to the 69th percentile.
- **STAAR Math, Grades 3 to 5.** In grades three through five, the TIF4 program did not appear to have a large effect on mathematics achievement in any year of the grant period.

The third and final report overviews the performance-based compensation strategies implemented through the TIF4 grant, as well as situates that work in the context of HISD's challenges for teacher retention and mobility. Key findings include:

- The TIF4 schools paid out about ten $5,000 retention bonuses for each $10,000 recruitment bonus (178 Retention vs. 18 Recruitment). This suggests that effective math and science teachers at hard-to-staff HISD schools find retention bonuses to be meaningfully more compelling than larger recruitment bonuses.
- In Years Three, Four, and Five, the TIF4 schools retained 75% of their Effective and Highly Effective math and science teachers.
- During the grant period, HISD directed $3,330,781 of federal, state, and local resources into the ASPIRE Award at the TIF4 project schools. Over a thousand (1,012) ASPIRE Awards were paid to educators at the TIF4 campuses during this time. Every TIF4 school had at least one educator who received an ASPIRE Award during the grant.
- By the start of the third year after their initial hire, 46% of new teachers had left the HISD school where they started. This attrition rate is higher for new math (60.8%) and new science (61.2%) teachers.
- During this period, the top ten percent of HISD schools (90th percentile and upward) annually retained over 80% of all their high TADS teachers, regardless of subject area or years of experience.

Taken together, these findings strongly suggest that the high turnover among HISD's math and science teachers can be mitigated through investment in retention bonuses for effective and highly effective teachers already working at specific campuses.

Should you have any further questions, please contact Carla Stevens in Research and Accountability at 713-556-6700.

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Attachments (3)

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HOUSTON INDEPENDENT SCHOOL DISTRICT

RESEARCH

Educational Program Report

TEACHER INCENTIVE FUND STEM GRANT IN HOUSTON ISD: A DESCRIPTIVE OVERVIEW

HISD | Research and Accountability

ANALYZING DATA, MEASURING PERFORMANCE.

2018 BOARD OF EDUCATION

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Teacher Incentive Fund STEM Grant in Houston ISD: A Descriptive Overview

Executive Summary

Program Description

Supporting the federal priority to improve STEM education, the fourth cohort of the Teacher Incentive Fund grant competition (TIF4) included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education. Houston Independent School District's (HISD) approach to STEM education — described here — is an innovative policy response to the national challenges of preparing students for 21st century global citizenship. In HISD, the TIF4 grant supported program activities that reached students, teachers, and school-wide systems.

Highlights

- As a complex project with many components, the TIF4 grant supported teachers' effective STEM instruction, and student learning in math and science.
- TIF4 empowered teachers to bring cross-curricular instructional materials to their students. Project staff made carefully researched investments across five categories of STEM instructional materials: engineering, robotics and coding, science and mathematics, STEM literacy, and makerspaces.
- Through the STEM Design Challenges, students experienced project-based learning aimed squarely at the science and math standards that had represented the biggest challenge to their schools in previous years.
- Through this grant, students at TIF4 project schools were not encountering content areas as disconnected subject area silos — rather, the tools of technology and engineering were being used to facilitate cross-curricular thinking for science, math, and literacy.
- The TIF4 grant allowed HISD to provide a different experience for STEM teachers as well as their students. Master teachers with expertise in teaching STEM content (Teacher Development Specialists) coached teachers across all complex facets of instructional practice on site at the project schools.
- STEM teachers at TIF4 schools had priority access to professional development opportunities in specialized content-area and pedagogy, including the experience of professional learning within a community (the "STEM Cadre").
- Through these activities, HISD staff learned many lessons — about working with vendors and partner entities as an early adopter of a new curricular strategy, about building internal district capacity as a sustainability strategy, and about navigating state and federal regulations.

The lessons learned from HISD's human capital approach to strengthening STEM education hold value for other American school districts working with similar student groups and navigating similar challenges for STEM teacher recruitment, development, and retention. This descriptive overview of activities and interventions unique to the TIF4 project schools sets the context for a meaningful discussion of programmatic impact. Additional reports in this series will investigate specific outcomes of interest, including: how student outcomes for science and math at project schools compare to outcomes at similar schools not participating in TIF4, teachers' readiness (self-efficacy) for STEM instruction, and human capital outcomes for science and math teachers at project schools.

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Introduction

Defining STEM Education

Every working definition of "STEM education" encompasses the four content areas in the acronym S.T.E.M. – science, technology, engineering, and mathematics. In the public view of STEM education, these four content areas are treated as separate and distinct – with students encountering "math as part of the basics, science as important but secondary, and technology and engineering as supplementary add-ons that are only appropriate 'later' and for 'some students'" (Volmert, Baran, Kendall-Taylor, & O'Neil, 2013, p. 5). Increasingly, STEM experts advocate for these subjects to be taught in an integrated fashion, rather than as independent and self-contained content areas. A more contemporary approach to K-12 STEM education addresses it as "an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (Tsupros, Kohler, & Hallinen, 2009).

Thus, contemporary STEM education encompasses not only cross-disciplinary content in mathematics and science, but also technical skills (such as coding and robotics) and specific ways of posing and answering questions (such as the engineering design cycle). At a classroom level, STEM education is discussed in the context of curriculum content and pedagogy approach, valuing cross-curricular synthesis and creative connections in support of rigorous content. This approach is described by STEM education advocates as "all about curiosity, exploration, and invention" (Milgrom-Elcott, 2016). It is this approach that has informed the STEM programming addressed in this report.

The strength of American STEM education has repercussions far beyond an individual classroom. Houston Independent School District's (HISD) approach to STEM education – described here – is an innovative policy response to the national challenges of preparing students for 21st century global citizenship.

STEM Education is a National Priority

Because STEM education can support national workforce development goals as well as student learning (NASEM, 2016), the topic has received significant attention from business leaders and educators, as well as news media, private philanthropists, and policy makers. America's schools and universities, they argue, are not producing enough skilled STEM graduates from among our high school students to meet the country's upcoming needs for workforce and military readiness (NAS, NAE & IM, 2007). As evidence, they point to international indicators that show Americans lagging behind other industrialized nations in both mathematics and science (e.g., OECD, 2004). While the argument about American competitiveness is not a new argument for STEM education (e.g., Gardner, Larsen, & Others, 1983), contemporary stakeholders also recognize that global citizenship in the 21st century requires different skills and different ways of thinking than were needed even just a few decades ago (OECD, 2013).

To meet these complex emerging needs, the National Research Council in 2011 established three major goals for STEM education in the United States:

- Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields.
- Expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce.
- Increase STEM literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines (NRC, 2011; NAS, NAE & IM, 2011).

To advance these goals, in 2011, the White House created the Office on Science and Technology (OST) to bring public visibility to STEM education as a national priority (see **Figure 1**), and to coordinate and catalyze 130 STEM programs across 12 federal agencies. In that period, the OST coordination of existing programs was augmented by significant investment of new federal resources: in the 2017 federal budget sent to Congress, over $4 billion in mandatory spending and over $3 billion in discretionary resources were dedicated to STEM education for all students (OSTP, 2016).

Figure 1. Official White House Photo. March 23, 2015: President Obama greets four Girl Scouts from Tulsa, Oklahoma, as he viewed their exhibit during the White House Science Fair (Souza, 2015).

The Teacher Incentive Fund Grant Program and STEM Education

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education has supported human capital strategies "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science and math. Responding to the national agenda to improve STEM education, in 2012, the fourth cohort of the Teacher Incentive Fund federal grant competition (TIF4) included special consideration for projects designed to improve STEM education by identifying, developing, and utilizing master teachers as leaders of broader improvements (OESE, 2012a).

In September 2012, HISD was awarded a TIF4 grant for $15.9 million over five years (HISD Communications, 2012). The human capital strategies supported through TIF4 in Houston continue the successes and strategies of HISD's previous TIF grants, and are similar to strategies undertaken by the other 35 TIF4 grant recipients nationwide (OII, 2015). HISD was one of just six TIF4 grantees funded to support a "comprehensive approach to improving STEM instruction" as part of their overall human capital strategy (OESE, 2012b). Through TIF4, STEM grantees advanced the Absolute Priorities required of all TIF grantees – regarding human capital management systems, and educator evaluation – as well as a third Priority that incorporated STEM master teachers into their strategy for STEM improvement. Taking a human capital approach to strengthening the STEM teacher workforce addressed both the need for high-quality

STEM instruction for student learning, and the systemic challenges to teacher retention, development, and recruitment. For more information about the Teacher Incentive Fund grant and the Absolute Priorities for grantees, see **Appendix A**.

STEM Education and the TIF4-STEM Grant in HISD

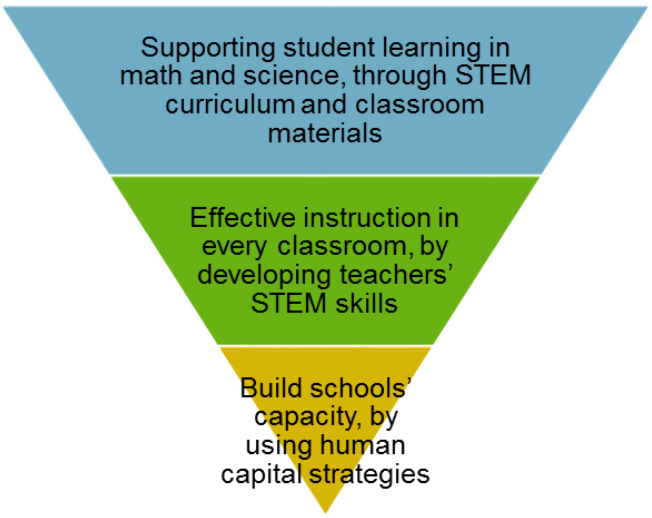
Since 2011, the number of STEM-related jobs, types of STEM degrees granted, and the level of student interest in STEM fields all continue to increase across the country (Neuhauser, 2015). But the national racial gaps identified in 2011 have persisted (Neuhauser & Cook, 2016). The ongoing confluence of these national needs and gaps presents a particular opportunity for STEM education programming in HISD.

As the fourth-largest city in the nation, Houston is home to the Texas Medical Center, NASA, and dozens of major multinational energy companies. Any STEM initiative in Houston will benefit the future needs of these institutions for employees with strong STEM knowledge and skills. Because HISD's students are culturally and linguistically diverse, any STEM initiative in HISD will also reach those demographic groups who are most under-represented in the national STEM workforce – 86% of HISD students are Hispanic or African-American (HISD, 2016). Consequently, the lessons learned from a successful programmatic approach to STEM education in HISD can also hold value for other American districts serving similar student groups and addressing similar challenges with STEM teacher recruitment, development, and retention.

In developing a comprehensive approach to improving STEM instruction in HISD, the grant supported program activities that reached students, teachers, and school-wide systems. As illustrated in **Figure 2** (below), student learning builds on effective instructional practice, which in turn builds on school capacity. These activities and interventions supported teachers' effective STEM instruction and student learning in math and science. Through human capital activities, HISD committed to *build schools' capacity*: providing financial incentives, professional development, and career pathway opportunities to effective and highly effective teachers in STEM-related fields at project schools. The human capital outcomes of the TIF4 grant will be examined in an upcoming report in this series.

To set the stage for meaningful discussion of student learning outcomes, this report provides an overview of the TIF4-funded activities that supported STEM implementation at the project schools – through job-embedded professional supports from STEM master teachers, and through STEM curriculum and classroom materials.

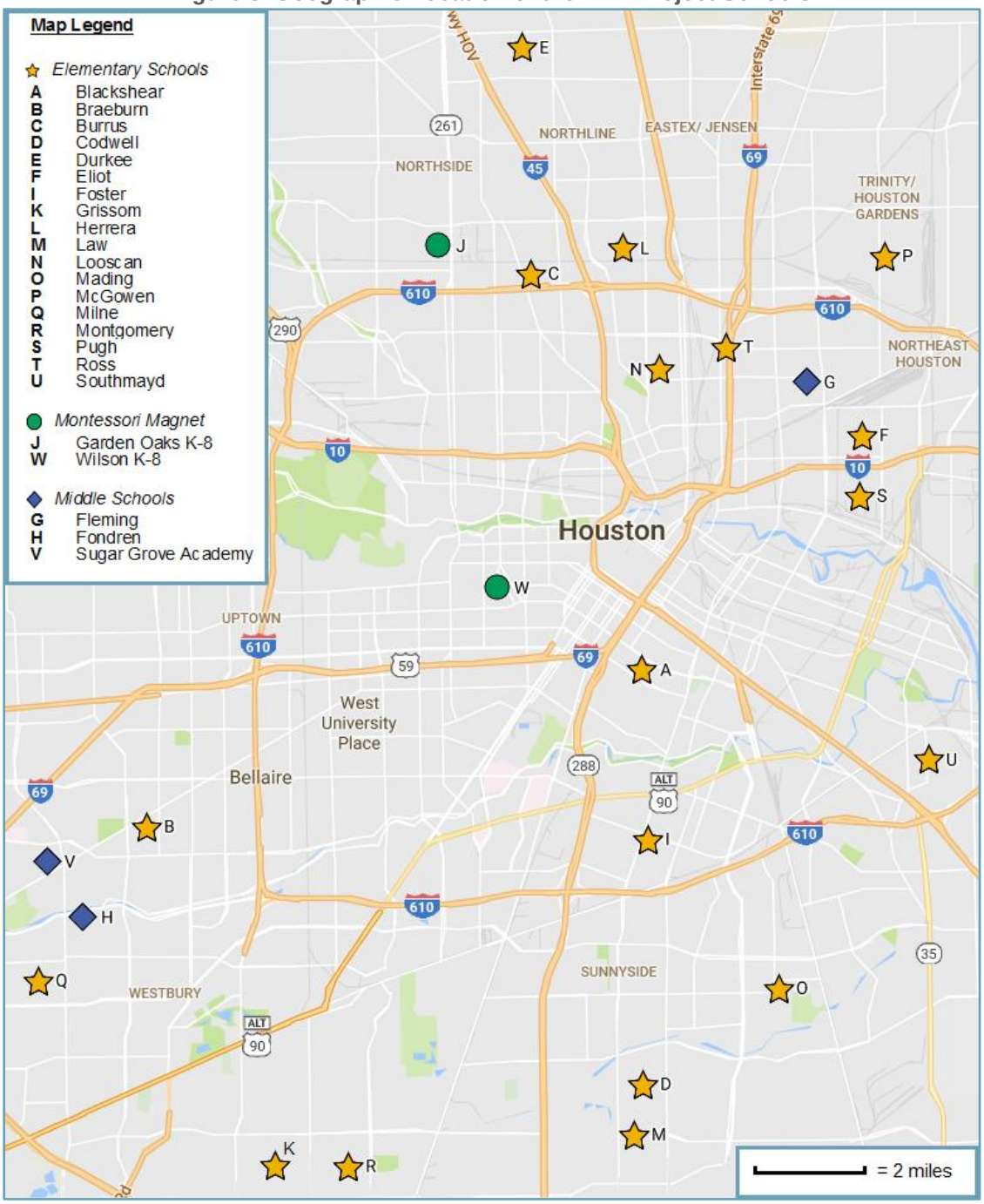
Figure 2. Three Levels of TIF-Supported Impact



TIF4-STEM Project Schools

In July 2012, HISD leadership identified specific schools to receive STEM programming through the TIF4 grant (HISD, 2012). These schools served almost every neighborhood in Houston (see **Figure 3**). Like most of the schools in HISD, the TIF4 project schools were considered "high-need" under the definitions in the U.S. Department of Education's Request for Application (OESE, 2012a). Among all "high-need" HISD schools, the TIF4 project schools each had a persistent track record of underperforming on the math and science exams required under section 1111(b)(3) of the Elementary and Secondary Education Act (NCLB, 2002).

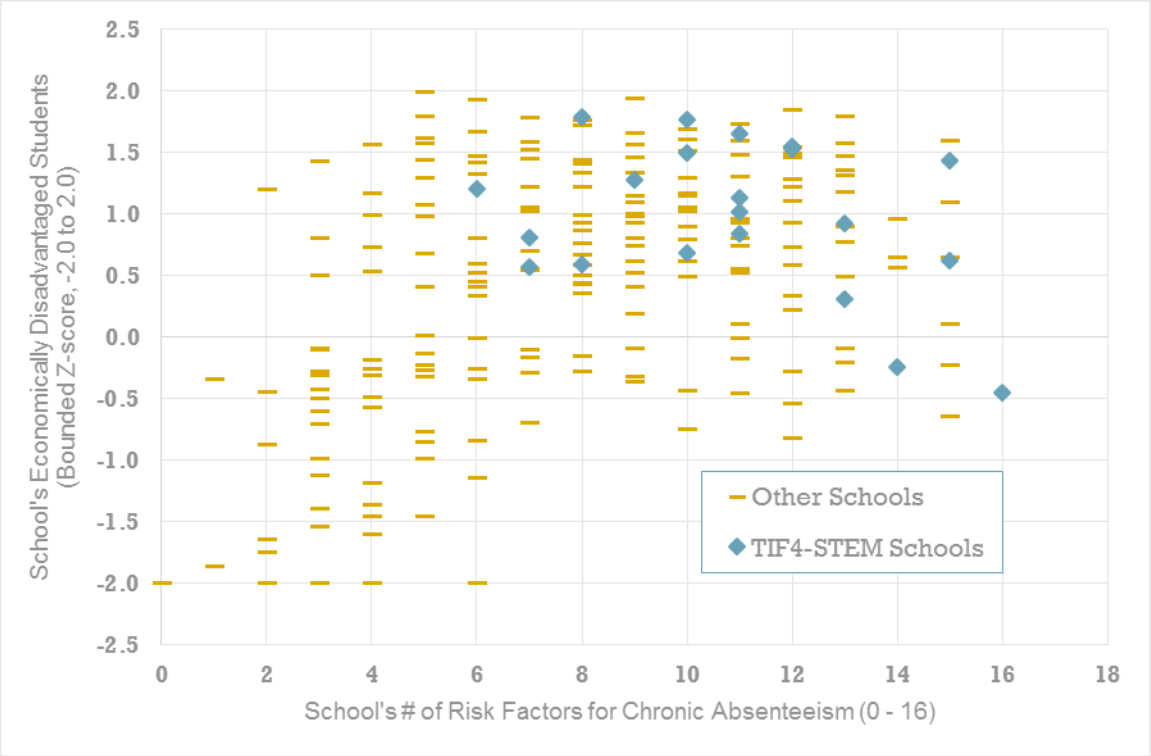
Figure 3. Geographic Location of the TIF4 Project Schools



The TIF4 project schools were considered "high need" based solely on the percentage of enrolled students considered to be economically disadvantaged. However, this can be a crude metric of the school's academic need when many factors correlate with academic performance and chronic absenteeism. In the report "A Better Picture of Poverty" (Reeves, McCarley, Mosier, & Carney, 2015), HISD staff identified two dozen risk factors that affect academic performance and correlate with chronic absenteeism. Overall, the 2015 *Risk Load* report showed two things – that HISD schools are facing complex issues, but that some schools are showing success even with a heavy "risk load." The same is true of the TIF4 project schools. **Appendix B** shows the "heat map" of each school's risk factors for chronic absenteeism.

These risk factors confirm the comparatively high need of the TIF4 project schools for specific intervention: according to their findings, the average TIF4 project school has more risk factors than other HISD schools serving grades K-8: the median number of Risk Factors facing a TIF4 school is 11, compared to 8 for the other HISD schools serving grades K-8. **Figure 4** illustrates the relationship between each school's number of risk factors for chronic absenteeism (X-axis) and their students' comparative economic disadvantage status (Y-axis). In the context of other HISD schools serving K-8 students (yellow dashes), the TIF4 project schools (blue diamonds) are among the schools with the highest student poverty and most risk factors for chronic absenteeism.

Figure 4. Economic Disadvantage and Risk Factors in HISD Schools Serving Grades K–8



The definitions and sources of these risk factor variables are found in **Appendix B**. The relationship of these variables to the project schools' academic outcomes will be explored in greater depth in the second report of this series.

Teacher and Student-Level Supports for STEM

Unlike other HISD schools, the TIF4 project schools had access to differentiated professional support for STEM instruction. The core of this support came from the twelve STEM master teachers, supported by the TIF4 grant. As defined by the USDE program officers, STEM master teachers are "teachers who serve as recognized leaders in STEM education improvement efforts, regardless of their specific duties." As master teachers, their roles and duties could include:

- Developing teaching capacity in STEM subject areas — for example, facilitating professional development programs, modeling instruction, observing instruction, coaching teachers in STEM subjects, mentoring new teachers, or
- Supporting other school/district STEM improvements — in other words, beyond developing the capacity of the teaching staff in STEM subjects (Zawaiza & Robinson, 2014).

The role within the TIF4 grant for ten of the STEM master teachers was the STEM Teacher Development Specialist (TDS). Each TDS provided job embedded support for all math, science, technology, and STEM teachers in the project schools. They also partnered with school leadership teams to plan and shape campus instructional decisions. In addition to this staff support, all TIF4 campuses received supplemental curriculum, instructional materials, and professional development opportunities to support implementation — organized and implemented by the two other master teachers in the roles of STEM TDS Team Lead and STEM Curriculum Manager. Due to turnover, the project employed a total of 19 STEM master teachers in the 12 positions during the five-year grant period.

What professional supports for STEM instruction were available to STEM teachers at TIF4 schools?

The goals of these professional supports were to strengthen STEM teachers' instructional practice and content knowledge in STEM subject areas. To do this, the project leveraged STEM master teachers to provide job-embedded support for math and science teachers at the project schools. **Table 1** (below) shows the staff roles made possible by the TIF4 grant.

Table 1. STEM Master Teacher Roles Funded by TIF4 Grant, 2013—2017

	2013—2014	2014—2015	2015—2016	2016—2017
Tchr. Development Specialists *Ten FTE per year* *See Appendix C*	Hired August 2013	Continued	Continued	Contracts concluded August 2017
TDS Team Lead (1 FTE) *Lead 1, 2013—2015;* *Lead 2, 2015—2017*	Hired June 2013	Continued	Staff transition July 2015	Contract concluded August 2017
Curriculum Manager (1 FTE) *Created Design Challenges,* *Managed curriculum, purchases*	Hired June 2013	Continued	Continued	Contract concluded August 2017

Broadly defined, professional development for teachers encompasses those "activities that are intentionally designed to support the learning of members of a particular role group" (Jackson & Cobb, 2013, p. 5). **Table 2** (p. 10) shows the main types of job-embedded professional development facilitated by these master teachers – one-on-one instructional coaching for teachers in their classrooms, collaborative learning meetings of the STEM Cadre, and TDS-led workshops outside the teachers' duty day.

Table 2. Job-Embedded Supports Funded by TIF4 Grant, 2013—2017				
	2013—2014	**2014—2015**	**2015—2016**	**2016—2017**
Instructional Coaching *Supports for individual teachers, and campus-wide as requested*	Began	Continued	Continued	Continued
The "STEM Cadre" *A cohort model for professional learning across campuses*	Began	Continued	Continued (With stipend)	Continued (With stipend)
Support for Other STEM Funding Opportunities *Resources for teachers and school leaders seeking additional funds for STEM at their school*	-	-	Began	Continued
TDS-Led Workshops				
Early Release Day Workshops	3 (plus two in-service)	Five (5)	Continued (5)	Continued (5)
Saturday Reboot Workshops	-	Began (2)	Continued	Continued
District & Regional Workshops	-	-	Teachers Also Co-Presented	Teachers Also Co-Presented
Lesson Labs	-	-	Began	Continued
STEM Summer Institute	August 2013	August 2014 (with Baylor)	August 2015; Teachers Also Co-Presented	August 2016; Teachers Also Co-Presented

Instructional Coaching by the STEM Teacher Development Specialists

The ten STEM Teacher Development Specialists (TDSs) supported teachers specifically with their STEM content and pedagogy development – as well as other teacher needs identified through student data and appraisal information. Each TDS was assigned to two or three project schools, and reported to these schools on a daily basis. **Appendix C** shows the annual alignment of each TDS with their project schools.

- These TDSs observed project school teachers and provided formative feedback, modeled instructional practices, enacted side-by-side teaching, and conducted other activities within the Coaching Cycle shown in **Figure 5** (p. 11).
- This job-embedded instructional coaching was aligned with the Instructional Practice Rubric from the district's Teacher Appraisal and Development System (TADS), as well as the district's scope and sequence for both math and science.
- In addition to providing personalized instructional coaching for individual teachers, the STEM TDSs facilitated Professional Learning Communities, delivered campus-based workshops, facilitated collaborative planning sessions with grade-level teacher teams, and supported school leaders in identifying campus-wide priorities aligned with teacher and student needs.
- Additionally, they supported new and veteran teachers in improving their instructional practice across multiple domains: setting goals, planning units and lessons, and developing assessments.
- These efforts were collaborative in nature and driven by the efforts of the campus teams. As a result, the STEM TDSs' roles and relationships varied between the project schools.

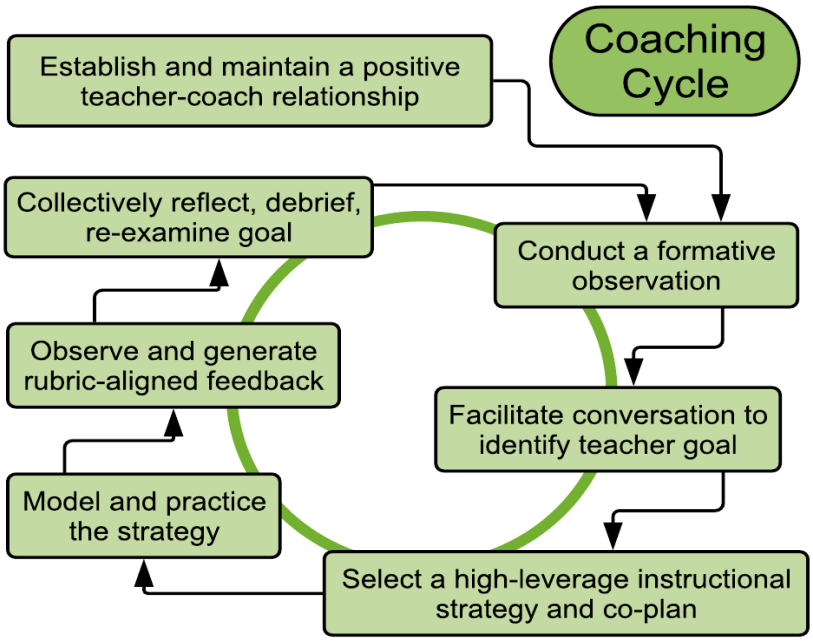
Although their work during the initial years was exclusively on the TIF4 project schools, in the final two years of the grant, the TDS team also delivered trainings to share their content area expertise with other

HISD teachers. These activities were part of a deliberate strategy to expand the reach of the "lessons learned" from the STEM work of TIF4. For example:

- Every member of the STEM TDS team presented workshops at NASA's Space Exploration Educators Conference (SEEC) in February 2016.
- Two of the TDS team served as facilitators for the district-wide Teacher Leaders program, working with larger groups of Teacher Leaders on skills such as instructional coaching.
- The entire team also supported the district-wide elementary mathematics and science summit by presenting workshops.
- Workshops were offered district-wide to support the introduction of the STEM Design Challenges (created through TIF4) availability to all HISD teachers. The trainings were offered at the elementary and middle school levels to cater to the specific needs of each grade span.
- A series of trainings centered around teaching with the programming language Scratch were created and presented to a district-wide audience, scaled for participants' aptitude levels (beginning, intermediate, advanced).

These STEM TDSs were initially chosen for their deep content knowledge and masterful pedagogy. An early team self-assessment in each of the STEM areas revealed that the team as a whole was highly skilled in math and science. However, through the grant period they continued to grow in their understanding of integrative STEM pedagogy. Through this growth, these TDSs embraced a more sophisticated definition of STEM education than when the grant period began. They internalized the guiding principles of design and the engineering design process, and how knowledge once regarded as too technical for children can make learning exciting and relevant when situated in real classroom experiences. No longer did they consider STEM simply as math instruction or science instruction that has been renamed. Rather, they understood that STEM means the teaching and acquisition of skills and content knowledge in an integrated fashion through project-based learning.

Figure 5. The STEM Teacher Development Specialist Coaching Cycle



The "STEM Cadre": A Cohort Model for Professional Learning

In response to the need to build teacher capacity at the TIF4 project schools, the HISD team focused on engaging a dedicated group of principal-selected teachers in STEM resources and pedagogical approaches. The purpose of the STEM Cadre was to develop a cohort of teachers who would, through STEM resources and professional supports, ultimately implement specific teaching practices and thereby impact student learning in math and science.

Cadre participants were selected by their principals for a wide variety of reasons, sometimes as a reward for their outstanding student performance metrics, and sometimes as a support for a specific teacher who needed to meet a school leader's expectations for math and science. In each year, some participants were wholly new to STEM education and some had previous experience with the Cadre program. Individual teachers formed multi-year professional relationships with colleagues outside their own school context – colleagues who were responsible for similar student outcomes while working in similar environments.

Unlike other compensation strategies supported by the TIF4 grant, STEM Cadre teachers did not require specific student performance metrics to receive a stipend at the end of the academic year. Rather, they committed to do specific STEM-related activities:

- To attend a total of 24 hours of STEM summer institute professional development, at least four of the five STEM Early Release trainings, at least one of the two STEM Saturday Reboot half-day trainings, and select STEM workshops or conferences attended outside the regular duty day;
- To plan and deliver at least six STEM lessons or activities to their own students (one per grading cycle);
- To engage in at least one coaching conversation per grading cycle with their school's STEM TDS, and;
- To expose STEM to other staff members, students, parents and the community of their campus.

Cadre members and their principals signed commitment forms outlining the expectations for activities required to earn the full stipend.

Each year, STEM Cadre teachers received curriculum and instructional materials for immediate implementation in their classrooms, and had unique opportunities to take part in STEM workshops delivered by outside vendors and institutional partners. The content of the STEM Cadre program evolved over four years: by the end of the grant period, STEM Cadre teachers were beginning to self-select into different content areas in order to specialize their content area expertise. Some focused on coding, some on botany, others on robotics, some on drones, and still others on 3D printing. They were continually seeking out more advanced, content-rich learning opportunities for themselves – and by extension, for their students.

"It's the most amazing networking. I love that I can come [to the Cadre workshops] and meet these [other Cadre] science and math teachers and collaborate and synthesize with them about what we're going to do – and then have fun together! Because that's how we make it fun for the kids. And I love fun."

– Jessica S., STEM Teacher from TIF4 Project School (HISD Communications, 2015)

Support for Other STEM Funding Opportunities

One of the STEM master teachers' priorities was empowering teachers and school leaders to be proactive during the grant period in order to sustain the STEM work on their campus after the conclusion of TIF4 support. To assist the TIF4 project schools with sustaining their STEM programming after the end of the grant period, the STEM Curriculum Manager shared out-of-district STEM funding opportunities on the project's webpage. The centralized availability of these funding opportunities lead to other streams of

funding for STEM programs at the TIF4 project schools. In one instance, a STEM Cadre teacher at a TIF4 project school successfully secured a donation of 150 laptops from Best Buy for her students – an occasion that drew coverage from the Houston Chronicle (Webb, 2018; see **Figure 6** below).

Figure 6. Fleming Middle School eighth graders partner to work the coding part of building a personal computer (Photo: Maria D. De Jesus, Houston Chronicle)

Shelby Webb, Houston Chronicle (2/9/2018)

Dozens of Best Buy employees and laptop kits lined the halls of Fleming Middle on Friday to help eighth graders build their own donated laptops. Students will get to keep the computers even after the school year ends.

…Sharell Webb, an eighth grade science teacher who wrote grants for the laptops being provided by Best Buy, said 85 to 99 percent of her students were affected by Hurricane Harvey, which swamped the northwest Houston neighborhood surrounding the school.

She said many of her students had lacked access to computers before the storm, but the problem only grew worse as families had to rebuild their lives. "When I first told them about this, it really didn't register until they saw the box. Then it was like, 'Hold on, can you repeat that?' They just gasped," Webb said, pausing after her voice broke. "Now they're going to have a boost of confidence because this has been a great incentive – [this opportunity to build their own laptop] has been like a sense of accomplishment."

TDS-Led Workshops: Early Release Days, Saturday Reboots, Lesson Labs

During each academic year, the STEM TDS team facilitated multiple short workshops on early release days, Saturday "reboot" training sessions, and – in the final two years – "lesson labs" in the early evenings. These workshops provided opportunities for TIF4 project school teachers to become familiar with the curricular content, instructional materials, and pedagogical approach embedded in the district-created STEM Design Challenges. As the primary audience for these trainings, the STEM Cadre teachers had first

priority for registration and attendance. The format and structure of these workshops changed slightly each year to respond to the lessons learned in the previous year.

- *Early Release Day Workshops.* Initially, these workshops were organized so that teachers were required to participate in a single track around a content area. Later on, these workshops were still organized into thematic tracks, but the teachers were not locked into a specific workshop if it did not meet their current needs. By 2016–2017, workshop schedules on early release days were organized to allow for even more choice – like menus with sections, rather than a prescribed course list.
- *Saturday Reboot Workshops.* The "reboot" Saturdays brought the content to participants who were relatively new to the Cadre program, and refreshed the content for those longer-commitment teachers who had been participating for a while.
- *Lesson Labs:* In the fall semester of 2015–2016, the TDS began to offer open "lesson labs" in a relatively unstructured format, from 4:30pm to 7:30pm. During the "lesson labs," teachers worked with a TDS to practice and troubleshoot a lesson plan before delivering it in front of students. For each lab, between five and ten teachers showed up to work through their instructional practice.
- *STEM Summer Institute:* For four consecutive summers, a week-long professional development training was offered, centering on a broad array of STEM content created for TIF4 campuses. Each year, the Summer Institute included workshops on coding, robotics, engineering design, and project-based learning. In 2015 and 2016, the STEM Summer Institute was featured on HISD's employee news site and on the district's YouTube channel (HISD Communications, 2015, 2016). See **Appendix D** for the sessions offered at the 2015 Summer Institute, and **Appendix E** for the sessions in 2016.

"I think the STEM Teacher Development Specialist team is amazing – what they're doing is really getting teachers the tools we need to go back to our classrooms and teach science with math and technology and engineering. So this overall [STEM Summer Institute] experience has been amazing, and giving us a lot to work with."

Christopher W., STEM Cadre Teacher from TIF4 Project School
HISD News for District Employees (8/4/2016)

In addition to the supports provided by the STEM team, teachers at the TIF4 project schools had unique opportunities to take part in workshops delivered by outside providers and institutional partners. See **Table 3** (p. 15) for the other workshops offered to STEM Cadre teachers during the grant period.

The Center for Educational Outreach at Baylor College of Medicine (BCM)

For three years, TIF4 funds supported The Center for Educational Outreach at Baylor College of Medicine to organize, plan, and deliver the Baylor Summer Science Institute (BSSI) and follow-up Science Saturday workshops, aligned to state standards and promoting the use of HISD curriculum documents and resources.

The Introductory BSSI was for PreK–5th grade teachers who had not completed a BSSI in the previous three years. The two-week program focused on deepening participants' science content knowledge, as well as present current and effective teaching strategies, in-depth lessons, assessments, and related reading and mathematics components—all aligned with Texas curriculum standards. The Advanced Level BSSI was for PreK–5th grade teachers who had attended a BSSI in the previous three years. The one-week Advanced institute focused on deepening participants' understanding of key science concepts while modeling instructional strategies that move students to advanced academic performance as outlined in the Texas Education Agency's state assessment performance level descriptors. Participants in both the Introductory and Advanced sessions received continuing education credit, science teaching books and

materials, and access to online science content aligned with Texas curriculum standards. Both summer institutes and the follow-up Saturday trainings were presented by Baylor faculty as well as "master teachers" who worked as elementary science teachers during the regular academic year.

"We want our teachers to feel comfortable so our students can be successful. This [Summer Science Institute] program provides teachers with this in-depth content and helps them understand it so they are able to take it back to their classrooms and break it down for the students so the students understand. "

Cheskisha W., STEM Teacher from TIF4 Project School and Baylor SSI instructor
The Center for Educational Outreach at Baylor College of Medicine, August 2016

Table 3. STEM Workshops Supported by TIF Funds, 2013—2017

	2014—2015	2015—2016	2016—2017
Baylor College of Medicine			
Summer Science Institute (SSI) for Elementary Teachers	July 2014	July 2015	July 2016
Summer Science Institute (SSI) for Secondary Teachers	July 2014	July 2015	-
Super Science Saturdays (5)	Fall (3) and Spring (2)	Fall (5)	-
Rice University			
Office of STEM Engagement 3D Engineering Academy	-	June 2015	-
Graphing Calculators; School Mathematics Project (RUSMP)	March 2015 T^3 in Fort Worth, TX	-	July 2016 – March 2017
Buck Institute			
Project Based Learning 101	-	August 2015	-
Space Center Houston			
Space Exploration Educators Conference (SEEC) at NASA Johnson Space Center	-	February 2016	February 2017
STEAM Teaching Workshops			
Alley Theatre, Main Street Theatre	Both Semesters	Both Semesters	Both Semesters

Rice University Office of STEM Engagement

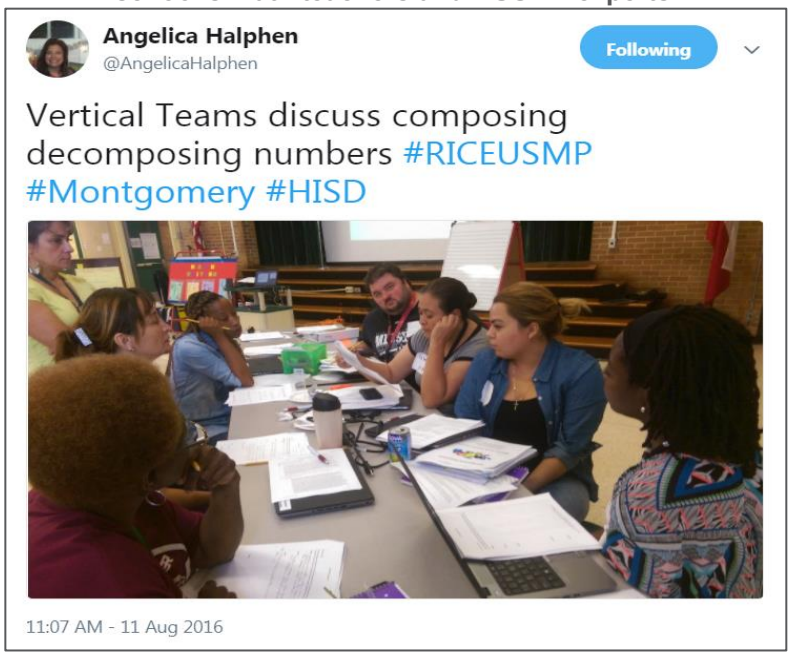
In June 2015, TIF4 funds braided with corporate philanthropic dollars from GE Oil & Gas to support a summer professional development partnership between HISD's Secondary Science Curriculum Department and the Rice University Office of STEM Engagement. This partnership offered secondary teachers the opportunity to implement innovative technology in the classroom, while inspiring middle school and high school students to explore careers in related fields. The 3D Engineering Design Academy (EDA) workshops were designed to provide middle and high school science teachers with the confidence and expertise to proficiently use 3D printers in their classrooms and to provide students with authentic engineering design experiences. Over ten days (a five-day workshop offered twice), teachers learned how to use TinkerCAD software, how to calibrate and troubleshoot common issues with 3D printers, how to

teach an open-ended design project (design an improved eating utensil for children with specific muscular impairment), how to teach prototyping with low resolution materials (such as fabric, paper, and cardboard), as well as pedagogy-specific skills and activities in engineering design – effective facilitation techniques, project planning, the types of assignments that can be used to promote student progress, and the use of peer review for assessment.

Rice University School Mathematics Project (RUSMP)

Supported by TIF4 resources, HISD made three specific investments in teaching mathematics with technology during the grant period. First, members of the Secondary Mathematics curriculum team attended the Teachers Teaching with Technology (T^3) International Conference in Fort Worth, Texas, in March, 2015. The curriculum specialists attended sessions to increase their content and technology knowledge while discussing the impact that technology has on pedagogy. Second, during the grant period, project staff purchased graphing calculators for the three project middle schools, so teachers could instruct students how to use them as part of their routine instructional practice. The most significant TIF4 investment in teaching with technology came in the final year of the grant period. HISD partnered with Rice University School Mathematics Project (RUSMP) to build capacity in the district's secondary mathematics teachers by targeting the development of their content knowledge and pedagogical skill around using graphing calculators to teach mathematics. Teacher training focused on the use of graphing calculators to instruct students at a deeper level is a crucial step towards increasing student achievement and providing access to quality instruction for all students (HISD Academics, 2016).

Figure 7. A STEM Master Teacher tweets about work with her school's math teachers and RUSMP experts



Buck Institute for Education (BIE)

As defined by the Buck Institute for Education, project-based learning (PBL) is "a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge" (BIE, 2013). During the summer of 2015, the TIF4 team partnered with the Buck Institute to provide a three-day professional development workshop in project-based learning (called "PBL 101") to all K–8 teachers in the district who wanted to attend. Priority registration was given to teachers in the TIF4 project schools. The master teachers chose to bring in an outside expert when they felt that the schools' STEM teachers were ready to start creating their own standards-based projects for students – rather than relying solely on the Design Challenges written by the TIF4 STEM curriculum manager.

Space Center Houston – Space Exploration Educators Conference (SEEC)

In February 2016 and February 2017, the TIF4 grant supported the cost of registration for STEM master teachers (TDS team) and Cadre teachers to attend the Space Exploration Educators Conference (SEEC) at Space Center Houston (SCH). SCH is the official visitor center of NASA Johnson Space Center (JSC). Less than 30 miles from downtown Houston, JSC is the training base and home for America's astronauts and the site of Mission Control, where a talented cadre of flight controllers monitors America's human space flight. Over three days, SEEC attendees earned up to 24 hours of continuing professional education credit, received numerous cross-curriculum ideas and ready-to-implement classroom activities, and made connections with STEM leaders during valuable networking opportunities. The educators went behind the scenes of the astronaut training facilities at NASA JSC and learned about the technology and research that is furthering NASA's current and future deep space missions (Space Center Houston, 2015). In 2017, TIF4 STEM master teachers and Cadre teachers presented sessions to other SEEC attendees.

STEAM Teacher Residency (Alley Theatre, Main Street Theater)

In the 2013–2014 school year, a teaching residency program called Staging STEM was piloted in five of the TIF4 project schools by the Alley Theatre. It received such rave reviews from teacher participants that the project staff decided to expand support to each of the 20 TIF4 elementary schools. During each two-week residency, students learned core science and math content through the dramatic arts. Additionally, classroom teachers learned — via the modeling of the Alley Theatre teaching artists — how to utilize theater games and arts integration to teach hard to teach standards. Prior to each residency, the teaching artists meet with the school's entire team of teachers to determine the state curriculum standards to be addressed and to build specific curriculum. At the end of each residency, students put on a school performance and invited parents and community members to see their work. A similar program was later created for middle school grades at TIF4 project schools by the Main Street Theater, called "STEAM Works!" (see **Figure 8**).

Figure 8. STEAM Teacher Residency in Action

What STEM curriculum materials and teaching resources were available to teachers at the TIF4 project schools?

In addition to professional supports, teachers at project schools also had early access to resources for STEM instruction, assessment, and planning that were not generally available to other HISD schools.

Table 4. Resources for STEM Instruction, Assessment, and Planning, 2013—2017

Instruction and Assessment	**2013–2014**	**2014–2015**	**2015–2016**	**2016–2017**
STEM Design Challenges		*~ All documents updated annually ~*		
Grades 3 through 5	Introduced to TIF4 schools	Available to TIF4 schools	Available across HISD	Available across HISD
Grades 6 through 8	-	Introduced to TIF4 schools	Available across HISD	Available across HISD
Grades K through 2	-	-	Introduced to TIF4 schools	Available across HISD
Drone Curriculum *Grades 4 through 8*	-	-	-	Available across HISD
Grading Rubrics *Grades K through 8 Supporting district-wide initiatives around authentic assessment*	-	-	Available across HISD	Available across HISD
Code.org *Hour of Code, Crack the Code*	-	Hour of Code Dec. 2014	Crack the Code Jan. 2016	Crack the Code Dec. 2016
STEM Readiness and Planning				
STEM Standards for K-12	-	Committee convened to shape v. 1	Updated for 2015–2016	Updated for 2016–2017
Walk-Through Documents *Classroom Walk-Through School Walk-Through*	-	-	Available as Word and PDF documents	Tools digitized with Kickup through pilot
Games Robots Play *Hosting a Student Robotics Tournament*	-	-	April 2016	February 2017

STEM K–8 Design Challenges

At the very beginning of the grant period, project staff conducted thorough research on the STEM curriculum options available commercially. These commercial options were assessed on their appropriateness based in part on the criteria outlined in resources from TIF grant Technical Assistance providers Horizon Research Inc. and Westat (2014a, 2014b).

- Is the [subject-area-specific] content in the instructional materials sound, coherent, and aligned to our standards?
- Do the materials align with our vision and what is known about effective [subject-area-specific] instruction?

- What do the materials include to support the teachers who will use them?
- How do the materials address student diversity and differentiated instruction?
- Is there existing evidence of effectiveness?

Through the master teacher's research, it soon became apparent that many vendors were only offering a rebranded version of their previous science or math content, repackaged as "STEM curriculum" and retrofitted to align to state and district standards. Rather than spending TIF4 resources on curricular content that did not precisely meet district needs, project staff chose to create the district's central STEM curriculum in-house – ensuring quality content aligned to standards at every step.

During the grant period, the TIF4 STEM Curriculum Manager created over 40 STEM project-based learning experiences for classroom use, referred to as Design Challenges. These Design Challenges addressed the specific math and science standards where the TIF4 project schools demonstrated the least mastery on the 2014 State of Texas Assessments of Academic Readiness (STAAR) exams. These were written to complement, reinforce, and overlay the district's scope and sequence documents for math and science in each grade level. When scope and sequence timelines changed, as happened each year, the Curriculum Manager adapted the content across the content areas to ensure constant alignment to standards, and created new STEM Design Challenges as needed (see Cycles 1, 2, and 3 for Fall 2017 in **Appendix F**).

The tasks aligned to state math and science standards, as well as Career and College Readiness Standards (CCRS), and English Language Proficiency Standards (ELPS). Design Challenges were presented in an engineering design context. All included differentiation and extension strategies for diverse learners, as well as multiple formative assessments that could be completed at the conclusion of each stage of the engineering design cycle. Grading rubrics, supply lists, and all necessary handouts to implement these hands-on projects were also included.

Project staff also took an important step to protect the availability of the Design Challenges for HISD students after the conclusion of the grant period. To ensure that outside entities could not legally repackage them for commercial sale, the STEM Design Challenges were licensed under Creative Commons (CC BY-NC-SA 4.0). While protecting HISD's intellectual property and financial interests, this strategy also anticipated the new regulation on educational materials supported by competitive grant funds from the U.S. Department of Education (Open Licensing Requirement for Competitive Grant Programs, 2017).

During the 2014–2015 school year, select teachers from TIF4 project schools began implementing STEM lessons in their classrooms. In 2015–2016, select kindergarten, first, and second grade teachers began piloting STEM Design Challenges as well; these were then available across the district for 2016–2017.

HISD Drone Curriculum

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot aboard. In the 2016–2017 school year, the TIF4 STEM Curriculum Manager launched the released of drone curriculum suitable for students in kindergarten through eighth grade. In each task, students are guided through learning how to use a drone; the curriculum was written for use with Parrot® products, but can be adapted for other product lines. With the drone curriculum, students were encouraged to experiment with and use drone technology as a tool for academic learning. Tasks could be completed by students working alone, with a partner, or as part of a small group at a work station or learning center. The tasks also served to extend the learning of those students that need to be challenged.

Twenty (20) work station or small group tasks were created to be completed at students' own pacing, and with little to no teacher intervention. These lessons were not intended as a replacement for direct instruction; rather, the teacher remained an important initiator of the student's learning. In this curriculum, tasks are arranged in increasing complexity so that students, regardless of their grade level, can continue along the continuum of learning at their own pace. The first 19 tasks align to technology, math, and science standards directly. The final task challenges students to take all of the skills they have learned and to weave them into a project-based learning activity of their choice that could align to any academic subject that they might propose to do. This final capstone project allows students the freedom to exercise judgment over their final project choice and ownership of their academic learning.

Code.org – Hour of Code, and Crack the Code

Code.org® is a non-profit dedicated to expanding access to computer science in schools and increasing participation by women and underrepresented minorities (Code.org, 2014) – goals that dovetail neatly with the TIF4 goals for STEM in HISD. All of the TIF4 project schools participated in a national Hour of Code event in December 2014. In December 2015, HISD and Code.org formally entered a partnership agreement to bring their Creative Commons curriculum, professional learning courses, and open source technology into specific schools; several of the first schools to volunteer were TIF4 project schools.

Building on the Code.org work that the project school teachers were implementing, in Year Four, the TIF4 STEM project staff held HISD's first invitational coding competition ("Crack the Code") for 200 students at Southmayd Elementary. In Year Five, the team held two simultaneous events at separate schools, in order to accommodate more of the many HISD schools that had demonstrated interest in participating.

Figure 9. The TIF4 STEM Curriculum Manager was interviewed on HISD media about Hour of Code. "Logic, creativity, problem solving – these foundational skills form the backbone of computer science." (HISD Communications, 2014)

HISD STEM Grading Rubrics

Initially, grading STEM projects was difficult. The common grading systems for science and mathematics (letter grades, scoring bandwidths) do not reflect the 21st Century Skills in learning and innovation skills – critical thinking, communication, collaboration, and creativity. Consequently, STEM teachers were reporting difficulty in translating their students' learning into grade marks on a traditional scoring line.

Starting in 2015–2016, grading rubrics were created to provide teachers with summative assessment tools for STEM projects such as the Design Challenges (rubrics for grades K–2, 3–5, and 6–8). The rubrics assess students' 21st Century Skills use throughout the design process and provide teachers with a final, numerical grade for projects – defining how the evidence should map onto a traditional letter grade. Use of this resource also reflected the district's increasing emphasis on authentic assessment of student learning as a complement to standardized, multiple-choice assessments.

STEM Standards and Corresponding Walk-Through Documents

As the result of a collaborative effort between several departments, STEM standards were created to help schools develop a cohesive STEM program. The standards connect the work of HISD's STEM schools to university, industry, and community-based partners. The HISD standards fall into five categories: (1) Mission and Vision, (2) Culture and Design, (3) Teaching and Learning, (4) Professional Development, and (5) STEM Alliances. Each of these categories encompasses multiple aspects of a school's STEM implementation. Corresponding STEM Walk-Through documents, aligned to the standards, were created for school leaders, teacher development specialists, coaches, and teachers to use for reflection and self-assessment purposes. One document was intended for administrators to evaluate campus-wide STEM programs, while the other document was intended for teachers to use to plan or evaluate their own STEM classroom instruction. These documents — the STEM Standards, administrator Walk-Through guide, and teacher Walk-Through guide — were each updated annually. In the 2016–2017 school year, these tools were digitized through a partnership with education technology provider KICKUP.

Games Robots Play (GRP)

Unlike other tournaments for robotics students, Games Robots Play (GRP) is designed not as a competition, but as a three-hour event for school-based teams to practice and reinforce their computer coding and robotics skills in a friendly, collegial event. Teams build robots to do small tasks ("games") within a short window of time. Because the full parameters of the games are not announced until the event begins, students experience ill-defined scenarios, and must think on their feet, apply their knowledge, and work with their peers to finish the tasks without adult assistance.

At the April 2016 and February 2017 GRP events, students played right next to teams of TIF4 STEM cadre teachers — eager to learn and experiment right alongside their students. Each Games Robots Play event was completely designed and facilitated by students from career and technical education (CTE) classes at HISD's Waltrip High School. These high school students designed and built the games and served as scorers and mentors on the day of the challenge, as younger student participants worked to play the games using the autonomous robotic platform of their choice. Each of the robot games focused on a different superhero and challenged students in engineering, programming, and critical-thinking skills.

The first GRP tournament (in April 2016) was open only to the TIF4 project schools. The following year, the event was opened to TIF4 schools (priority registration) and other HISD schools on a space-available basis. Over 300 students and teachers from 31 HISD schools participated in "Engineering is my Superpower" — Games Robots Play 2017 at HISD's Waltrip High School (HISD Communications, 2017).

Figures 10–13: Elementary students from TIF4 schools work on their robots — coding, assembling, testing, and making adjustments. Figure 14: A STEM teacher from Blackshear Elementary assesses her team's work at Games Robots Play (February, 2017).

Figures 15–17: Middle and elementary school students from TIF4 schools work on their robots. Figure 18: Three STEM Teacher Development Specialists collaborate on next steps as students and teachers huddle in teams at Games Robots Play, at Waltrip High School in HISD. This event was completely designed and facilitated by students from CTE classes at Waltrip. (Photo credits, Figs. 10–18: Rebecca Witherspoon)

What STEM instructional materials were purchased for the TIF4 project schools?

In addition to professional supports, teachers at project schools also had access to STEM teaching materials not accessible to other HISD schools. These materials were chosen based on how well they met the changing needs of the TIF4 project schools within the following categories identified by the TIF4 Curriculum Manager (Provencher, 2016) — Engineering / Project-Based Learning; Robotics, Coding, and Aerial Technology; Science and Mathematics; STEM Reading, and; Makerspaces / 3D Printing. Within each category, items are listed in alphabetical order by product name; the vendor is listed in parentheses.

Engineering and Project-Based Learning

Engineering is Elementary (Museum of Science Boston)

Description: Developed by the Museum of Science, Boston, Engineering is Elementary (EiE) materials are project-based learning units designed to be taught in conjunction with corresponding science topics. The Curriculum has three components – a materials kit, a storybook to set context for the problem-solving activity, and a teacher guide containing lesson plans, suggestions for English language learner (ELL) differentiation, and grade level adaptation. EiE units do not explicitly teach science content, so HISD teachers must still use the district's adopted materials to teach science concepts. Rather, these units reference, review, and provide a means for students to apply their science and math knowledge as they complete EiE engineering design challenges. Therefore, EiE units fit well as part of the Elaboration stage of the lesson cycle. EiE was evaluated by STEMworks as "Accomplished" for meeting Design Principles for Effective STEM Philanthropy (WestEd, 2014).

Deliverables: In 2014–2015, three units of EIE curriculum were purchased for each elementary school — Earth/Space Science (1), Life Science (1), and Physical Science (1). In 2016–2017, additional units were purchased to meet the needs of specific elementary schools.

STEM in Action Kits (hand2mind)

Description: Developed in partnership with Purdue University and Texas A&M University, STEM in Action® is a supplemental, module-based curriculum for grades Pre-K through 5. Modules follow the engineering design process. STEM in Action meets national and state science standards and an emphasis on engineering as well as hands-on, problem-based learning. Each module also integrates science, math, and literacy practices and standards. STEM in Action was evaluated by STEMworks as "Accomplished" for meeting Design Principles for Effective STEM Philanthropy (WestEd, 2017).

Deliverables: In 2014–2015, project staff purchased STEM in Action kits for each pre-kindergarten, kindergarten, first, and second grade classroom. That year, the kits for third, fourth, and fifth grade were pilot tested at the six STEM Lab project schools.

Coding, Robotics, and Aerial Technology

Scratch and Scratch Junior (The Logo Foundation)

Description: A free educational programming language developed by the Massachusetts Institute of Technology Media Lab, Scratch was designed to be fun, educational, and easy to learn for both teachers and students. Block-based coding was introduced to teachers and their students via two programs (Scratch, and Scratch Junior). These programs allow students to use and manipulate computer code to reinforce their understanding of math, science, and technology concepts to create projects and demonstrate their learning in creative ways.

Deliverables: Staff members from The Logo Foundation delivered workshops in 2013–2014, 2014–2015, and 2015–2016. For grades 3–8, teachers were given teacher accounts and training on how to use coding in the classroom.

Simple Machines, WeDo, Lego™ MINDSTORM/EV3 Robotics (Lego, Robomatter, Girls, Inc.)

Description: These cross-curricular kits from Lego™ aided educators in creating engaging learning experiences in science, literacy, math, and social studies. Teachers were able to create lessons supporting critical thinking, problem solving, and creativity using the hardware and software in combination with the

learning activities available. Elementary level teachers received WeDo and Simple Machines materials. Secondary teachers received Mindstorms – programmable robotics construction set that enables students to build, program and control custom-built robots.

Deliverables: In 2013–2014, project staff purchased Lego materials to support each school's grade levels: grades K–2 (Simple Machines), grades 3–5 (WeDo and WeDo extensions), and grades 6–8 (MINDSTORM kits utilizing the EV3 software). As their robotics programs expanded, additional robotics units were purchased to meet the needs of specific schools. Similarly, in 2015–2016, project staff purchased more advanced EV3 curriculum (Robomatter) for the five TIF4 project schools serving grades 6–8. In 2016–2017, four elementary school leaders requested grant support for STEM programming specifically for their female students. Responding to these specific needs, the STEM Curriculum Manager researched the local options for high-quality after-school STEM programming, and brought in the Girls Inc. of Greater Houston to deliver their "Operation SMART" Robotics Program (Girls Inc., 2017).

Unmanned Aircraft Parrot Drones (B&H Photo, Amazon.com)

Description: STEM Cadre teachers had been persistently asking to use drones in their teaching since the beginning of the grant period, but it was not until September 2015 that the Federal Aviation Administration (FAA) released guidance to state education agencies on the potential use of unmanned aircraft systems (UAS) or drones by school districts and charters at school-related activities (Texas Education Agency, 2015). Only after that guidance was issued could HISD's STEM master teachers confidently move ahead with using drones in the classroom. Students could use the drones to solve math, science, and other tasks, as well as practice the coding to control them.

Deliverables: Parrot drones were purchased in 2016–2017 for the TIF4 project schools that elected to use the drone curriculum written by the TIF4 STEM Curriculum Manager.

Supplemental Science and Mathematics Content

Gizmos, and STEMScopes (Lazel, Accelerate Learning)

Description: Gizmos are interactive online math and science simulations, aligned to the state standards for both math and science. STEMScopes is an online science curriculum program that provides hands-on inquiry activities, assessments, problem-based-learning, intervention tools, acceleration materials, and teacher support resources. Materials are 100% aligned to the Texas Essential Knowledge and Skills (TEKS) for math and science, and are designed to meet the rigor and depth of the state assessments. The STEMScopes materials are available in Spanish and contain suggestions and activities for differentiated instruction, including intervention and acceleration. Both STEMScopes and Gizmos are supplements to – not replacements for – the existing district-adopted curriculum for math and science.

Deliverables: The TIF4 grant supported the annual purchase of STEMScopes licenses for online content (one 12-month license per student, grades K-8). Curriculum kits aligned to STEMScopes Version 1.0 were purchased in 2013–2014 for elementary grades. Since STEMScopes kits were not available for secondary grades in 2013–2014, project staff purchased kits from Carolina Biological to meet this classroom need. STEMScopes kits aligned to Version 2.0 were purchased for secondary grades in 2014–2015. The TIF4 grant also supported the annual purchase of Gizmos licenses for math content for grades six, seven, and eight in 2014–2015, 2015–2016, and 2016–2017; the Gizmos science licenses for these grade levels were supported by a different federal grant. The vendors provided orientation trainings for teachers to become familiar with the online tools and physical teaching resources.

Origo Box of Facts and Number Cases, Singapore Math Online (Origo Education, Singapore Math)

Description: Origo Education makes supplemental materials (the Box of Facts and Number Cases), which are visual aids to assist teachers in helping students to develop number concepts and to develop mathematics thinking strategies in addition, subtraction, multiplication, and division. These visual models work as supplemental support to the Houghton Mifflin *Texas Go Math* series. The online software subscription to Singapore Math Online was pilot-tested at one school, as an alternative to the Origo products. Ultimately, the online Singapore Math product was not expanded to other schools because Origo met schools' needs better: the tangible teaching items from Origo met a developmentally appropriate mathematics goal that the wholly-online Singapore Math curriculum did not. Additionally, a yearly subscription was required for Singapore Math, whereas Origo required only a one-time purchase.

Deliverables: The Box of Facts and Number Case kits, one set per classroom, were ordered for the TIF4 project schools that requested them (2016–2017), after a successful pilot with the STEM lab schools.

STEM Reading

STEM Class Leveled Book Sets, STEM Library Supplement Sets (Booksource, National Geographic)

Description: Each TIF4 project school received class sets of leveled books for the general reader related to STEM concepts taught at each grade level. Teachers were encouraged to incorporate the use of these books across the content areas and especially as a focus of language arts instruction. These books help students learn about key math, science, technology, and engineering ideas within the context of their broader learning goals. The following year, each school library received expository texts especially for English Language Learner (ELL) students in grades 4 and 5, covering a variety of STEM content areas. These specific grade levels were targeted for support to complement the district's "Literacy By Three" initiative supporting early readers through third grade.

Figure 19. Students at a TIF4 project school enjoy their STEM library books.

Deliverables: In 2013–2014, one leveled class set per grade level (K–8) was purchased for each project school. In 2014–2015, one library supplement set (with Dewey Decimal labeling) was purchased for each elementary school's school library.

Makerspaces and 3D Printing

3D Printers, Scanners, and K–8 Engineering Curriculum (STEAMtrax/3DSystems, Teaching Systems)
Description: STEAMtrax is a curriculum that integrates 3D printing technology, engineering and CAD modeling with fundamental academic streams like science, arts, math, language, social studies, and art. STEAMtrax integrated its 3D design, printing, and scanning programs with the Cube 3D printer (2nd generation) and Sense Scanner, both from 3D Systems.

When HISD engaged STEAMtrax under contract in spring 2014, the TIF4 schools at HISD represented STEAMtrax's largest project to date. In spring 2015, STEAMtrax was acquired by the industry leader in 3D printing, 3D Systems, to be their education unit; they were then sold to Polar 3D in April 2016 (Zacks Equity Research, 2016). In December 2015, 3D Systems announced that it was discontinuing production of the Cube® 3D printer. During this transition, STEAMtrax rewrote their curriculum to support additional 3D printers instead of working only with the (discontinued) Cube® printers.

Deliverables: For the 2014–2015 school year, each TIF4 project school received two 3D printers, a 3D scanner, filament, a site license for the Cube software, and one year of online curriculum modules for students in grades 4–8 (later extended through the 2015–2016 year). The grant also supported STEAMtrax classroom lesson kits for the project schools based on their grade levels served: "Creating Crab Coverings" and "Making Morse Messages" for grades 3–5, and "Fabricating Football Helmets" and "Synthesize a Solar Leaf Model" for grades 6–8. The vendor also provided orientation trainings for teachers to become familiar with the online tools and physical teaching resources.

In the 2016–2017 school year, 14 schools indicated that they would like to continue their 3D printing and CAD modeling in the classroom, but their 2014 Cube® printers had reached their point of planned obsolescence. The grant supported a Makerbot Replicator Mini Plus for each of these schools, plus filament, an additional extruder, and an extended service warranty period.

BeeBot and Makey Makey (Terrapin, Lakeshore Learning, JoyLabz, Barnes & Noble)
Description: A BeeBot is a small, bee-shaped acrylic robot designed for use by young children – a tool for teaching sequencing, estimation, and problem-solving to early elementary students. Directional keys are used to enter up to 40 commands, so that children can enter creative and complex command sequences. A Makey Makey is an electronic invention tool and toy that allows users to connect everyday objects to computer programs. Using a circuit board, alligator clips, and a USB cable, the toy uses closed loop electrical signals to send the computer either a keyboard stroke or mouse click signal. This function allows the Makey Makey to work with any computer program or webpage since all computer programs and webpages take keyboard and mouse click inputs. These were piloted at the six STEM Lab schools in 2014–

2015; students and teachers loved these simple electronic invention kits especially for young users to test and reinforce concepts about conductivity and electricity. Based on this positive feedback, they were rolled out to the other TIF4 elementary campuses in 2016–2017. Notably, although BeeBots were intended specifically for the youngest learners, teachers found it easy to scale their use all the way up to the 5th grade with appropriate lesson adaptations.

Deliverables: Class sets of BeeBots, plus teacher curriculum and materials to go with them, were first ordered for the six TIF4 lab schools (2014–2015) and then for the elementary project schools that requested them (2016–2017). Makey Makeys for classroom use (sets of six) were ordered for each school that requested them (2016–2017). Thanks to the simplicity of the technology and ease of implementation, teacher training was led by the STEM Teacher Development Specialist team.

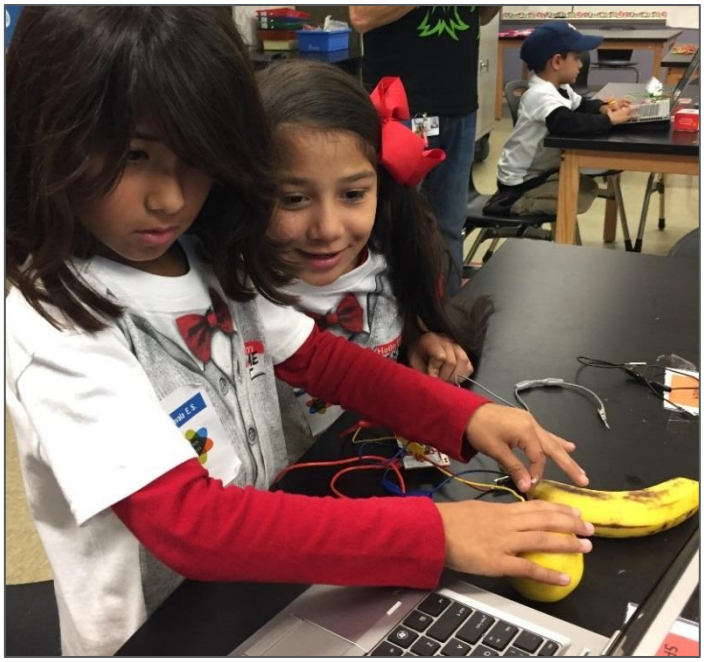


Figure 20. Students from Herrera Elementary use Makey Makeys to take on coding and circuits at "Crack The Code", December 2016. (Photo: Sabrina Provencher)

Cubelets, littleBits, and other Makerspace products (Follet School Solutions)

Description: Makerspaces continue to gain momentum in the K–12 library world to encourage students' inquiry, and to foster inventiveness and exploration through hands-on production. To this end, TIF4 project staff purchased Follett Makerspace bundles for schools that requested them. The age-level specific bundles are individually tailored for elementary and middle grades, and are composed of a variety of diverse materials, including books, building supplies, and specialized robotic kits.

Deliverables: Grade-appropriate Makerspace bundles were ordered for the TIF4 project schools that requested them (2016–2017). HISD's Library Services department also delivered a workshop on Makerspaces at the August 2016 STEM Summer Institute.

What lessons did HISD learn during the adoption of STEM instructional materials and supports provided by vendors and partners?

As a complex project with many components, the TIF4 grant supported program activities that reached students, teachers, and school-wide systems. Through these activities, TIF4 project staff learned many lessons — about working with vendors and partner entities as an early adopter of a new curricular strategy, about building internal district capacity as a sustainability strategy, and about navigating state and federal regulations.

1. Vendors do not always meet the most critical deadline for product availability: the start of the new school year. Rollout delays or mid-year content changes both dampen implementation efforts.

- In summer 2013, TIF4 STEM staff spent significant resources on kits to accompany a vendor's online curriculum for grades 3–5. These kits were not delivered to the schools until the end of the first semester

(December 2013). This delay was caused because the vendor did not have the capacity to fill an order of that size, and ultimately had to outsource the project to another vendor.

- In summer 2014, the TIF4 STEM staff ordered curriculum kits to support a vendor's online curriculum for grades 6–8. Those kits were delivered several weeks after the start of classes.
- In 2014–2015, a vendor completely overhauled their online curriculum – both the content and the user platform. However, their new product (called "Version 2.0") was not rolled out until October. This did not align with the schools' needs: the Version 1.0 content was no longer available to teachers, so the lesson plans and careful sequencing prepared the previous year were suddenly obsolete. The time-consuming task of "rostering" student users had to be repeated; and teachers and students alike had to spend time learning a new user interface instead of focusing on STEM content.
- In the middle of the 2014–2015 school year, a vendor transitioned their product from an after-school model to an in-school model. This required some flexibility on the part of teachers and STEM staff to re-structure the sequencing and presentation of content, but did not involve major changes in the content itself. Once the transition was completed, the in-class setup resulted in more student exposure to robotics — which was an unexpected benefit.
- At one point, a vendor's "pilot" deliverables for digital content were so far behind schedule that the TIF4 staff engaged the vendor's representative in dispute resolution until the product (online curriculum) was fully delivered.

2. The vendor may exaggerate their capacity to meet expectations, or may not be clear that what you are buying has not yet been created, or will soon enter planned obsolescence.

- While they may be able to handle individual schools and small districts, newly established vendors may not be sufficiently prepared to serve a district of HISD's size. This includes being prepared to implement universal best practices for online curriculum platforms such as single-sign-on ("thin cartridge") to support school- and class-level rostering by integrating with existing SIS frameworks. The administrative burdens (e.g., uploading rosters 'manually') created a process bottleneck, which depressed end user engagement for students and teachers. Additionally, some vendors of online content did not provide sufficient support for the technical problems that campus-level staff were encountering; this then required the TIF4 STEM project staff to spend time on system-administrative tasks rather than on writing lessons, or job-embedded coaching.
- Vendors can be bold about selling expensive products designed for planned obsolescence, or with limited useful service periods.
    - Instructional equipment, such as 3D printers, will not hold up to multiple years of hard use in a classroom setting. The warranties on these items may cover as little as 90 days of support.
    - Instructional kits purchased for 2013–2014 were made obsolete just nine months later with the release of Version 2.0 of a vendor's online curriculum. The vendor did not disclose to TIF4 STEM staff in summer 2013 that these kits would soon be made obsolete by the new curriculum – a fact that was known by the vendor at the time.
    - One vendor decided to wipe all of the previous year's student data in the transition between each academic year. This made it impossible to track student progress across grade levels, or between teachers or schools. This was contrary to the longitudinal tracking that had been communicated to HISD teachers and instructional staff. The outcome, not surprisingly, was a loss of credibility, and a reduced rate of teacher and student usage for the product.
- Vendors can be bold about selling a product that they have not yet fully developed. Even in the "pilot" phase, there are certain expectations on HISD's part about the form, timeframe, and quality of content used in the STEM classroom.

3. Exercise skepticism about "evidence" provided by the vendor.

- One vendor provided HISD decision makers with published findings on the effects of their curriculum intervention product, without disclosing the authors' product-related financial conflicts of interest.
- One vendor made repeated claims about their program's effect on student outcomes (STAAR scores and classroom behavior) that were not supported by evidence gathered through rigorous program evaluation. These claims were used on the vendor's website, and in marketing materials received by other HISD schools.
- Two vendors employed insufficient quantitative strategies to support the causal relationships they reported on their product's impact on HISD's outcomes.

4. STEM advocacy includes educating district procurement, finance, and asset management teams.

- At the beginning of the grant period, the district itself had no definition for STEM education, and there was as yet no district-wide directive to promote STEM education. Since it was not a stated district-wide priority, HISD purchasing managers could not make it a high priority to seek new vendors for instructional materials supporting technology and engineering. Consequently, the TIF4 project staff had difficulty contracting with vendors that could not be clearly defined as science or mathematics.
- It took until 2015 to create new, appropriate processes for purchasing STEM items – by reassigning what had been previously considered "sole source" products into multiple, new, and more generalized product categories, and by generally educating the district's procurement and financial management teams about the ways in which STEM educational materials need to be handled as core content. This delayed several major purchases until later in the project period.
- Until changes were implemented in product categories, STEM content strategies did not fit the default assumptions built into the budgeting, procurement, and asset management systems:
    - A 3D printer for use in an elementary classroom is not a "printer" in the traditional sense, yet with no specific product categories for "engineering" or "STEM", the 3D printers at the TIF4 schools were considered part of the district's spending on printing assets.
    - With no product category available for the purchase of "drones" or "aerial technology," the only way to purchase drones for the STEM classrooms was to procure them as if they were "photography equipment accessories."

5. Early adopters have a limited market for developmentally appropriate, high-quality instructional materials.

- The field of STEM curricular supports for young children was relatively sparse in 2013, with only a few high-quality vendors. This limited competitiveness affected how HISD purchasing managers were able to prioritize a bid project for elementary STEM instructional materials and supports.
- HISD would have preferred to purchase 3D printers with much longer service periods under warranty than the 90 days provided by the vendor chosen. However, the STEM curriculum manager's research showed that the options were quite limited: there were very few 3D printers available that met safety standards for use by children in grade school; the extruders on some 3D printers attain such high temperatures that they were not considered appropriate for use by young students.
- When it came time to choose an outside expert to present PBL workshops to the teachers at the TIF4 project schools, two strong candidates were identified above the appropriate quality threshold ("A" and "B"). All else equal, the Master Teachers would have preferred to bring in A – given the strength of their model, their relatively local availability, and shared constraints around standards and assessment. However, B received the project because A was not prepared to provide training specific to teachers of elementary grade levels.

6. Your staff will outgrow your outside experts and trainers. Start sustainability conversations early.

- In the first years of implementation, the HISD STEM team was not yet sufficiently comfortable with training their teachers in computer science. Consequently, the availability of an outside subject-area expert was invaluable to build the master teachers' skills. However, as the STEM team developed their command of the Scratch programming environment and acquired experience coaching their teachers on using Scratch in the classroom, it became unnecessary to bring in the consultant. HISD's internal capacity was more than sufficient to deliver high-quality trainings and provide ongoing support.
- When the project budget was written in 2012, HISD anticipated using outside experts to deliver science, mathematics, and STEM trainings through the end of the grant period. In summer 2016, HISD's curriculum staff piloted the delivery of high-quality, content-specific workshops to elementary and secondary math and science teachers across the district. By 2017, HISD staff were ready to go to scale and provide these trainings in-house.
    - This shift required some flexibility from the TIF program officers at the US Department of Education. HISD grant staff requested – and received – a budget amendment to move funds out of the contracted services line, in order to support the change in HISD's strategy for providing teachers with high-quality professional development in math and science.
    - This flexibility allowed HISD to build a program that could be sustained after the end of the grant period.

7. Take chances and pilot new content strategies – give feedback to vendors, and educate decision-makers.

During the grant period, STEM teachers at TIF4 project schools worked with many different instructional materials and saw content from many different curriculum providers. The feedback that they and the STEM TDSs provided each year was invaluable for the Curriculum Manager in making purchasing decisions to meet the unique needs of each TIF4 project campus.

- Sometimes this feedback was provided to vendors, so they could make adjustments for future programming. For example: collaborating with arts providers to incorporate multi-sensory teaching approaches can provide students with multiple entry points into the content. Since artists and teachers come at the objective (student learning) from different perspectives, these can complement each other well. However, coordinating these perspectives requires significant time and a lot of structure to align the work. The STEM master teachers worked closely with the STEAM Teacher Residency providers to pilot the program at a small number of TIF4 project schools before the program was opened to the other TIF4 schools. The narrow focus in the first year allowed for the arts providers to receive significant initial hands-on direction from central office staff, which was critical to ensuring the alignment of goals. Since HISD's TIF-supported pilot in 2013–2014, one specific arts provider has expanded their STEAM program from five TIF4 schools to reach over 130 schools across the Houston metro area.
- By Year Three of the grant period (2014–2015), six of the TIF4 project schools dedicated classroom space and a teacher's salary to a STEM Lab. On occasion, the STEM Lab teachers at these six schools received instructional materials that others did not – with the explicit purpose of pilot testing them in a classroom before deciding to make a project-wide investment. The lab school teachers' feedback was used internally to inform the STEM curriculum manager's decisions about upcoming materials for other TIF4 schools. For example, the expansion of robotics programming at the TIF4 campuses in Years Four and Five came after pilot testing the products and strategies in the lab schools in Year Three. In turn, product-specific feedback from the TIF4 teachers to the STEM curriculum manager was used to inform purchasing decisions for the district as a whole:
    - One specific provider of online content was especially well-received by teachers and TIF4 STEM staff at the TIF4 project schools; based on their use and recommendation, the district purchased the vendor's science content for the other forty schools in the district reaching those grade levels.

- One specific line of supplemental mathematics teaching materials was so well-regarded by the mathematics teachers at the TIF4 schools – and by the STEM master teachers – that the STEM curriculum manager connected the company sales representative with the central office's leadership over elementary mathematics. On the strength of the TIF4 schools' experience with these materials, the elementary mathematics TDSs moved forward to formalize this relationship – building upon what was done at the TIF4 schools by suggesting the product to other struggling campuses, supporting implementation, and providing training for the whole district. The district's curriculum leadership also brought this vendor to the RFP process, so any HISD school can purchase these valuable supplemental resources in the future.

8. State and federal regulations can affect your STEM project in surprising ways

During the project period, two changes in state and federal regulations affected the TIF4 STEM project: getting ready for "new EDGAR," and a new USDE regulation regarding open licensing.

New EDGAR and STEM Instructional Materials

In 2014, the federal government issued new regulations that affected the spending of grants and funds from the U.S. Department of Education. These new regulations stipulate that if $1 of federal money is spent on a contract it triggers the new Education Department General Administrative Regulations (EDGAR) requirements for HISD to comply with the most restrictive rule (HISD Procurement, 2016).

- Under HISD's interpretation of the Texas Education Code governing purchasing and contracts (EDUC § 44.031), any purchase within a product category where annual district-wide spending exceeds $50,000 must be awarded through a competitive process such as a request for proposal (RFP).
- At the time of implementation (2015–2016), HISD's $1.8 billion dollar annual budget made it extremely rare that any single purchase or contract would not be subject to the "$50,000 per category per year, district-wide" threshold requiring a competitive process.
- Consequently, in fall 2015 HISD's new Officer for Procurement paused all spending within specific product categories, in order to incorporate the newly restrictive requirements into RFPs in early 2016. This spending pause affected all of the categories that encompassed STEM instructional materials.
- This directive affected the Year Four budget for the TIF4 grant, as project staff could not spend the funds budgeted for STEM instructional materials. After much consideration, the HISD project staff requested – and received – a budget amendment to use those unspent funds to extend the contracts of the STEM Teacher Development Specialists through the end of Year Five. This shift of strategy — from STEM instructional materials to STEM professional supports — required flexibility from the TIF program officers at the U.S. Department of Education.

Open Licensing, Intellectual Property, and Work for Hire

During the five-year grant period, multiple vendors and partner agencies created copyrightable intellectual property (IP) thanks to the sole support of the TIF4 grant.

- In June 2014, the USDE's Office of Education Technology (OET) published online the Open Licensing Requirement for Competitive Grant Programs, a proposed new regulation "to require that all Department grantees awarded direct competitive grant funds openly license to the public all copyrightable intellectual property created with Department grant funds" (OET, 2014).
- For nearly 18 months, it was not entirely clear whether this regulation – if implemented – would affect the TIF4 grant, or only new projects. It would no longer be acceptable to use certain kinds of federal money to support the development and piloting of copyrightable materials where the vendor would be entitled to use the materials for commercial purposes after the conclusion of the contract with HISD.

By the time it was clear that the TIF4 work would not be affected (USDE, 2015), the TIF4 project staff had already initiated proactive conversations about intellectual property created through the TIF4 grant. Within HISD, the decision was made to license the STEM Design Challenges under a Creative Commons (CC) Attribution-NonCommercial-ShareAlike 4.0 International License, or CC BY-NC-SA 4.0.

- The STEM Curriculum Manager and STEM TDSs felt that this license best represented the creative and generous spirit in which the lessons had been written; they wanted to ensure that the content would always remain free to students and teachers.
- This license lets others remix, tweak, and build upon the STEM master teachers' work non-commercially, as long as they credit the original writer(s) and license their new creations under the identical terms (Creative Commons, 2013). All Design Challenges carried the CC information from that point onward.

Conclusion

Supporting the federal priority to improve STEM education, the fourth cohort of the Teacher Incentive Fund grant competition (TIF4) included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education. In HISD, the TIF grant supported program activities that reached students, teachers, and school-wide systems.

For students, TIF4 empowered teachers to bring cross-curricular instructional materials to their students. Project staff made carefully researched investments across five categories of STEM instructional materials: engineering, robotics and coding, science and mathematics, STEM literacy, and makerspaces. Through the STEM Design Challenges, students experienced project-based learning aimed squarely at the science and math standards that had represented the biggest challenge to their schools in previous years. Through high-quality curriculum supplements and STEM instructional materials, students from early elementary to Algebra I were going beyond the district and state adoptions, going broader and deeper than the tested standards. Through this grant, students at TIF4 project schools were not encountering content areas as disconnected subject area silos — rather, the tools of technology and engineering were being used to facilitate cross-curricular thinking for science, math, and literacy.

The TIF4 grant allowed HISD to provide a different experience for STEM teachers as well as their students. Master teachers with expertise in teaching STEM content (STEM Teacher Development Specialists) coached teachers across all complex facets of instructional practice on site at the project schools. These TDSs made sure that STEM teachers at project schools had the professional resources necessary to focus on classroom instruction, and to develop their practice of integrative STEM pedagogy. TIF4 funds enabled HISD to pay retention bonuses to those STEM teachers with qualifying metrics upon returning to their project school for another year of instruction. STEM teachers at TIF4 schools had priority access to professional development opportunities in specialized content-area and pedagogy, including the experience of professional learning within a community (the "STEM Cadre").

Through these activities, HISD staff learned many lessons — about working with vendors and partner entities as an early adopter of a new curricular strategy, about building internal district capacity as a sustainability strategy, and about navigating state and federal regulations. The lessons learned from HISD's human capital approach to strengthening STEM education hold value for other American school districts working with similar student groups and navigating similar challenges for STEM teacher recruitment,

development, and retention. This descriptive overview of activities and interventions unique to the TIF4 project schools has set the context for a meaningful discussion of programmatic impact. As a complex project with many components, the TIF4 grant supported teachers' effective STEM instruction, and student learning in math and science. Additional reports in this series will investigate specific outcomes of interest, including: how student outcomes for science and math at project schools compare to outcomes at similar schools not participating in TIF4, teachers' readiness (self-efficacy) for STEM instruction, and human capital outcomes for science and math teachers at project schools.

Houston Chronicle: "Community support can boost schools' STEM efforts"

"…Urban cities, including Houston, lack necessary resources needed to assist teachers in preparing students for the jobs of the future, including those in STEM fields.

"Consider that public school teachers spent an average of $485 of their own money last year to pay for needed supplies and materials. Personal efforts like these on the part of dedicated teachers will never holistically solve the problem or adequately equip Houston classrooms and students with the means necessary to cultivate the culture of creativity, advanced learning and innovation needed to ensure Houston continues to thrive.

"… We can ensure that the right resources - those that foster creativity and innovative ideas in our classrooms - are accessible to all of Houston's children. Better-prepared students not only contribute to a sustainable work force, but are well-positioned to lead it.

Ultimately, they add strength to Houston's thriving economy and serve as our community's ultimate return on investment."
HISD Chief Academic Officer Dan Gohl (January 22, 2015)

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Appendix A: Teacher Incentive Fund

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education (the Department) has supported human capital strategies for teachers and school leaders, "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science and math. While the specific programming supported through the TIF grant program has evolved since 2006 (Miller et al., 2015), TIF projects are supported by the Department to develop and implement sustainable performance-based compensation systems (PBCSs) for teachers, principals, and other personnel in high-need schools in order to increase educator effectiveness and student achievement. HISD was awarded over $43 million as part of the first and third cohorts of TIF grantees – $11.8 million in 2006, and $31.3 million in 2010. A recap of these program activities is available on HISD's website (Price & Stevens, 2017).

In September 2012, HISD was awarded a TIF grant for $15.9 million over five years (OESE, 2012b) — one of just six STEM projects funded among the fourth cohort of awards (TIF4-STEM): HISD, plus Calcasieu Parish (LA), National Institute for Excellence in Teaching (IA), Orange County (FL), Washoe County (NV), and the South Carolina Department of Education.

These grantees committed to the two Absolute Priorities required of all TIF grantees, as well as a third Priority that was specific to STEM programming:

- **Priority 1 (all grantees):** "An LEA-wide human capital management system (HCMS) with educator evaluation systems at the center that (a) is aligned with the local education agency's (LEA's) vision of instructional improvement and (b) uses information generated by the evaluation system to inform key human capital decisions, such as recruitment, hiring, placement, dismissal, compensation, professional development, tenure, and promotion."
- **Priority 2 (all grantees):** "An LEA-wide educator evaluation system based, in significant part, on student growth. The frequency of evaluation must be at least annually and the evaluation rubric should include at least three performance levels and (a) two or more observations during each evaluation period, (b) student growth for the evaluation of teachers at the classroom level, and (c) additional factors determined by the LEA. In addition, the evaluation system must generate an overall evaluation rating based, in significant part, on student growth and the evaluation system must be implemented within the timeframe specified in Priority 2."
- **Priority 3 (STEM grantees):** "Improving STEM achievement by developing a corps of skilled STEM master teachers by providing additional compensation to teachers who (a) receive an overall evaluation effectiveness rating of effective or higher under the evaluation system, (b) are selected based on criteria that are predictive of the ability to lead other teachers, (c) demonstrate effectiveness in one or more STEM subjects, and (d) accept STEM-focused career ladder positions. In addressing this priority, each LEA needs to identify and develop the unique competencies that, based on evaluation information or other evidence, characterize effective STEM teachers. Projects also need to identify hard-to-staff STEM subjects and use the HCMS to attract effective teachers, leverage community support and expertise to inform the implementation of its plan, ensure that financial and non-financial incentives are adequate to attract and retain persons with strong STEM skills in high-need schools, and ensure that students have access to and participate in rigorous and engaging STEM coursework."

See http://www2.ed.gov/programs/teacherincentive/2012-374ab.pdf for the full text of the application package for TIF4 (OSEA, 2012a).

Appendix B: A Better Picture of Poverty at TIF4 Project Schools

"Leaders at every level of the school system are being challenged to think and act differently to address the effects of income inequality on academic performance. The majority of schools within Houston ISD are located in high-poverty areas, so it is important to understand which may need the most help – and what kind of help would be most useful. However, simple proxies for poverty, like the proportion of students who receive free and reduced lunch, fail to capture the volume and nature of the challenges that many Houston schools face. Inspired by the November 2014 research report, *A Better Picture of Poverty*, by the Center for New York City Affairs, we identified 23 school and neighborhood risk factors that contribute to chronic absenteeism and low student performance. When the factors are displayed using [color-coding] there emerges a very clear picture of both the kinds of and the volume of educational disadvantage associated with that location; a "heat map" of educational disadvantage."

Excerpt, Campus Risk Load Profiles Fall 2015 (Reeves, McCarley, Mosier, & Carney, 2015)

Risk Factors for Chronic Absenteeism at the TIF4 Project Schools

Overall, the 2015 *Risk Load* report showed two things – that HISD schools are facing complex issues, but that some schools are showing success even with a heavy "risk load." The same is true of the TIF4 project schools. Figure B-1 shows the "heat map" of each school's total risk factors, chronic absenteeism, and the 22 factors associated with it. The median number of Risk Factors facing a TIF4 school is 11, compared to just 8 for the other HISD schools serving grades K–8.

The sources and definitions of these variables are found in the rest of Appendix B. The impact of these variables on the project schools' academic outcomes will be explored in greater depth in the second report of this series.

Figure B-1. 2015 Family, School, and Neighborhood Risk Factors for Chronic Absenteeism

Total Number of Risk Factors	2015 Rating	School Name	Chronic Absenteeism	Free Lunch Eligible	Students in Temp. Housing	Special Ed. Students	Black or Hispanic	ELL Students	Students Not Ident. as GT	Immigrant Students	Refugee Students	Principal Turnover	Teacher Turnover	Teacher Vacancy	Student Mobility	Student Transfers	Student Suspensions	Student Safety Issues	CPS Involvement	Child Poverty	Poverty Rate	HS Education or Below	Lack of Adult Professionals	Male Unemployment	Public Housing	Homeless Shelter
18	IR	Sugar Grove MS	-0.100	0.100	1.270	-0.566	-1.089	-1.268	-1.458	-0.758	-1.829	-2.000	-1.079	-2.000	-0.459	-2.000	-0.100	-1.169	-1.143	-0.431	-0.313	-0.308	0.568	0.696	2.000	-2.000
	MET	Fleming MS	0.420	-1.557	-1.105	-0.882	-1.907	0.629	-1.648	1.656	-0.145	-0.111	-0.210	-1.219	-0.392	-2.000	-1.605	0.100	2.000	-1.814	-2.000	-1.119	-0.607	-0.906	2.000	-2.000
17	IR	Blackshear ES	-0.567	-0.390	0.100	-0.143	-1.626	1.152	-1.160	1.793	-0.173	-2.000	-2.000	2.000	-0.748	-2.000	-2.000		2.000	-1.407	-1.428	-0.100	-1.526	-0.823	-2.000	-2.000
		Fondren MS	-0.469	0.313	0.312	-0.286	-0.308	-0.920	-1.690	0.335	-1.890	-0.111	-1.778	-0.810	-0.596	-2.000	-1.239	-0.179	2.000	-0.769	-0.568	0.201	-0.377	-0.314	2.000	-2.000
15	MET	Grissom ES	0.100	-1.467	-2.000	0.321	-1.528	-0.415	-0.573	1.186	2.000	-1.216	-1.507	2.000	0.251	-2.000	-0.100		-2.000	-0.289	-0.238	-0.490	-1.070	-0.606	2.000	2.000
		McGowen ES	0.112	-0.735	-0.657	-0.977	-1.921	1.856	-0.857	1.867	2.000	-0.100	-0.738	2.000	0.111	-2.000	-1.258		-2.000	-0.200	-0.100	-0.838	-2.000	-2.000	2.000	2.000
14	IR	Mading ES	-1.061	-0.100	-0.305	-1.534	-1.784	1.530	-1.509	1.906	2.000	-1.216	-1.138	2.000	-0.100	2.000	-1.611		2.000	-0.500	-0.143	-0.649	-2.000	-2.000	2.000	2.000
13	IR	Foster ES	-1.963	-1.592	0.709	-1.024	-1.764	1.973	-1.775	2.000	2.000	-0.100	0.515	2.000	-0.232	-2.000	-2.000		2.000	-1.054	-0.939	-0.421	-1.539	-0.668	2.000	2.000
	MET	Looscan ES	-0.460	-0.986	2.000	-1.163	-1.843	-0.237	-0.596	1.633	2.000	-0.100	-2.000	2.000	0.109	-2.000	-0.296		2.000	-1.607	-0.921	-0.956	-0.882	0.273	2.000	2.000
		Durkee ES	0.678	-0.641	2.000	-1.441	-1.685	-0.439	-0.612	1.671	2.000	-0.100	-0.151	2.000	0.361	-2.000	0.263		2.000	-1.319	-1.653	-1.726	-0.149	-0.370	2.000	2.000
		Pugh ES	0.684	-1.446	2.000	-1.116	-1.784	-0.285	-0.787	0.346	2.000	-0.100	-0.873	2.000	0.510	2.000	-0.242		2.000	-0.542	-0.407	-1.422	-0.502	-0.565	2.000	2.000
11	IR	Burrus ES	-0.100	-0.850	-0.101	0.738	-1.587	1.867	-1.266	1.630	2.000	2.000	-0.668	2.000	-0.148	2.000	0.773		2.000	-0.764	-0.802	-0.459	-0.100	-0.509	2.000	2.000
	MET	Eliot ES	0.875	-1.415	1.512	-1.395	-1.843	-0.189	-0.435	0.685	2.000	-0.100	-0.873	2.000	-0.310	-2.000	0.846		2.000	0.100	-0.167	-1.808	0.815	1.014	2.000	2.000
10	IR	Montgomery ES	-0.770	-0.349	-2.000	-0.097	-1.626	0.143	-0.647	0.499	1.383	2.000	0.284	2.000	0.317	-2.000	-0.272		2.000	0.175	0.303	-0.489	-0.478	-0.248	2.000	2.000
		Ross ES	0.739	-0.464	0.100	0.599	-1.626	1.072	-0.751	2.000	2.000	-1.216	-0.100	2.000	0.100	2.000	0.623		2.000	-0.926	-0.825	-0.985	-0.302	-0.249	2.000	2.000
	MET	Southmayd ES	0.177	-1.153	1.607	-0.375	-1.862	-0.487	0.318	1.837	2.000	-0.100	0.529	2.000	0.347	-2.000	1.765		2.000	-0.100	-0.252	-1.051	0.167	0.157	-2.000	2.000
		Herrera ES	0.703	-1.760	2.000	-0.560	-1.508	-0.424	-0.488	1.799	2.000	2.000	-0.181	-1.195	0.872	2.000	1.935		2.000	-0.201	-0.514	-1.645	0.969	1.051	2.000	2.000
		Braeburn ES	1.426	-1.728	1.091	0.182	-1.705	-1.593	-0.477	-0.966	-0.339	2.000	0.812	2.000	0.624	-2.000	0.318		2.000	-1.224	-1.151	-0.362	0.299	0.680	2.000	2.000
9	IR	Milne ES	-1.084	-1.070	2.000	-0.606	-1.390	0.831	-0.855	1.670	2.000	-0.100	-0.380	2.000	-0.197	-2.000	-1.211		2.000	0.338	0.152	0.762	0.160	0.325	2.000	2.000
	MET	Law ES	-0.234	-0.600	1.617	-0.560	-1.331	0.420	-0.392	1.921	2.000	2.000	-0.104	2.000	-0.308	-2.000	1.103		2.000	1.045	1.162	0.591	-0.100	-0.523	2.000	2.000
7	IR	Codwell ES	-1.450	-0.328	0.906	0.135	-1.725	1.856	-1.218	2.000	2.000	-0.100	0.830	2.000	0.163	2.000	-1.790		2.000	0.116	0.446	0.100	-1.060	-0.322	2.000	2.000
3	MET	Wilson Mont.	1.519	1.449	1.444	-0.100	2.000	-0.315	0.395	1.335	2.000	2.000	1.910	2.000	0.197	2.000	1.759		2.000	1.655	1.369	1.731	2.000	2.000	2.000	-2.000
1	MET	Garden Oaks M..	1.388	1.466	0.760	0.431	1.723	-0.107	0.308	1.259	2.000	2.000	0.605	2.000	0.555	2.000	1.931		2.000	1.340	1.219	0.890	1.427	1.143	2.000	2.000

White cell indicates data unavailable.

-2.000 2.000

Sorted by count of school's factors that are below HISD average (0.00). Showing bounded Z-Scores. Elementary and secondary schools not compared to each other.

Data Source Abbreviations

- ACS: American Community Survey 5 Year Estimates, 2010–2014, from the US Census Bureau (Tract Data)
- City: The City of Houston's Housing and Community Development Department.
- HRIS: Houston ISD's Human Resource Information Systems.
- PEIMS Snapshot: The Public Education Information Management System (PEIMS) encompasses all data requested and received by TEA about public education, including student demographic and academic performance, personnel, financial, and organizational information. Data from the October 31, 2014 "PEIMS Snapshot".
- TAPR: Texas Academic Performance Report (TAPR) 2014–2015.
- SIS: Student Information System, called Chancery. SIS "At Risk" Report from HISD Federal and State Compliance Department.
- YourVoice: A customer satisfaction survey conducted by HISD vendor RDA (2013, 2014, 2015). Student survey items must have a 50% response rate to be included and reported.

Student Variables

1. Free/Reduced Lunch Eligible. Percentage of school's students enrolled at the PEIMS snapshot who received free or reduced-price lunch subsidies under the Richard B. Russell National School Lunch Act, or are considered to be economically disadvantaged by the Texas Education Agency. Source: TAPR 2014–2015, from PEIMS Snapshot.

2. Black or Hispanic. Percentage of school's students enrolled at the PEIMS snapshot who are identified as belonging to one of the following groups: African American, or Hispanic. Source: TAPR 2014–2015, from PEIMS Snapshot.

3. English Language Learner (ELL). Percentage of school's students enrolled at the PEIMS snapshot identified as participating in programs for English language learners (ELL). Students are identified as ELL by the Language Proficiency Assessment Committee (LPAC). Source: TAPR 2014–2015, from PEIMS Snapshot.

4. Immigrant. Percentage of school's students enrolled at the PEIMS snapshot identified as Immigrants. Source: PEIMS Snapshot.

5. Asylee/Refugee (Secondary only). Percentage of school's students enrolled at the PEIMS snapshot whose initial enrollment in a school in the United States in grades 7 through 12 was as an unschooled asylee or refugee per Texas Education Code (TEC) Section 39.027(a-1). Source: PEIMS Snapshot.

6. Special Education. Percentage of school's students enrolled at the PEIMS snapshot identified as students with disabilities. Students are placed in special education by their school's Admission, Review, and Dismissal (ARD) committee. Source: TAPR 2014–2015, from PEIMS Snapshot.

7. Students NOT identified as Gifted/Talented: Percentage of school's students enrolled at the PEIMS snapshot who are NOT identified and served in state-approved gifted and talented programs. Source: TAPR 2014–2015, from PEIMS Snapshot.

Family Variables

8. Child Protective Services. Percentage of students removed from the school by Department of Family and Protective Services (a.k.a. Child Protective Services) during the school year. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.

9. Homeless/Housing Insecure. Percentage of school's students enrolled at the PEIMS snapshot who are qualified for at-risk status due to either being flagged as homeless or having residential placement. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.

10. Student Mobility. Percent of school's students who have been in membership at a school for less than 83% of the school year (missed six or more weeks). Source: TAPR 2014–2015.

11. Chronically Absent. Percentage of school's students enrolled at the PEIMS snapshot who missed 18 or more days of school. Source: Barbara Bush Foundation for Family Literacy, 2014–2015 Data.

12. Suspended Once or More. Percentage of school's students enrolled at the PEIMS snapshot who attend at least one day in a school who received at least one In-School Suspension or Out-of-School Suspension during the school year. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.

13. If Ss left > Ss transferred in. A binary variable (1/0) capturing whether (1) or not (0) more students left the school than joined the school throughout the year. Source: HISD Demographer in Student Support Services.

14. Student Safety Score (*Secondary only*). Percentage of student respondents who "agree" or "strongly agree" with the statement, *"Overall, I am satisfied that my school is safe and secure".* Source: YourVoice Survey.

15. Teacher Turnover, 2014 to 2015. Percentage of teachers *not* retained at the same campus from the 2013–2014 school year to the 2014–2015 school year. Source: HRIS.

16. Mid-Year Teacher Vacancies. Percentage of teaching positions vacant at the campus on December 1, 2015, as a percentage of total possible teacher population for that campus. Source: HRIS.

17. Principals (Count), 2011 to 2015. Number of unique principals at the school over the previous five years. Source: HRIS.

Neighborhood Variables

18. Children in Poverty. Percentage of school's zoned census tract residents ages 18 and younger who live in households below the federal poverty level. Source: ACS.

19. HS Grad or Less. Percentage of school's zoned census tract residents ages 25 and older who attained less than or equal to high school graduation (i.e., no additional formal education after high school). Source: ACS.

20. Neighborhood Poverty. Percentage of school's zoned census tract residents (all ages) who live in households below the federal poverty level. Source: ACS.

21. Adults in Workforce. Percentage of school's zoned census tract residents ages 16 and older who are employed in the civilian labor force. Source: ACS.

22. Unemployed Men, Age 20-64. Percentage of school's zoned census tract male residents ages 20 to 64 who are not employed. Source: ACS.

23. If Public Housing in Zone. Binary variable capturing whether (1) or not (0) a school has Public Housing zoned for attendance. Source: City.

24. If Homeless Shelter in Zone. Binary variable capturing whether (1) or not (0) a school has a homeless shelter zoned for attendance. Source: City.

Appendix C: TDS Assignments to TIF4 Project Schools

Table C-1. STEM Teacher Development Specialist Assignments to TIF4 Project Schools

Elementary Schools	2013—2014	2014—2015	2015—2016	2016—2017
Blackshear ES	F	F	N	B
Braeburn ES	E	E	A	A
Burrus ES	E	E	E	E
Codwell ES	A	K	A	A
Dodson ES *	J	-	-	-
Durkee ES	E	G	I	I
Eliot ES	I	I	O	O
Foster ES	F	F	N	N
Grissom ES	B	B	B	B
Herrera ES	I	G	G	P
Law ES	C	C	C	C
Looscan ES	G	G	G	P
Mading ES	A	K	A	A
McGowen ES **	I	E	O	O
Milne ES	B	B	B	N
Montgomery ES	C	C	C	C
Pugh ES	G	I	I	I
Ross ES	I	I	B	B
Southmayd ES	J	M	M	M
Montessori Schools				
Garden Oaks K-8	E	M	M	M
Wilson K-8	F	M	M	M
Middle Schools				
Fleming MS	D (Math) H (Science)	L (Math) H (Science)	L (Math) H (Science)	L (Math) Q (Science)
Fondren MS	D (Math) H (Science)	L (Math) H (Science)	L (Math) H (Science)	L (Math) Q (Science)
Sugar Grove MS	D (Math) H (Science)	L (Math) H (Science)	L (Math) H (Science)	L (Math) Q (Science)

* Dodson ES was closed in 2014 due to low enrollment; students were then zoned to Blackshear.
** Houston Gardens ES was renamed McGowen ES in 2014.

Note: For confidentiality, the name of each Teacher Development Specialist was masked and replaced with an alpha character.

Appendix D: 2015 STEM Summer Institute, August 3 – August 6

Menu of Workshops Offered

Herrera Elementary School - 525 Bennington St. Houston, TX 77022

Monday, August 3

EV3: Build Your First Robot! (Grades 3 - 8) *[Presented by STEM Master Teachers]*
Step into the world of robotics with this beginner's session using the Lego EV3 robotics kits, which will soon be delivered to all of the TIF4 elementary campuses. Participants will build a basic robot and program simple moves in this hands on session. Robot structures, functions, and classroom management tips, along with an introduction into the RoboMatter video training software that each TIF4 school will receive this year are included. Please bring personal headphones to the session.

String on the Math (Grades 4 – 8) *[Presented by STEM Master Teachers]*
The possibilities of geometric designs are virtually unlimited. Join us as we create geometric designs using simple multiplication and equations from a circle and a square template. Be amazed by your creation!

The Artist and the Engineer – Turning STEM into STEAM (Grades K - 8) *[STEM Master Teachers]*
What are the connections between STEM and Art? This hands-on session will provide relevant experiences that demonstrate how visual art can be integrated into STEM to make it STEAM. By immersing yourself in a fun, creative world you will learn how to take Math, Science and STEM Design Challenges to the next level by adding an artist's touch.

Blast Off with STEM (Grades 3-8) *[Presented by STEM Master Teachers]*
Tap into your student's curiosity about space by engaging in an engineering challenge to design and build a thrust structure that will withstand three rocket launches. This STEM challenge will incorporate physical science concepts and a wide variety of math skills for grades 3-8.

Let's Connect- In 140 Characters or Less (Grades K-8) *[Presented by STEM Master Teachers]*
Do you ever wonder what other schools in the TIF4 grant are doing in STEM? Learn how to use Twitter to collaborate, share, and connect with other TIF4 STEM schools. Join us for an engaging hands-on workshop. Walk out with a school Twitter account and the tools to build your own STEM Twitter Page.

Up Up & Away - Hot Air Balloons (Grades 3 - 8) *[Presented by STEM Master Teachers]*
Are you tired of the old sink/float design activities? Let us take you to the next level of experiencing density by designing your own hot air balloon. You will construct your own hot air balloon to learn about volume, buoyancy, and density using the engineering design loop.

Breaking the Code (Grades K-8) *[Presented by STEM Master Teachers]*
Participants will engage in an introduction to coding in the classroom, an integral piece of STEM education. Join us as we move through self-paced workstations that integrate coding into your instruction and increase your students' problem solving abilities.

SCRATCH 101 (Grades 3-8) *[Presented by STEM Master Teachers]*
Are you curious about coding but think you need to be a computer expert? Well, the answer in NO and this class is for you! Join us as we introduce a fun and easy way to learn about coding through SCRATCH, an engaging program to learn about coding.

Tuesday, August 4

Tinkering with 3D Printing (Grade K-8) *[Presented by STEM Master Teachers]*
What am I supposed to do with this 3D printer? Want a refreshing idea on incorporating your 3D printer in the classroom? TinkerCAD offers an innovative strategy that engages students while incorporating Readiness Math TEKS. Build your computer animated design skills while designing a STEMtropolis.

Houston, We are GO for Exploration! (Grade K-8) *[Presented by NASA Education Outreach Staff]*
NASA Space Suit engineers, Su Curley and Mallory Jennings will be sharing information about past, present, and future space suits, as well as the engineering that goes into building them. They will also be bringing an activity that you can take back to your classroom called, *Packing the PLSS*.

Bag of Bones and Lost in Space: Bone Density (Grades 6-8) *[NASA Education Outreach Staff]*
Participants will apply the scientific method to determine degrees of bone loss and demonstrate why healthy bones are important in space and on Earth. We will use linear equations and functions, explore slope and the effects of a change of slope to analyze bone density loss and the effects of exercise and microgravity.

Feel The Heat and Keeping your Cool! (Grades 3-5) *[Presented by NASA Education Outreach Staff]*
Participants will be challenged to design and build a solar hot water heater and see how big a temperature change they can get as a team. Teams of participants will be challenged to design and build a water cooling system that could be used inside an astronaut's space suit for keeping them cool.

EV3: Find the Buried Treasure (Grades 3 - 8) *[Presented by STEM Master Teachers]*
The captain has buried his treasure, will your robot be able to find it? In this intermediate session with Lego EV3 robots, participants will learn to navigate a course to find the treasure, avoiding hazards along the way. They will build a simple robot and learn to write pseudocode before programming their robot to find the treasure. The session will focus on using the RoboMatter video curriculum as an instructional tool for teaching EV3 programming. Please bring personal headphones to the session.

Wednesday, August 5

STEMScopes (Grades K - 8) *[Presented by trainer from curriculum vendor]*
Three sessions, by grade level. Understand how STEMscopes 2.0 activities connect to Houston ISD Initiatives and go beyond 100% alignment to Texas Science standards.

STEAMTrax: Rocks are Everywhere (Grade K-2); Making Morse Code Messages (Grade 3-5); Football Helmets (Grade 6-8) *[Presented by trainer from curriculum vendor]*

- Grades K-2: Explore rocks as an important natural resource found on the surface of Earth in many sizes and forms! Participants trace their rock, measure their 2D sketch to emphasize the difference between a two-dimensional representation and a three-dimensional object, then design and print a 3D rock stand. Science concepts: Properties and uses of rocks, weathering, fossils, and natural resources.
- Grades 3-5: Participants design and create a 3D printed Morse code device that can send a messages using an electrical circuit and a dot and dash pattern. Science concepts: Forms of energy, transfer of energy, electrical circuits, and analyzing patterns of information.
- Grades 6-8: Participants design, print and test a helmet-like covering for eggs that undergo simulated collisions resembling the collisions of football players during a game or practice. Science concepts: forces, motion, energy, Newton's laws, concussions

Future Goals-Hockey Scholar (Grade 4-7) *[Presented by trainer from curriculum vendor]*
The National Hockey League and the National Hockey League Players' Association have partnered with EverFi to launch *Future Goals - Hockey Scholar*, an online learning course that brings STEM concepts to life through the game of hockey. From puck angles to states of matter, the session will cover an in depth training on the curriculum content, a demo of the 8 modules as well as setting up your teacher account. Come learn how you can use this online tool as a wraparound resource for math, science, technology & engineering while assessing students' mastery of key concepts.

Thursday, August 6

Computer Coding and TEKS Essentials (Grades K-8) *[Presented by STEM Master Teachers]*
How do you teach the TEKS essentials in math, reading, and science? Learn how to use Scratch and WeDo to build visualization, sequencing, and other critical thinking skills to support student learning. Your students will have a blast engaging in critical thinking while learning to code.

EV3: The Strawberry Challenge (Grades 3 - 8) *[Presented by STEM Master Teachers]*
It's growing season and the farmers are sending their produce to market. Can you program a robot to sort the containers and make sure the orders are filled? This advanced session will focus on using sensors to program loops and switches as the robot makes decisions based on data. Using the RoboMatter video curriculum, participants will work through levels of the challenge with the final goal of creating a tool to keep the warehouse organized and the orders filled. Please bring personal headphones to the session.

Engineering Adventures (Grades 3-8) *[Presented by STEM Master Teachers]*
Looking for a way to engage your students in Project Based Learning and introduce them to the Engineering Design Cycle? Then look no further, come have fun while designing race cars out of different materials to race to test the fastest design! Are you up to the challenge?

EV3: RoboMatter, On Your Own (Grades 3 - 8) *[Presented by STEM Master Teachers]*
Differentiation you say? This self-paced advanced robotics session is designed for teachers who have been using the Lego EV3 systems with their students and are ready to move into more complicated programming. Participants will use the RoboMatter video series to explore higher level learning in a self-study format. Each participant will decide where to begin their learning based on a self-assessment, and will move through the work at their own pace. Please bring personal headphones to the session.

Let's Build a Bridge! A STEM Challenge for Grades K-2 *[Presented by STEM Master Teachers]*
What ever happened to the Troll? Did the Big Bad Wolf ever eat his dinner? How did the Three Bears keep intruders out of their house? Join us as we explore fairy tales as young scientists, engineers and mathematicians. We will design, create, test and redesign structures, devices and tools that would have been very useful in our favorite fairy tales.

Combustion! STEM & Theatre Arts Integration (Grade K-8) *[Presented by Alley Theatre trainer]*
Play with the combustible chemistry between arts integration and STEM; learn about changes in test scores, see how arts integration changes classroom climate, experience what teachers say re-invigorated their teaching. This workshop is half "What is it?' and 'How to' and half brain-storm with peers.

Appendix E: 2016 STEM Summer Institute, August 1 – August 4

Welcome to

STEM

Science Technology Engineering Mathematics

Summer Institute

When:
August 1st through 4th, 2016

Location:
Herrera Elementary School
525 Bennington St
Houston, TX 77022

Information

Registration from 7:30 to 8:00 AM • Keynote Sessions at 8:00 AM • Morning sessions 9:00 to 11:30 AM • Afternoon sessions 12:30 to 3:15 PM • Lunch from 11:30 AM to 12:30 PM • Food trucks available each day.

Monday

Morning Session:
- Drone 101 (K-8 Grade)
- Level Up With EV3 (3-8 Grade)
- Scratch at Your Level (K-5 Grade)
- Engineering Buffet (K-8 Grade)
- No Paper Required: 5E Model With Web 2.0 (K-8 Grade)

Afternoon Session:
- Drone 101 (K-8 Grade)
- Level Up With EV3 (3-8 Grade)
- Scratch at Your Level (K-5 Grade)
- Engineering Buffet (K-8 Grade)
- No Paper Required: 5E Model With Web 2.0 (K-8 Grade)

Tuesday

Morning Session:
- You Don't Know Jack! (K-2 Grade)
- PBL CELL-ular (6-8 Grade)
- Makerspace (K-8 Grade)
- STEAM on a Dime (K-5 Grade)
- Power Up Your STEM Night With PBL (3-5 Grade)

Afternoon Session:
- You Don't Know Jack! (K-2 Grade)
- PBL CELL-ular (6-8 Grade)
- Oh! What a Drag... (6-8 Grade)
- STEAM on a Dime (K-5 Grade)
- Power Up Your STEM Night With PBL (3-5 Grade)

Wednesday

Morning Session:
- Learn Your Way Around Your 3D Printer (K-8 Grade)
- Beebot: Innovative Lab + Workstations (K-2 Grade)
- Engineering in Space (3-5 Grade)
- Get SMART (K-8 Grade)
- Reverse Engineering (4-8 Grade)

Afternoon Session:
- LEGOS, LEGOS, We Do LEGOS! (K-5 Grade)
- Clean the Patch (4-8 Grade)
- Engineering in Space (3-5 Grade)
- Mazing Through the City (5-8)
- Early Childhood + STEM Stations = 21st Learning Century (K-2)

Thursday

Morning Session:
- Crack the Code Tournament
- EV3 Tournament

Afternoon Session:
- Crack the Code Tournament
- EV3 Tournament

For further information please contact:
Susan Laforet • STEM Team Lead
• slaforet@houstonisd.org 713.696.0600

STEM Team • Houston ISD
• Advanced Academics
• 4001 Hardy Street • Houston, TX 77009

MONDAY

Drone 101: Learn the fundamentals of flying drones and apply the new skills in an indoor obstacle course.

Level Up With EV3 Robotics: Explore EV3 Robotics through a multidisciplinary lens.

Scratch at Your Level K-8: Experience coding with Scratch at your level in the areas of storytelling, science processes, and math problem solving.

Engineering Buffet: Indulge in the Engineering Buffet where you will select two entrees from the Daily Specials menu, and take away a plethora of STEM activities that can be implemented in the classroom right away.

No Paper Required: 5E Model With Web 2.0 Tools: Take part in a digital learning experience covering force and motion and have an opportunity to plan a digital learning experience for your students.

TUESDAY

You Don't Know Jack!: Take a look at literary elements of Jack and The Beanstalk and partake in three STEM challenges centered around the classic fairytale.

PBL CELL-ular: Join us for an overview of Project Based Learning (PBL), by engaging in an activity involving family cell phone plans.

Makerspace: (Presented by Library Services) Makerspaces are a great way for students to explore, create, and discover without the pressures usually associated with learning.

STEAM on a Dime 3-5: Create Photon Flowers, Shoebox Ecosystems, Soundproof Cell Phone Boxes, Pom Pom Launchers, Place Value Pictures and more!

Power Up Your STEM Night With PBL: Using the Problem Based Learning model, come ready to plan a Family STEM Night for your campus, integrating number relationships and fractions.

Oh! What a Drag...: Partake in rain gutter drag races incorporating principles of physics and engineering.

WEDNESDAY

Learn Your Way Around Your 3D Printer: Learn how to troubleshoot error messages, calibrate the printer for quality printouts, and learn tips and tricks to maintain optimal performance of a second generation Cube printer.

Bee-Bot (Innovative Lab + Workstations): Create innovative math and science workstations that are aligned to daily objectives, using a programmable robot.

Engineering in Space 3-5: Use problem-solving skills and engineering to design mechanisms to help you survive on a new undiscovered planet!

Get SMART: Explore various classroom applications of the SMART Board technology to enhance student learning.

Reverse Engineering: Learn how to improve technology by disassembling push-toys and redesigning them for functionality and cost effectiveness.

LEGOS, LEGOS, LEGOS – WEDO LEGOS! These hands-on problem solving solutions will ignite children's natural desire to explore and discover.

Clean the Patch: Participants will engineer a device to purify dirty water on a budget.

Mazing Through the City: Create a maze city and program an Ev3 robot to cruise and wheel through the maze, applying mathematical, engineering, and technical skills.

Early Childhood + STEM stations = 21st Learning: Explore ways to integrate robotics, coding, and problem based learning to build students' global graduate skills with an emphasis on math content.

THURSDAY

Crack the Code Tournament: Test your skills with other teachers in this coding challenge!

EV3 Tournament: Let's play some robot games!

Appendix F: STEM Design Challenges and Alignment to Texas Essential Knowledge and Skills (TEKS)

STEM Design Challenge Topics and TEKS Standards

for Fall Semester 2017*

Cycle 1	Science Unit	Topic	Sci/Math Standards
Kindergarten	Unit 4: Exploring Energy	Design a Kaleidoscope	SciK.5A and SciK.6A MaK.8A
1st	Unit 3: Light, Heat, and Sound Energy	Design a Solar Still	Sci1.4A, Sci1.5B, and Sci1.6A Ma1.1A and Ma1.1D
2nd	Unit 4: Effects of Light, Heat, and Sound Energy	Design a Solar Cooker	Sci2.5C and Sci2.6A Ma2.1A and Ma2.7C
3rd	Unit 3: Matter	Designing Clay Boats	Sci3.5A and Sci3.2B Ma3.1C and Ma3.1D
4th	Unit 2: Investigating Force and Motion	Design a Bridge to Withstand Forces	Sci4.6D and Sci4.2B Ma4.1A and Ma4.11A
5th	Unit 3: Matter	Design an Electromagnet	Sci5.5A and Sci5.6A Ma5.1D and Ma5.1E
6th	Unit 2: Metals, Nonmetals, and Metalloids	Designing Test Procedures	SCI 6.4A and Sci6.6A Ma6.1A and Ma6.1C
7th	Unit 2: Structure and Function of a Cell	Design Mock Facebook Profiles	Sci7.12C and Sci7.12D Ma7.1A and Ma7.1C
8th	Unit 2: Chemical Reactions	Solving a Real World Problem	Sci8.3C, Sci8.5D, Sci8.5F Ma8.1A and Ma8.5E
Cycle 2	**Science Unit**	**Topic**	**Sci/Math Standards**
Kindergarten	Unit 5: Motion, Location, and Position	Magnets in Motion	SciK6B and SciK2E MaK.1Dand K.1E
1st	Unit 6: Earth Materials	Changing Spoils into Soils	Sci1.7A and Sci1.3A Ma1.1A and Ma1.5D
2nd	Unit 5: Parts Working Together	Design a Bridge	Sci2.5C and Sci2.5D Ma2.4D and Ma2.10B
3rd	Unit 5: Natural Resources	Design a Water Filter Using Natural Resources	Sci3.7D and Sci3.2B Ma3.1A and Ma3.1E
4th	Unit 5: Investigating Circuits	Design a Light-up Greeting Card	Sci4.6A and Sci4.6C Ma4.1A and Ma4.1E
5th	Unit 6: Earth's Resources	Design a Model of Sedimentary Rock	Sci5.7A and Sci5.2D Ma5.1A and Ma5.1D
6th	Unit 4: Energy Introduction	Design a Catapult	Sci6.8A Ma6.11A, Ma6.11D, Ma6.13B
7th	Unit 3: Genetics	Design Bug Models	Sci7.14B and Sci7.2E Ma7.1A and Ma7.4B
8th	Unit 4: Laws of Force and Motion	Designing a Zip-Line	Sci8.6C and Sci8.2C Ma8.1B and Ma8.5H
Cycle 3 (MS Only)	**Science Unit**	**Topic**	**Sci/Math Standards**
6th	Unit 5: Thermal Energy	Design a House	Sci6.2E and Sci6.9B Ma6.1A and Ma6.1B
7th	Unit 5: Human Body Systems	Design a Touch Experiment	Sci7.13A and Sci7.2B Ma7.1E and Ma7.1F
8th	Unit 5: Earth, Sun, and Moon	Design a Moon Phaser	Sci8.4A and Sci8.7A Ma8.1A and Ma8.1G

**All design challenges are also aligned to ELPS and CCRS standards. Please find this information, along with the other STEM design challenge materials for each grade and cycle, in the K-8 science and math HUB resource folders.*

HOUSTON INDEPENDENT SCHOOL DISTRICT

RESEARCH

Educational Program Report

TEACHER INCENTIVE FUND STEM GRANT IN HOUSTON ISD: A MATCHED-COMPARISON ANALYSIS OF MATH AND SCIENCE STAAR SCORES

HISD | Research and Accountability

ANALYZING DATA, MEASURING PERFORMANCE.

2018 BOARD OF EDUCATION

This work was supported by U.S. Department of Education Award No. S374B120011.

The opinions expressed are those of the authors and do not represent the views of the HISD Board of Education, or the U.S. Department of Education.

Suggested Citation:
Price, L.E., Christian, M., & Stevens, C.J. (2018). *Teacher Incentive Fund STEM Grant in Houston ISD: A Matched-Comparison Analysis of Math and Science STAAR Scores.* Houston ISD: Department of Research and Accountability.

Houston Independent School District
Hattie Mae White Educational Support Center
4400 West 18th StreetHouston, Texas 77092-8501

www.HoustonISD.org

Teacher Incentive Fund STEM Grant in Houston ISD: A Matched-Comparison Analysis of Math and Science STAAR Scores

Executive Summary

Program Description

The fourth cohort of the Teacher Incentive Fund grant competition (TIF4) included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education. A human capital approach to strengthening STEM education addressed the TIF4 project schools' need for high-quality supports for student learning, and the systemic challenges to teacher retention, development, and recruitment in hard-to-staff subjects. The previous report in this series provided a descriptive overview of activities and interventions unique to the TIF4 project schools, setting the context for a meaningful discussion of programmatic impact. This analysis addresses student outcomes for STAAR Mathematics (grades three through eight) and STAAR Science (grades five and eight), during the grant period of 2012–2013 to 2016–2017.

Highlights

Through a matched-comparison group design, a regression analysis was implemented to detect causal relationships between students' STAAR achievement and the school's participation in the TIF4 programming. Specifically, the annual dependent variable for each school was the mean scale score of all students in each grade level who took the STAAR exam in either English or Spanish. In grades three through five, the TIF4 program did not appear to have a large effect on mathematics achievement in any year of the grant period. However, this analysis demonstrates that the TIF4 grant did produce substantive, statistically significant results for science and for secondary mathematics.

- **STAAR Science, Grades 5 and 8.** Over the grant period, the cumulative impact of the TIF4 program on Grade 5 Science was an increase in student achievement of about a fifth of a standard deviation (0.20 SD). The impact on Grade 8 Science was about a quarter of a standard deviation (0.24 SD). Both estimates are statistically significant, although the evidence in eighth-grade science is less compelling.
- **STAAR Math, Grade 6.** The point estimates suggest a cumulative impact over the grant period of about a fifth of a standard deviation (0.21 SD). These estimates were not considered statistically significant at conventional levels.
- **STAAR Math, Grades 7 and 8.** Over the grant period, the cumulative impact of the TIF4 program on Grade 7 Math was about half of a standard deviation of student achievement (0.49 SD). The impact on Grade 8 was about four-tenths of a standard deviation (0.39 SD). Both estimates were statistically significant at conventional levels.

The TIF4 programming produced substantive, meaningful improvements in student achievement. With a fifth of a standard deviation of improvement, a student initially at the 50th percentile would improve to the 58th percentile. A quarter standard deviation improvement moves a student from the 50th percentile to the 60th percentile. A half-standard-deviation increase would improve the achievement of a student at the 25th percentile to the 43rd percentile, or a student at the 50th percentile would then grow to the 69th percentile.

Notably, these outcomes are meaningfully stronger than the findings of recent high-quality research on the effects of teacher coaching on student outcomes. This suggests that the complex programmatic aspects of the TIF4 program produced substantive results, where simpler programs may have fallen short. Future reporting in this series will investigate human capital outcomes for science and math teachers at the TIF4 project schools.

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Figures

Introduction

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education (USDE) has supported human capital strategies "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science and math. Responding to the national agenda to improve STEM education, in 2012, the fourth cohort of the Teacher Incentive Fund federal grant competition (TIF4) included special consideration for projects designed to improve STEM education by identifying, developing, and utilizing master teachers as leaders of broader improvements (OESE, 2012a).

In September 2012, HISD was awarded a TIF4 grant for $15.9 million over five years (HISD Communications, 2012). The human capital strategies supported through TIF4 in Houston continue the successes and strategies of HISD's previous TIF grants (Price & Stevens, 2017), and are similar to strategies undertaken by the other 35 TIF4 grant recipients nationwide (OII, 2015). For more information about the Teacher Incentive Fund grant, see **Appendix A**.

HISD was one of just six TIF4 grantees to support a "comprehensive approach to improving STEM instruction" as part of their overall human capital strategy (OESE, 2012b). STEM grantees advanced the Absolute Priorities required of all TIF grantees — regarding human capital management systems, and educator evaluation — as well as a third Priority that incorporated "STEM master teachers" into their strategy for STEM improvement at the TIF4 project schools. In the verbiage of the TIF program officers, "STEM master teachers" are those educators "who serve as recognized leaders in STEM education improvement efforts regardless of their specific duties" (Zawaiza & Robinson, 2014). In HISD, the TIF4 grant supported twelve full-time positions for "STEM master teachers" — a STEM Curriculum Manager, ten STEM Teacher Development Specialists (TDS), and a STEM TDS Team Lead.

A human capital approach to strengthening STEM education addressed the project schools' need for high-quality supports for student learning, and the systemic challenges to teacher retention, development, and recruitment in hard-to-staff subjects. For a comprehensive overview of the supports for STEM teaching and learning at the TIF4 project schools, see the first report on TIF4 on HISD's website (Price, Provencher, & Stevens, 2018).

Theory of Action

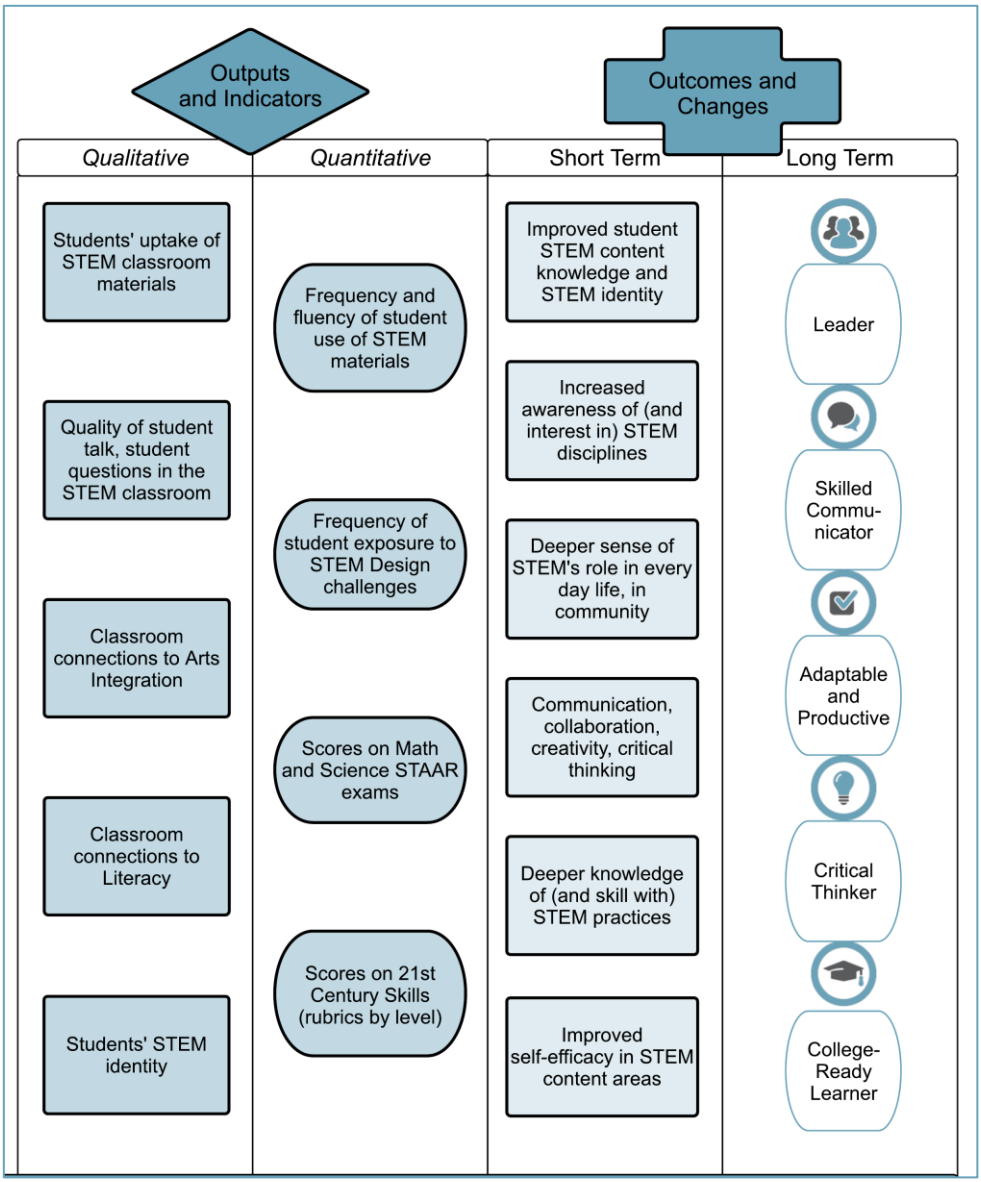
Under the assumptions guiding the TIF grant program, student outcomes are a function of human capital management (HCM) inputs — educator recruitment, retention, selection, assessment, professional development and supports, and performance-based compensation (Miller et al., 2015) — as mediated by teaching and learning behaviors. Through the TIF4 grant, HISD supported some HCM activities that addressed teaching and learning across all content areas, and some HCM activities that addressed teaching and learning only within the STEM content areas. Within this theory of action, the TIF activities focused explicitly on STEM teaching would affect students' science and mathematics learning at the project schools. Consequently, it is important to examine those outcomes, and to evaluate whether it is appropriate to make causal statements about the relationship between the TIF4 activities and the student outcomes at the grant schools.

Even under perfectly controlled experimental conditions, there are many intermediate steps between the efforts to shape teachers' professional activities and their students' learning outcomes; all of them need to succeed in order to see an effect in student outcomes. In other words, it is a complex theory of action with many mediating variables. In their August 2013 webinar to grantees, the TIF4 STEM Technical Assistance providers identified broad steps in this causal pathway, from: (1) Inservice Teacher Professional

Development, to (2) Teacher Knowledge, Skills, Beliefs, and Intentions, to (3) Classroom Practice, to, finally, (4) Student Outcomes (Weiss, 2013). Each are critical to the STEM instructional strategies employed at the TIF4 project schools.

Student exam scores are not the only outcomes of these interventions. As shown in **Figure 1**, students' math and science scores are just one of the indicators and outputs of the TIF4 strategies for STEM instruction in HISD: (1) Students' uptake of STEM classroom materials; (2) Quality of student talk, and student questions in the STEM classroom; Classroom connections to both (3) arts integration and (4) literacy; (5) Students' STEM identity; (6) Frequency and fluency of student use of STEM materials; (7) Frequency of student exposure to STEM Design Challenges; (8) student scores on Math and Science STAAR exams; and (9) student scores on 21st Century Skills rubrics, by Grade Level.

Figure 1. Student-Level Outcomes, Indicators, and Changes from TIF4 STEM Strategies



Despite the complexity of these mediating variables, sufficient high-quality research has been conducted so that it is possible to make some educated estimates about the impact of the "master teachers" approach in HISD supported through TIF4. A recently published meta-analysis of 37 high-quality studies on teacher coaching explored the complicated relationship between student outcomes and professional supports for teachers (Kraft, Blazar, & Hogan, 2018). The authors' theory of action — reproduced in **Figure 2**, from a pre-publication version — outlines dynamics between programmatic inputs (coaching, curricular materials, and training sessions/workshops), interim outcomes (teacher knowledge and teaching behavior), and the long-term student outcomes.

In their careful meta-analysis, the authors wrote candidly about the "strong supporting evidence" for a causal relationship between instructional practice and students' academic outcomes. However, they also cautioned readers to recognize the implications of this connection — that even modest changes in student achievement are the result of "relatively large improvements in instructional quality" (p. 22). This meta-analysis underlines the complexity of the work at hand: the grant-funded activities to improve STEM instruction at the TIF4 project schools must have surpassed a certain threshold of impact on teachers' instructional practice in order for a causal analysis to detect corresponding change in student outcomes.

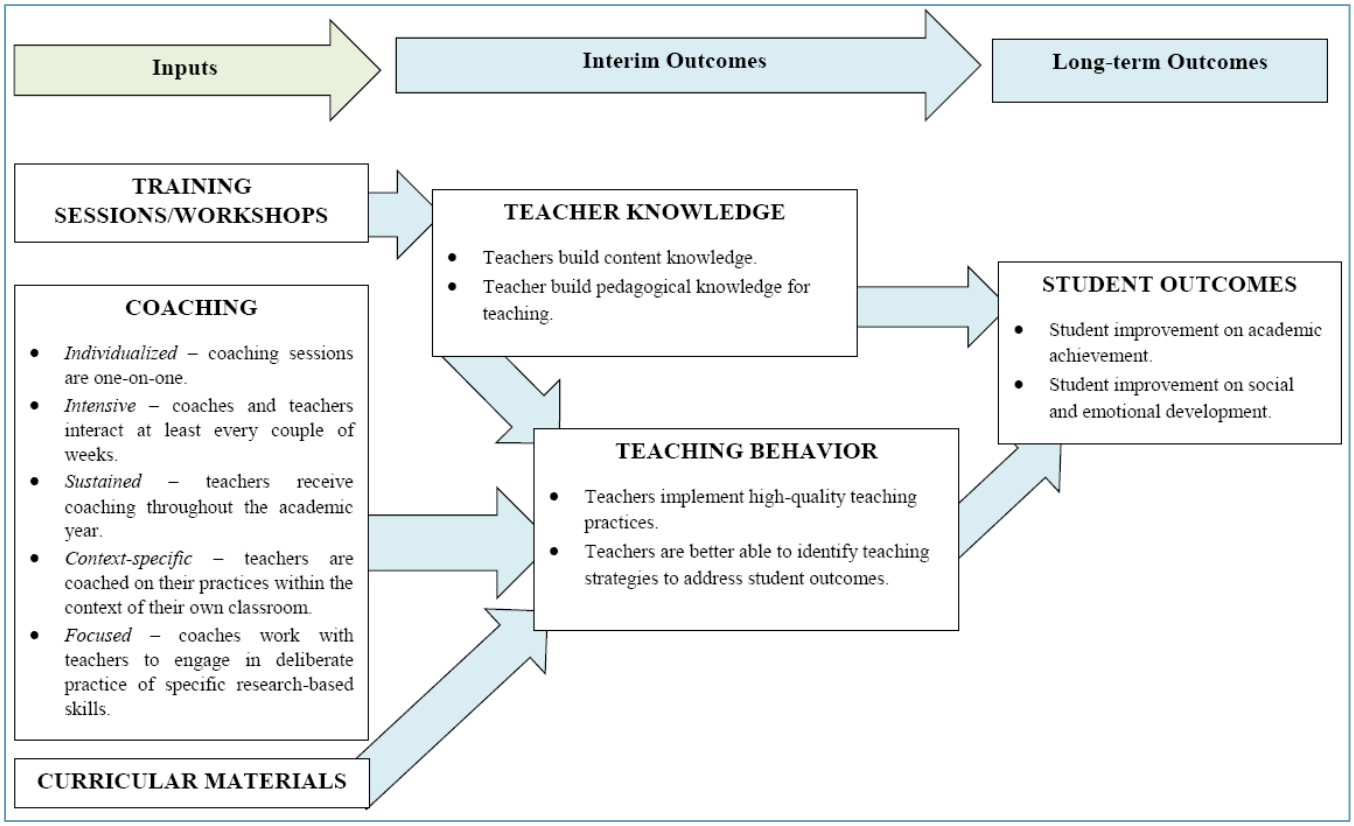
Purpose

Under the definitions[i] used in federal law (ESSA, 2015), the TIF4 STEM master teachers strategy can already be described as "evidence based" to improve instructional practices. However, this report represents the first investigation into the relationship between HISD's master teachers strategy, and students' math and science scores. If well-designed and well-implemented, this quasi-experimental[ii] study analysis could provide "Moderate Evidence" for the impact of the TIF-supported strategy on student learning outcomes, thereby making available additional funding opportunities for the District and also better informing leadership conversations about goals and priorities in an environment of limited financial resources.

The purpose of this report is to provide HISD leadership and USDE program staff with a detailed examination of the math and science student outcomes for schools participating in the TIF4 STEM grant (Award #S374B120011) from 2012–2013 through 2016–2017. The report addresses the grade-level scale scores used in the state-wide criterion-referenced STAAR (State of Texas Assessments of Academic Readiness) exams required under section 1111(b)(3) of the federal Elementary and Secondary Education Act, as well as the proficiency levels used in state accountability metrics (TEC § 39.023 and § 39.053). Wherever possible, this report was done in alignment with the standards and procedures of the What Works Clearinghouse™ (WWC). Established under the Education Sciences Reform Act of 2002, the WWC is an initiative of the U.S. Department of Education's Institute of Education Sciences (IES, 2017a).

Internal reports during the grant period suggested the project schools were experiencing meaningful gains in their students' math and science metrics — do these trends hold up to more rigorous analytic methods that could detect a causal relationship between student outcomes and the grant activities? Informal assessments during the grant period showed evidence of changes in teachers' own employment decisions, as well as positive changes in the instructional practice of specific STEM teachers — so if student outcomes could be attributed to the school's participation in the TIF grant, then it is reasonable to assume that the human capital strategies deployed through TIF were sufficient to impact student math and science metrics. Additional reporting in this series will evaluate those specific retention, compensation, development, and recruitment strategies at the TIF4 project schools.

Figure 2. Theory of Action for Teaching Coaching (Kraft, Blazar, & Hogan, 2016, p. 43)

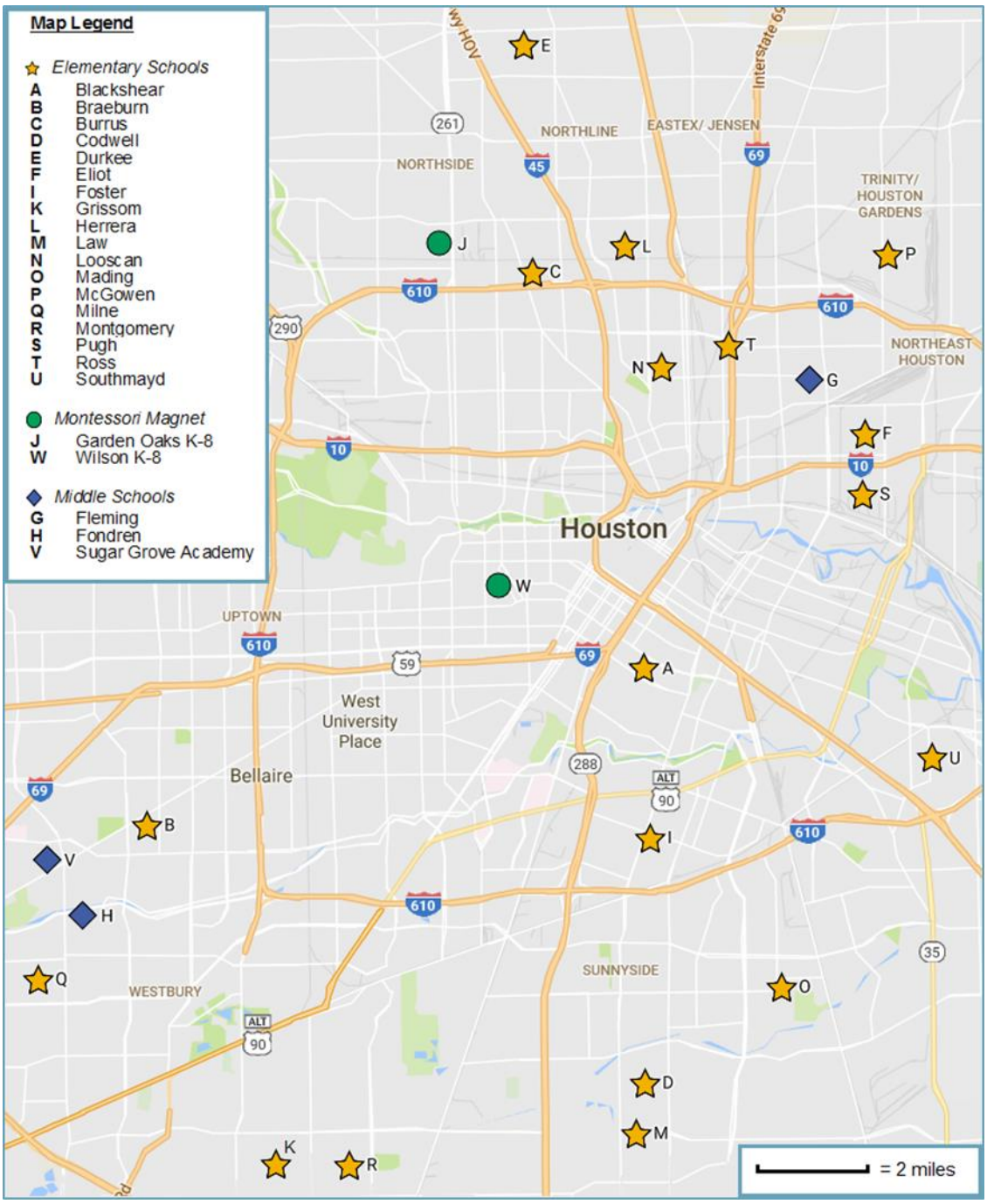


Methods

Research Design

In July 2012, HISD leadership identified specific schools to receive STEM programming through the TIF4 grant (HISD, 2012). Each year, these schools served approximately 7,500 students from pre-kindergarten through eighth grade — located in almost every quadrant of Houston (see **Figure 3**). Like most of the schools in HISD, the TIF4 project schools were considered "high-need" under the definitions in the U.S. Department of Education's Request for Application (OESE, 2012a). Additionally, the TIF4 project schools each had a persistent track record of underperforming on the science STAAR exams required under the Elementary and Secondary Education Act (NCLB, 2002). Their inclusion in the TIF4 grant was intended to address student learning and achievement in both math and science. The TIF4 project schools were identified based on their need for supports, rather than randomly. Consequently, HISD project staff were precluded from conducting a randomized controlled trial, which is considered to be the most rigorous research design for making causal inferences (Murnane & Willett, 2011).

Figure 3. Geographic Location of the TIF4 Project Schools



To appropriately account for the selection of the TIF4 schools in the assessment of impact, HISD project staff chose a matched-comparison group (MCG) research design. Considered to be a “rigorous design” for education research, a MCG design is comprised of a treatment group and a comparison group. When these two groups are highly similar at the beginning of the intervention, differences between the groups after the intervention are likely due to the intervention itself rather than some other pre-existing difference (Hanita, Ansel, & Shakman, 2017). Here, the MCG design allowed project staff to estimate the size of the TIF4 intervention on the math and science outcomes of those schools’ students. To evaluate the impact of the

STEM interventions on math and science scores at the TIF4 project campuses, then, project staff set out to identify comparable schools that could be an appropriate comparison group.

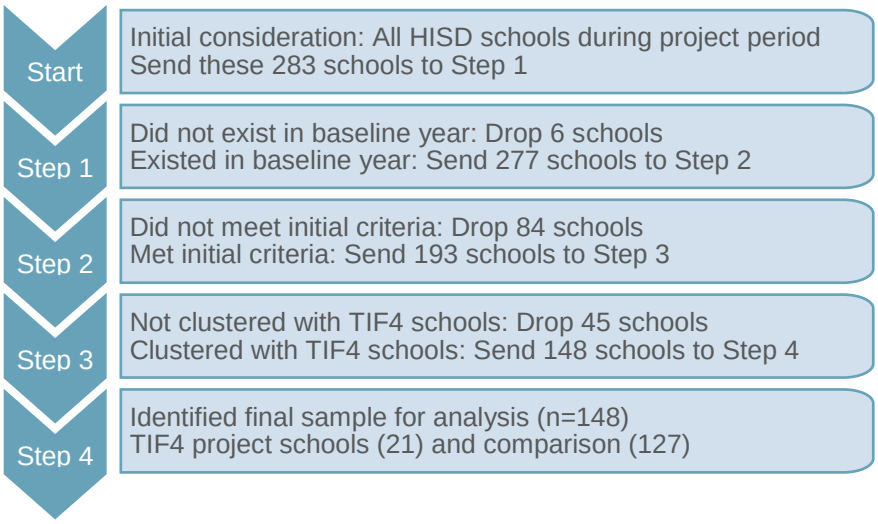
Identifying a Comparison Group

In short, a matched-comparison group research design requires a matched-comparison group. For this, project staff relied on the work published in the 2014 internal memorandum to HISD Chief School Officers, "Identification of Homogenous School Clusters" (Chang, 2014; see **Appendix B**). For details on the advantages and tradeoffs of this approach, see the "Limitations" section of **Appendix E**.

A "comparable school" was defined as a school serving the same grade levels, with similar enrollment size, and similar relationships between the following indicators in 2012–2013: Students identified as economically disadvantaged (%), students identified as at risk (%), annual student mobility rate (%), students who are zoned for the school (%), students identified as English Language Learners (%), students identified as African American, Hispanic, and White (%). **Figure 4** illustrates the steps to identify the matched-comparison group from among the 283 schools in HISD during the grant period (2012–2017).

- Step 1: From the 283 schools initially considered, drop the six schools that did not exist in the baseline year for student data (PEIMS, 2013).
- Step 2: From the 277 remaining, drop 84 schools that did not meet initial criteria for inclusion:
    - Did not serve grades K–8 (n=23)
    - Did not have comparable schools in HISD (n=60). *Note*: Garden Oaks Montessori and Wilson Montessori (K–8) were both dropped from the analytic sample due to this step, even though they participated in the TIF4 programming.
    - Did not have three years of student data (n=1; Dodson Elementary was closed after 2013 and its zoned students incorporated into the nearby Blackshear Elementary)
- Step 3: From the 193 remaining, drop 45 schools that were not comparable to the TIF4 schools.
- Step 4: The remaining 148 schools comprise the analytic sample for this analysis: 21 TIF4 project schools (also "treatment"), and 127 comparison schools:
    - 132 elementary schools (18 TIF4 schools and 114 comparison)
    - 16 middle schools (3 TIF4 schools and 13 comparison)

Figure 4. Steps in Identifying Matched-Comparison Group



For the names, clusters, and sample grouping of these 148 schools, see **Appendix C**. Any HISD school not named in Appendix C was not included in the sample as a treatment school or comparison school.

Assessing the Baseline Equivalence of the Analytic Sample

Identifying sample schools through the steps described above ensured that the Treatment and Comparison schools would be similar along the characteristics used in clustering. Project staff then examined the standardized mean difference between the groups in 2013, to gauge whether the groups were similar enough to be considered equivalent at baseline; under the WWC Procedures, a difference of $g \leq 0.05$ meets the criterion of the baseline equivalence[iii]. The standardized mean difference between the groups (Hedges' g) for these variables did not satisfy the baseline equivalence requirement ($g \leq 0.05$) for these variables, and so these variables were included as covariates (i.e., "controlled for") in the analysis best suited for detecting causal impact.

Table 1. School Characteristics at Baseline — Mean, Standard Deviation, and Effect Size

Variable in 2013	TIF4		Comparison		|g|
	Mean	SD	**Mean**	SD	
Percent African-American	45.1	(34.3)	27.0	(28.3)	0.62
Percent designated as Limited English Proficient or English Language Learner	5.4	(10.8)	3.4	(5.9)	0.29
Percent with Disabilities	7.88	(2.9)	7.2	(3.3)	0.19
Percent Economically Disadvantaged	94.9	(2.9)	91.7	(7.7)	0.45
Percent Immigrant	1.9	(3.3)	3.3	(3.7)	0.39
STAAR Reading, Grade 3	1373.3	(35.9)	1391.7	(40.1)	0.47
STAAR Reading, Grade 4	1442.4	(28.2)	1463.8	(40.1)	0.56
STAAR Reading, Grade 5	1492.8	(19.0)	1512.5	(34.6)	0.60
STAAR Reading, Grade 6	1489.6	(9.9)	1526.6	(55.8)	0.72
STAAR Reading, Grade 7	1554.3	(19.6)	1598.6	(51.5)	0.92
STAAR Reading, Grade 8	1601.9	(6.0)	1639.1	(48.4)	0.83
Note: Hedges' g corrected for uneven group sizes was calculated with Tannenbaum (2013).					

Project staff conducted additional testing of the sample balance, drawing on the internal report "A Better Picture of Poverty" (Reeves, McCarley, Mosier, & Carney, 2015). In this report, HISD staff used 2014 data and identified two dozen school and neighborhood risk factors that affect academic performance and correlate with chronic absenteeism. This additional analysis, along with variable definitions and sources, can be found in **Appendix D**. For the limitations in assessing baseline equivalence, see **Appendix E**.

Dependent Variable

This analysis addresses student outcomes for STAAR Mathematics (grades three through eight) and STAAR Science (grades five and eight), during the five-year grant period of 2012–2013 to 2016–2017. The 2012–2013 outcomes serve as pre-intervention baseline: even though the grant was awarded in October 2012, in-school supports for STEM did not begin until the 2013–2014 school year. Specifically, the annual dependent variable for each school is the mean scale score of all students in each grade level who took the STAAR exam in either English or Spanish[iv]. Analysis shown in **Table 2** illustrated that the TIF4 schools at baseline demonstrated a particular need for science and math intervention: the standardized mean difference between the groups (Hedges' g) for these variables does not satisfy the baseline equivalence requirement ($g \leq 0.05$) for the dependent variable. Note that the TIF project staff chose scale scores because the performance levels on the STAAR assessments changed during the grant period; by using scale scores, the modeling was not affected by changes in performance levels. See **Appendix E** for an overview of the STAAR performance levels, and the considerations given to various limitations within STAAR indicators.

Table 2. Difference between TIF4 and Comparison Schools in Baseline Year (2013)

2013 STAAR Exam	TIF4		Comparison		|g|
	Mean	SD	**Mean**	SD	
Math, Grade 3	1398.0	46.7	1438.3	50.8	0.80
Math, Grade 4	1456.8	45.7	1514.8	53.6	1.10
Math, Grade 5	1514.7	37.8	1554.7	50.5	0.82
Math, Grade 6	1533.3	31.9	1566.4	61.9	0.57
Math, Grade 7	1516.1	8.7	1559.4	27.5	1.70
Math, Grade 8	1620.0	9.9	1643.9	47.6	0.50
Science, Grade 5	3506.4	104.6	3671.3	160.9	1.06
Science, Grade 8	3547.0	159.9	3718.9	278.5	0.65
Note: Hedges' g corrected for uneven group sizes was calculated with Tannenbaum (2013).					

Unit of Analysis

This analysis focuses on school-wide metrics, not on the metrics of individual students and not on the aggregate metrics of students linked to a specific teacher.

- First, this is consistent with the program's theory of action: that the availability of job-embedded professional supports for STEM will improve science and math outcomes across all grade levels.
- Second, student mobility through regular grade promotion would confound a by-student analysis of four years of "treatment." This is simply due to typical grade promotion practice: a third grader at a TIF4 project school in 2013 would have moved up to another school for sixth grade by 2016, and not necessarily one of the three middle schools participating in the grant.
- Third, while all the TIF4 project schools experienced specific STEM activities, there was meaningful variation between schools in the exact order and manner in which those activities unfolded. Although components were targeted at specific teachers, the intervention was not identical for any two teachers.

In other words, the STEM master teachers required flexibility to meet each school's unique and evolving needs. Rather than prioritizing uniformity of implementation (as would befit a teacher-level or student-level analysis), they prioritized *differentiating each school's STEM supports based on the school's specific needs.* For more on the choice of dependent variable and unit of analysis, see **Appendix E**.

Three Phases of Analysis

The first phase of analysis simply compares the TIF4 project schools to themselves — specifically, the trends in their students' performance levels over the grant period. On their own, these performance levels would be insufficiently rigorous measures for making causal inferences. However, these trends can offer suggestive evidence for the impact of the TIF4 project. Additionally, they reflect the indicators that HISD reported to USDE program officers in annual performance reports. The second phase of analysis addresses the gaps in mean scale scores between TIF4 and comparison schools. If the TIF4 intervention was having an effect on students' math and science scores, then one point of evidence could be whether the TIF4 schools shrank the annual achievement gaps by outpacing the comparison schools during the grant period.

Both the first and the second analyses are insufficiently rigorous to make causal inferences about the effect of the TIF interventions, but they are important for other reasons: they underpin state accountability metrics, school leader appraisal scores, district-wide goals, and the TIF4 progress measures reported to the USDE each year. The third step of analysis employs a statistically sophisticated model to examine the causal effect of a school's participation in TIF4 on their school's science and mathematics scores, in each year and for each grade and subject. For details on the model, see **Appendix E**.

Results

Result 1: TIF schools saw meaningful change in their students' math and science proficiency levels. As detailed above, the first analysis addresses the trends in students' performance levels over the grant period. The cut scores for these performance levels are determined annually by the Texas Education Agency (TEA), and reflect the student's mastery of the content for their current grade level (Student Assessment Division, 2017). See **Appendix E** for an overview of the performance levels.

Table 3: Annualized Rate of Change, Count of TIF4 Students at Each Proficiency Level (2013–2017)

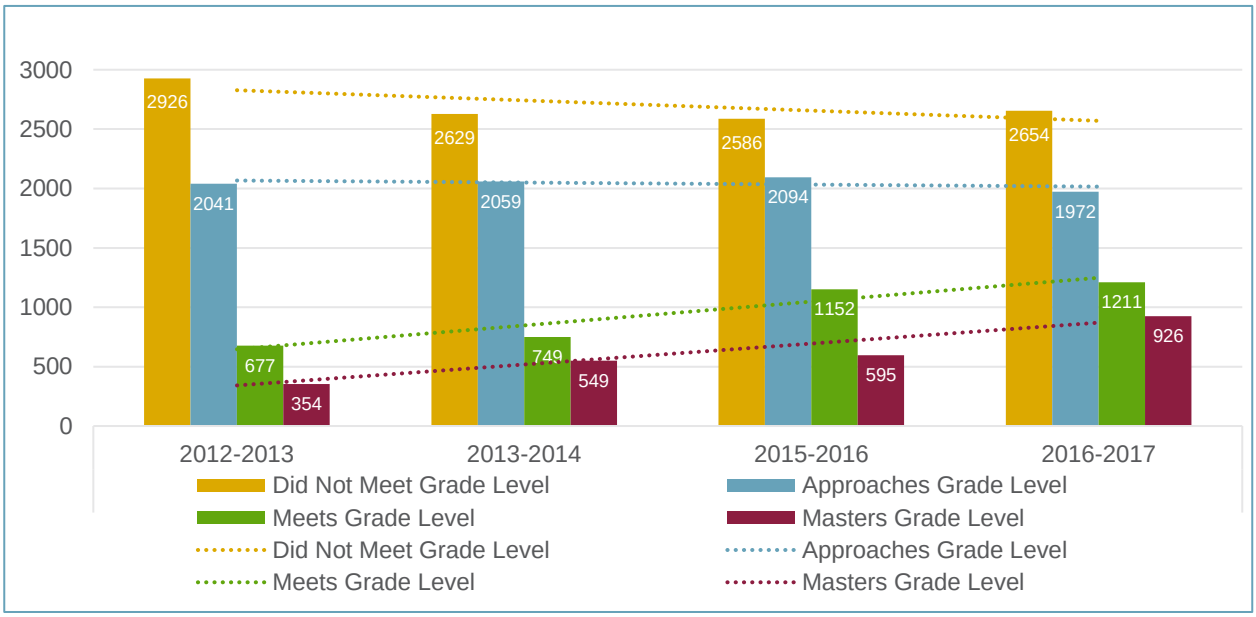
Subject and Exam	Did Not Master Grade Level	Approaches Grade Level	Meets Grade Level	Masters Grade Level
STAAR Math (Grades 3–8)	-85.9	-17.2	+200.0	+176.2
STAAR Science (5 & 8)	-35.5	+1.0	+48.4	+27.7
Algebra I EOC	-2.0	-6.3	+1.1	+8.4

STAAR Math, Grades 3–8

Figure 5 shows the number of students at the TIF4 project schools who scored at each proficiency level on the STAAR Math exam in English (grades 3–8) and in Spanish (grades 3–5) during the grant period. The linear trend for each level is represented with a dotted line in the same color; the first row of **Table 3** shows these linear rates of change as an annual figure. Over the grant period (2013–2017):

- The number of students at TIF4 schools at the Did Not Meet Grade Level standard on the STAAR Math exam decreased by 9.3% (272 students), at an average linear rate of -85.9 students per year.
- The number of students at TIF4 schools at the Approaches Grade Level standard on the STAAR Math exam decreased by 3.4% (69 students), at an average linear rate of -17.2 students per year.
- The number of students at TIF4 schools at the Meets Grade Level standard on the STAAR Math exam increased by 78.9% (534 students), at an average linear rate of 200 students per year.
- The number of students at TIF4 schools at the Masters Grade Level standard on the STAAR Math exam increased by 161.6% (572 students), at an average linear rate of 176.2 students per year.

Figure 5. STAAR Math (3–8) at TIF4 Schools: Proficiency Levels, 2013–2017



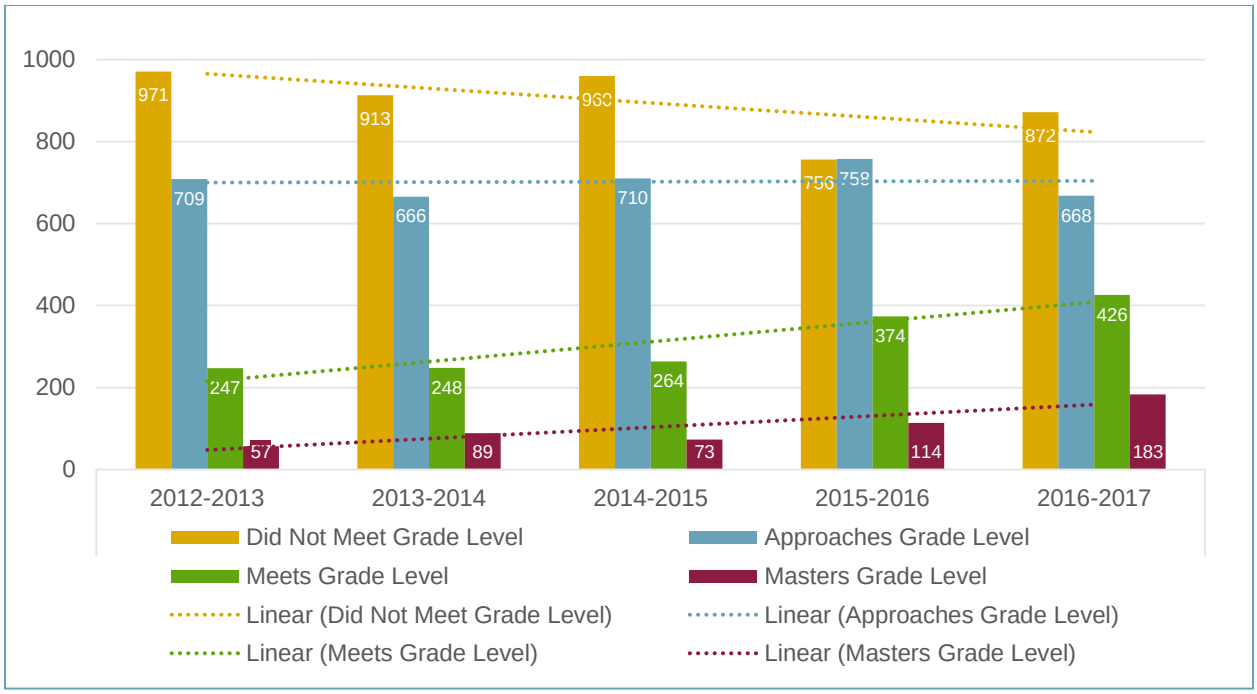
Note: The number of students at each proficiency level — as presented here — is mutually exclusive.

STAAR Science, Grades 5 and 8

Figure 6 shows the number of students at the TIF4 project schools who scored at each proficiency level on the STAAR Science exam in English and Spanish (grades 5 and 8) during the grant period. The linear trend for each level is represented with a dotted line in the same color; the second row of **Table 3** shows these linear rates of change as an annual figure. Over the grant period (2013–2017):

- The number of students at TIF4 schools at the Did Not Meet Grade Level standard on the STAAR Science exam decreased by 10.2% (99 students), at an average linear rate of -35.5 students per year.
- The number of students at TIF4 schools at the Approaches Grade Level standard on the STAAR Science exam decreased by 5.6% (41 students), but at an average linear rate of 1 student per year.
- The number of students at TIF4 schools at the Meets Grade Level standard on the STAAR Science exam increased by 72.5% (179 students), at an average linear rate of 48.4 students per year.
- The number of students at TIF4 schools at the Masters Grade Level standard on the STAAR Science exam increased by 68.9% (126 students), at an average linear rate of 27.7 students per year.

Figure 6. STAAR Science (5 and 8) at TIF4 Schools: Proficiency Levels, 2013–2017



Note: The number of students at each proficiency level — as presented here — is mutually exclusive.

STAAR Algebra I, Grade 8

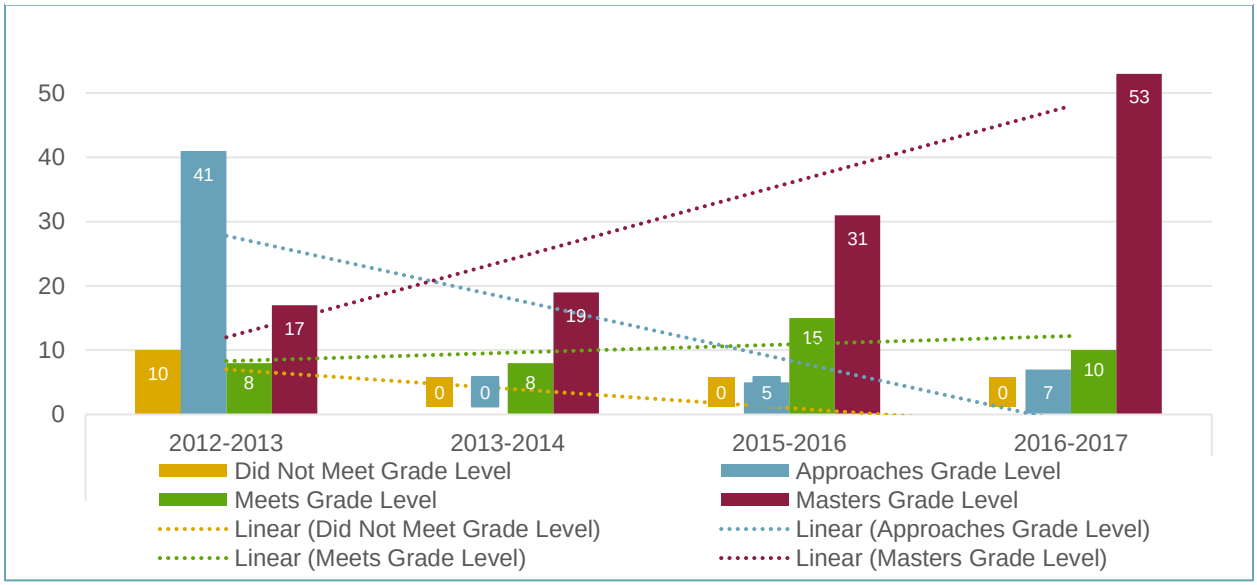
Figure 7 shows the number of students at the TIF4 schools taking the exam for the first time who scored at each proficiency level on the STAAR Algebra I End of Course (EOC) exam during the grant period. The linear trend for each level is represented with a dotted line in the same color; the third row of **Table 3** shows these linear rates of change as an annual figure. Although the EOC exams are not assigned to students by grade level, the students taking this Algebra I exam at these schools were all in the 8th grade. This EOC is only offered in English, whereas STAAR Math is offered in both English and Spanish for grades 3–5.

- Over the grant period, the number of students at TIF4 schools at the Did Not Meet Grade Level standard on the Algebra I exam decreased by 100% (10 students), at an average linear rate of -2 students per year. This annual rate is deceptive, however: **Figure 7** illustrates zero students at this level after 2013.

- Over the grant period, the number of students at TIF4 schools at the Approaches Grade Level standard on the Algebra I exam decreased by 64.2% (34 students), at an average linear rate of -6.3 students per year.
- Over the grant period, the number of students at TIF4 schools at the Meets Grade Level standard on the Algebra I exam increased by 20.0% (2 students), at an average linear rate of 1.1 students per year.
- Over the grant period, the number of students at TIF4 schools at the Masters Grade Level standard on the Algebra I exam increased by 67.9% (36 students), at an average linear rate of 8.4 students per year.

The changing number of students each year reflects changes in which schools offered Algebra I to their eighth graders: In 2013, all three middle schools offered Algebra I. In 2014, only one TIF4 school offered Algebra I; in 2016, two schools offered Algebra I, and by 2017, all three were again offering Algebra I. This also affected the number of eighth graders taking the STAAR Math exam, as addressed in the third analysis.

Figure 7. Algebra I EOC at TIF4 Schools: Proficiency Levels, 2013–2017



Note: The number of students at each proficiency level — as presented here — is mutually exclusive.

Result 2: Comparing scale scores over time, the TIF4 schools closed the gaps on every metric.

While certainly encouraging, the first results could be a function of factors other than TIF4 participation (e.g., changes in cut scores, or which students sit for which exams). If the TIF4 intervention was having an effect on students' math and science scores, then a point of evidence could be whether the TIF4 schools shrank the gaps in achievement by outpacing the comparison schools in their growth.

Elementary — Math, Grades 3 to 5

Figure 8 illustrates the average scale score for STAAR Math during the grant period (2013–2017) in grade 3 (blue), grade 4 (yellow), and grade 5 (green) for both comparison (circle) and TIF4 (triangle) schools. For both the TIF4 and Comparison schools, all three grade levels saw an increase in their average scale score during the grant period. This increase in average scale scores in both groups and across all grade levels is a good sign for student learning. However, as illustrated in **Figure 9**, it also means that the gaps between TIF4 and comparison schools showed only modest decreases: a decrease of 0.4% or -5.5 points for grade 3, a decrease of 1.4% or -19.7 points for grade 4, and a decrease of 0.4% or -5.7 points for grade 5. Note:

Appendix F Table 1 shows each grade level's average scale score, the standard deviation (in parentheses), and the number of students who took the exam each year.

Figure 8. Scale Score Trends for STAAR Math, Grades 3–5 (2013–2017)

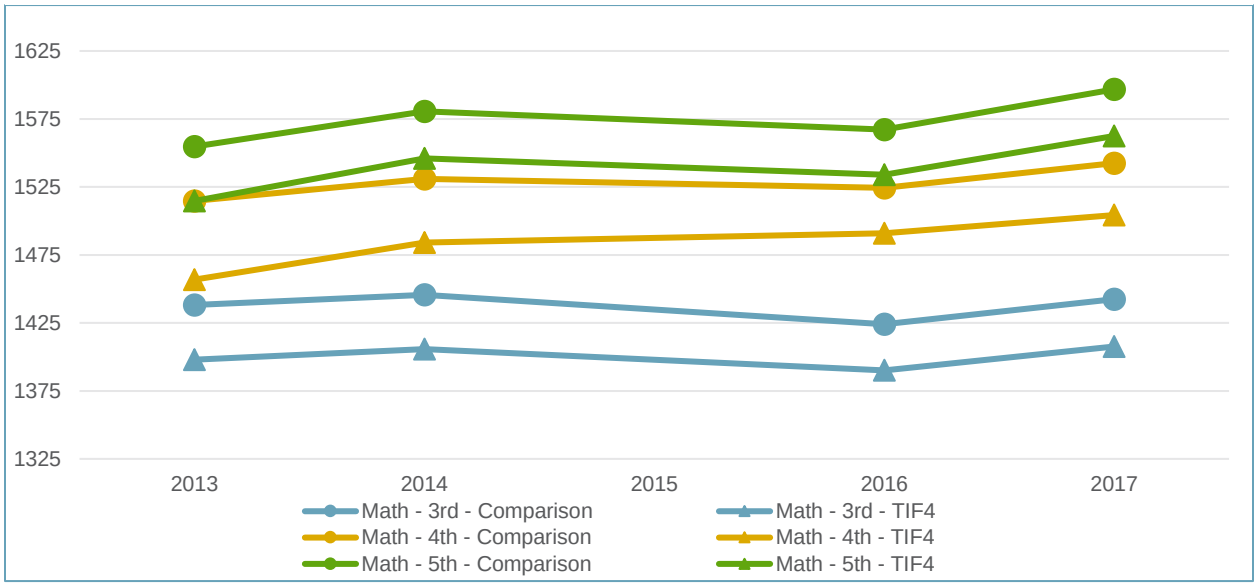
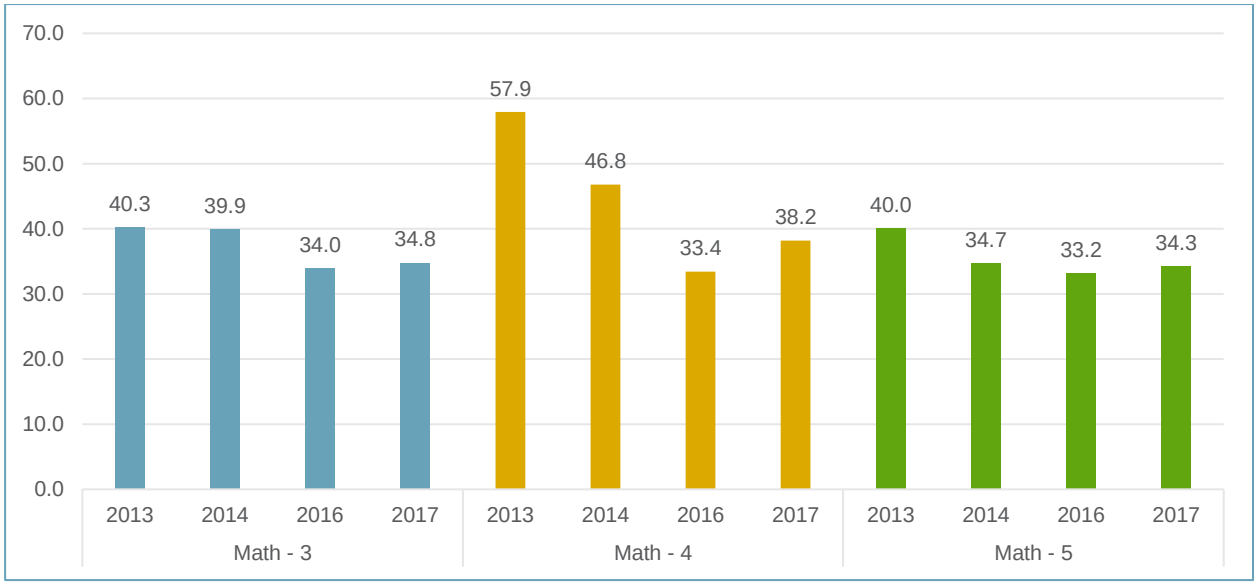


Figure 9. Annual Gap in Scale Score Points between TIF4 and Comparison Schools, STAAR Math 3–5



Science — Grades 5 and 8

Figure 10 illustrates the average scale scores for STAAR Science in grade 5 (blue) and grade 8 (yellow), for comparison (circle) and TIF4 (triangle) schools. Only Grade 8-Comparison did not experience real gains across the grant period. However, the linear trend in science proficiency levels (e.g., Figure 6) obscures the detail in that growth: on average, every grade experienced declines in scale scores between 2014 and 2015, and gains between 2015 and 2017. See **Appendix F Table 2** for each grade level's average scale score, the standard deviation (in parentheses), and the number of students who took the exam each year. Versus the comparison schools, the TIF4 schools decreased the scale score gap by about three percent

over the grant period: a decrease of 2.7% or -93.7 points for grade five, and a decrease of 3.4% or -121.1 points for grade 8. The trend shown in **Figure 11** is generally downward over the grant period.

Figure 10. Scale Score Trends for STAAR Science, Grades 5 and 8

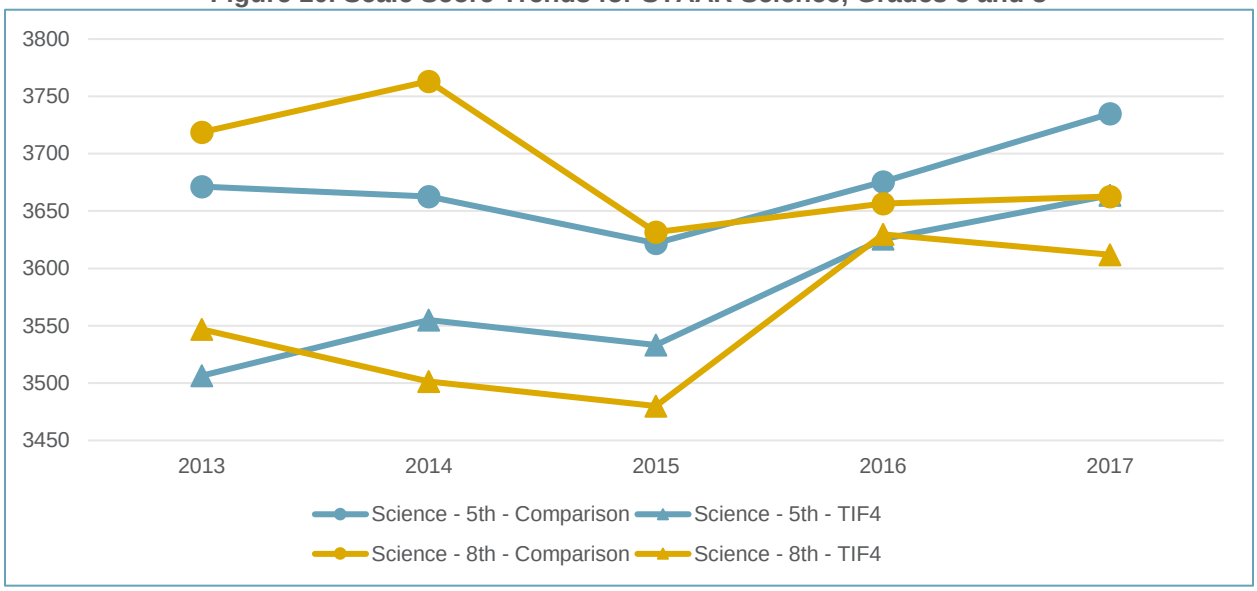
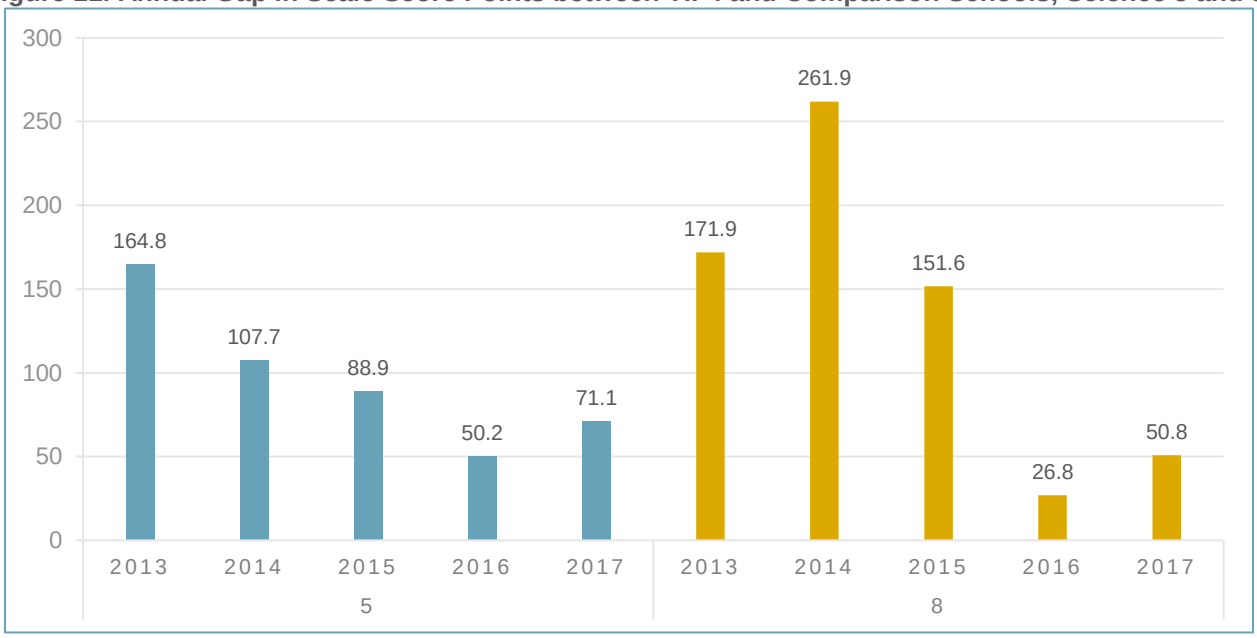


Figure 11. Annual Gap in Scale Score Points between TIF4 and Comparison Schools, Science 5 and 8



Middle — Math, Grades 6 to 8

Figure 12 illustrates the average scale score for STAAR Math during the grant period in grade 6 (blue), grade 7 (yellow), and grade 8 (green) for both comparison (circle) and TIF4 (triangle) schools. At the TIF4 schools, all three grade levels saw an increase in their average scale score during the grant period; at the Comparison schools, both 6th grade and 8th grade saw declines. Note: **Appendix F Table 3** shows each grade level's average scale score, the standard deviation (in parentheses), and the number of students who took the exam each year. The students at TIF4 schools overtook their counterparts, with a gap decrease of 2.8% or -42.9 points for grade six, a decrease of 5.2% or -79.2 points for grade seven, and

decrease of 3.9% or -63.4 points for grade eight. In **Figure 13**, the years in which TIF4 students overtook their Comparison counterparts are shown as negative.

Figure 12. Scale Score Trends for STAAR Math, Grades 6–8

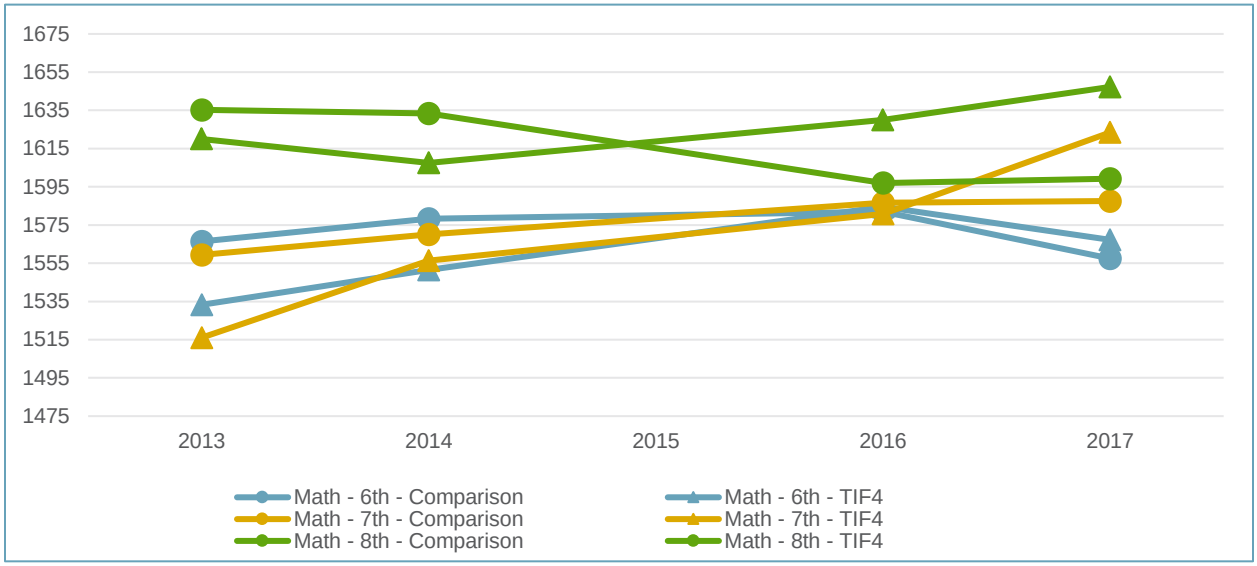
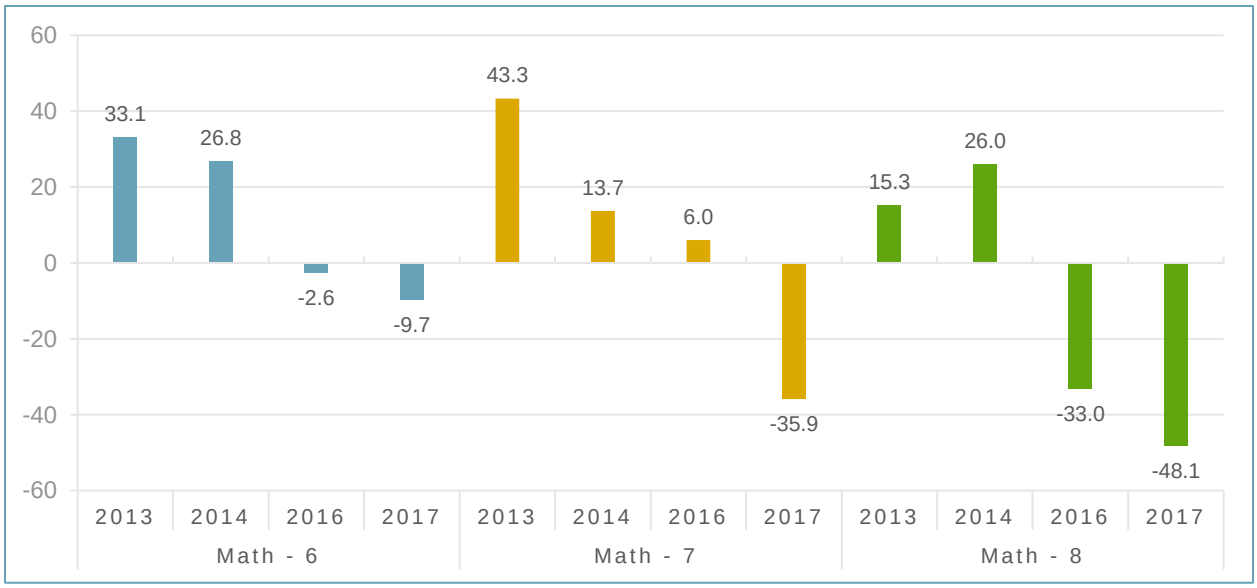


Figure 13. Annual Gap in Scale Score Points between TIF4 and Comparison Schools, Math 6–8



Result 3: Under analysis suited to isolate causal effects, some results are substantive.

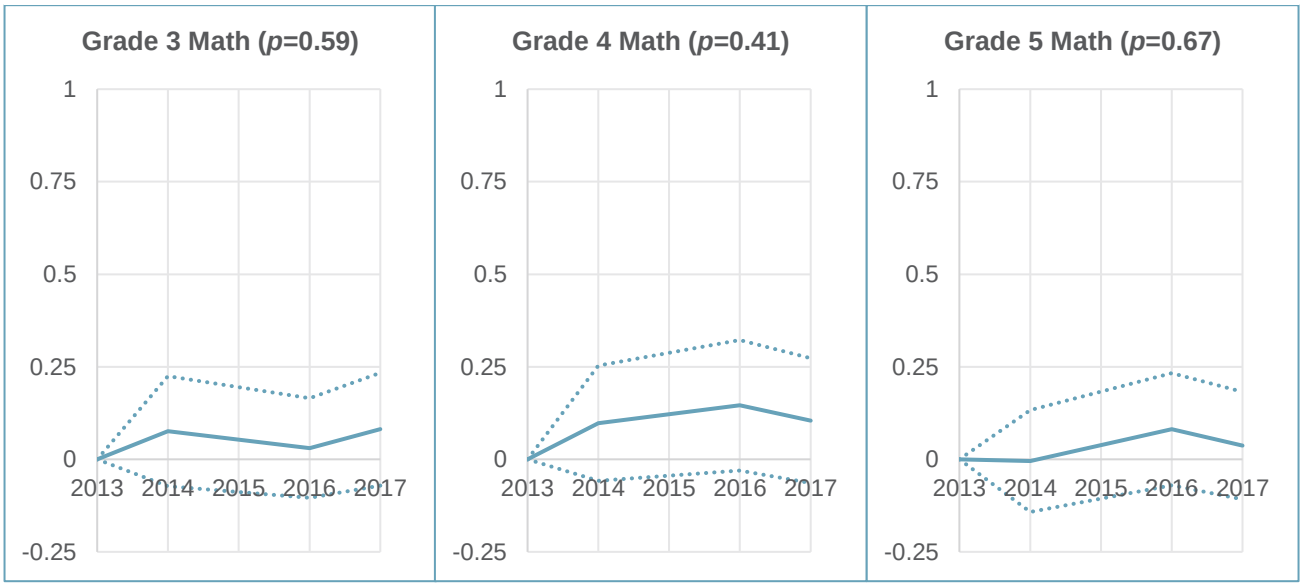
The model used to evaluate the impact of the TIF4 program can be expressed as follows:

$$y_{jt} = \beta_{0j} + \beta_{1t} + \beta_{2t}TIF_j + \beta_{3t}X_{jt} + \varepsilon_{jt}$$

where y_{jt} is the average STAAR score in science or mathematics at school *j* in year *t*; β_{0j} is a fixed effect for school *j*; β_{1t} is a fixed effect for year *t*; TIF_j is an indicator variable that equals 1 if school *j* is a participant in the TIF4 program and 0 if school *j* is a comparison school; and X_{jt} is a vector of characteristics of school

j in year *t*. For more details about this model, see **Appendix E**. Average STAAR scores are normalized by subject, grade, and year using the mean and standard deviation of STAAR scores across students in Texas. The plots present estimates of the year-specific β_{2t} coefficients on TIF_j for 2014, 2015, 2016, and 2017. The effect for the pre-TIF4 baseline year, 2013, is set to zero. These plot the estimated cumulative impact of having been in TIF4 since the start of the program up to that particular year. The impact is on student achievement in that particular year, measured in student-level standard deviations (details in Appendix E). Also included are error bands representing ±2.0 standard errors (an approximately 95% confidence interval). In the table that accompanies the plot is the *p*-value from an *F*-test of the hypothesis that all of the β_{2t} coefficients are equal to zero (**Tables 4, 5, and 6**). This *p*-value is the statistical significance of the results — the probability that the pattern observed would have been produced in the absence of any effect.[v]

Figure 14. Impact of TIF on School's Average STAAR Score, Math 3–5 (in Standard Deviations)



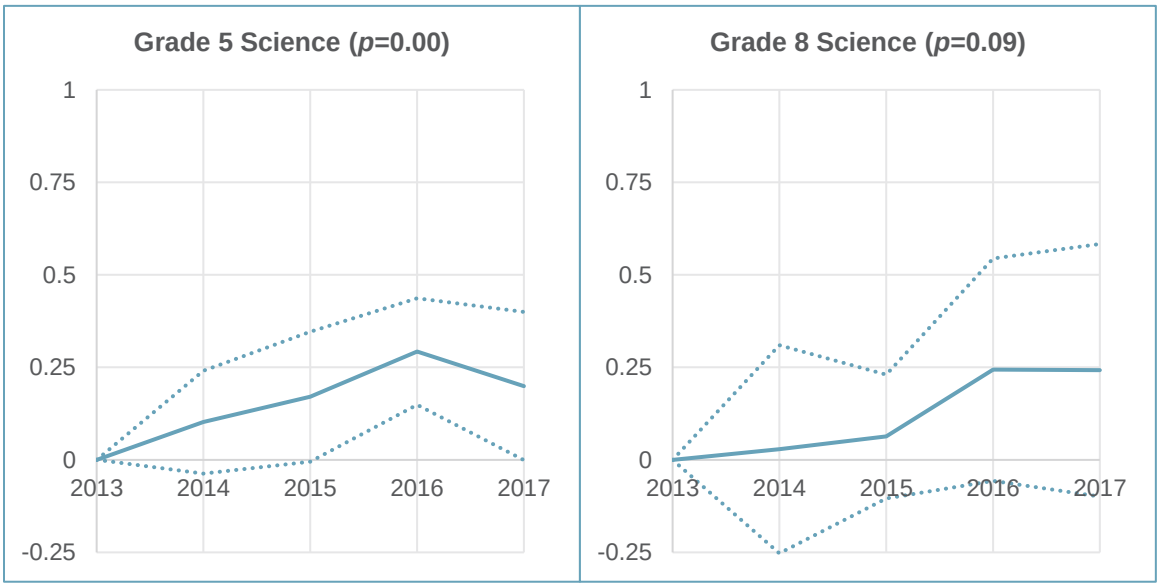
Elementary — Math, Grades 3 to 5

Figure 14 presents the estimated impact of TIF4 over the four years of its implementation on mathematics achievement in grades three through five. In grades three through five, the TIF4 program does not appear to have a large effect on mathematics achievement in any year (see coefficients in **Table 4**), and the estimated impacts are not statistically significant.

Table 4. Impact of TIF4 on Elementary Mathematics: No Large Effects

Grade	Subject	Year	Coefficient (SD)	SE	*p*-value
3	Math	2014	0.08	(0.07)	
3	Math	2016	0.03	(0.07)	
3	Math	2017	0.08	(0.08)	0.596
4	Math	2014	0.10	(0.08)	
4	Math	2016	0.15	(0.09)	
4	Math	2017	0.10	(0.08)	0.412
5	Math	2014	0.00	(0.07)	
5	Math	2016	0.08	(0.08)	
5	Math	2017	0.04	(0.07)	0.675

Figure 15. Impact of TIF on School's Average STAAR Score, Science 5 and 8 (in Standard Deviations)



Science — Grades 5 and 8

Figure 15 presents the impact of the TIF4 program on science achievement in fifth and eighth grades. We can see that, in both grades, the impact of participation in TIF4 accumulates positively over the first three years of implementation (2014 – 2016), and then levels out in the fourth year (2017). The total, cumulative impact of TIF over the course of the four years is an increase in student achievement of about a fifth of a standard deviation in grade five and about a quarter of a standard deviation in grade eight (see **Table 5**).

This is a substantive improvement. For example, with a fifth of a standard deviation of improvement, a student initially at the 25th percentile of achievement would improve to the 32nd percentile; one at the 50th percentile would improve to the 58th percentile; and one at the 75th percentile would improve to the 81st percentile. A quarter standard deviation improvement moves a student from the 25th percentile to the 34th percentile, from the 50th percentile to the 60th percentile, and from the 75th percentile to the 82nd.

Table 5. Impact of TIF4 on STAAR Science: Substantive Improvement

Grade	Subject	Year	Coefficient (SD)	SE	*p*-value
5	Science	2014	0.10	(0.07)	
5	Science	2015	0.17	(0.09)	
5	Science	2016	0.29	(0.07)	
5	Science	2017	0.20	(0.10)	0.003
8	Science	2014	0.03	(0.13)	
8	Science	2015	0.06	(0.08)	
8	Science	2016	0.24	(0.14)	
8	Science	2017	0.24	(0.16)	0.091

In fifth-grade science, the improvement in science STAAR scores among students in TIF4 schools is statistically significant. The evidence in eighth-grade science is less compelling, even given the substantive point estimate of the impact of the TIF4 program. This is because the sample of schools is sufficiently small that even a substantive measured impact is not necessarily statistically significant. See **Appendix E** for additional technical details about the model specifics for fifth grade science and eighth grade science.

Middle — Math, Grades 6 to 8

In contrast to the findings for grades 3 to 5, a more substantive effect of TIF4 is measured in mathematics in grades six, seven, and eight (see **Table 6** and **Figure 16**). See Appendix E for additional technical details. As shown in **Figure 16**, the point estimates suggest a substantive impact in sixth-grade mathematics — a cumulative impact over the four years of about a fifth of a standard deviation. These estimates are not sufficiently precise to be statistically significant at conventional levels (p=0.42).

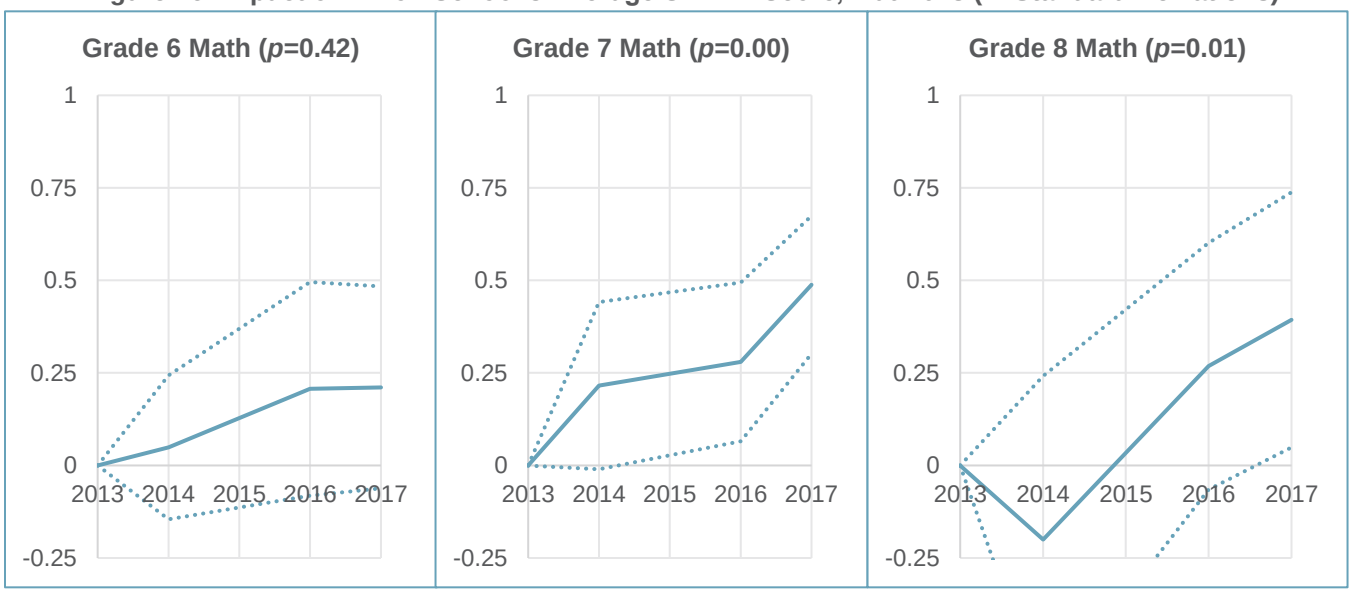
In seventh grade mathematics, the TIF4 program has an immediate effect of about one-fifth of a standard deviation of student achievement, which increases slightly to about a quarter of a standard deviation in the third year of TIF4. In the fourth year, the cumulative impact of the TIF4 program ticks upward to about half of a standard deviation of student achievement. A half-standard-deviation increase would improve the achievement of a student at the 25th percentile to the 43rd percentile; that of a student at the 50th percentile to the 69th percentile; and that of a student at the 75th percentile to the 88th percentile.

In eighth grade mathematics, we see achievement dip among TIF4 schools relative to non-TIF4 schools in the first year, only to recover in the third year to a level of about one-quarter of a standard deviation higher among TIF4 schools than among non-TIF4 schools, and to further improve to about four-tenths of a standard deviation higher in the fourth year. This suggests that, while we do not measure any positive immediate effect in the first year, we measure a substantive, significant cumulative effect by the end.

Table 6. Impact of TIF on STAAR Math 6–8: Substantive Improvement

Grade	Subject	Year	Coefficient (SD)	SE	*p*-value
6	Math	2014	0.05	(0.10)	
6	Math	2016	0.21	(0.14)	
6	Math	2017	0.21	(0.14)	0.424
7	Math	2014	0.22	(0.11)	
7	Math	2016	0.28	(0.11)	
7	Math	2017	0.49	(0.09)	0.001
8	Math	2014	-0.20	(0.22)	
8	Math	2016	0.27	(0.17)	
8	Math	2017	0.39	(0.17)	0.011

Figure 16. Impact of TIF on School's Average STAAR Score, Math 6–8 (in Standard Deviations)



Conclusion

Supporting the federal priority to improve STEM education, the fourth cohort of the Teacher Incentive Fund grant competition (TIF4) included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education. As a comprehensive intervention, the TIF4 approach to STEM education in HISD supported program activities that reached students, teachers, and school-wide systems — in short, the key programmatic aspects necessary to impact student outcomes as outlined in Figure 2 (Kraft, Blazar, & Hogan, 2016).

Kraft, Blazar, and Hogan (2018) found that coaching generally resulted in only weak improvements to student achievement (0.11 SD), because generally the changes to instructional practice were not sufficient to affect student outcomes. The evidence presented in this report strongly suggests that a school's participation in the TIF4 grant did impact teachers' instructional practice strongly enough for a causal inference analysis to detect subsequent changes in student outcomes.

Indeed, these findings comprise compelling evidence that the coaching-centered TIF4 STEM intervention caused substantive improvement in four areas of student achievement: fifth grade science (0.20 SD, $p<0.00$), eighth grade science (0.24 SD, $p<0.09$), seventh grade mathematics (0.49 SD, $p<0.00$), and eighth grade mathematics (0.39 SD, $p<0.01$). The evidence for TIF4 impact on sixth grade mathematics was also strong (0.21 SD) but not statistically significant at any traditional level of certainty ($p<0.42$). Notably, the TIF4 results for elementary mathematics were more in line with those found in Kraft, Blazar, and Hogan (2018): In grades three through five, the TIF4 program did not appear to have a large effect on mathematics achievement cumulatively or in any single year, and the estimated impacts are not statistically significant. This analysis did not include a specific investigation into possible reasons for the difference between elementary and middle school math TIF4 outcomes.

On the whole, this report suggests that the complex programmatic aspects of the TIF4 program produced substantive and reproducible results for student achievement through human capital strategies. Additional reporting in this series will investigate human capital outcomes for science and math teachers at the TIF4 project schools — including whether the implementation of TIF4 human capital strategies were meaningfully different between the elementary (3–5) level and middle grades (6–8).

Endnotes

(i) Under Section §8101(21)(A) of the Every Student Succeeds Act of 2015 (ESSA), "the term 'evidence-based', when used with respect to a State, local educational agency, or school activity, means an activity, strategy, or intervention that — (i) demonstrates a statistically significant effect on improving student outcomes or other relevant outcomes based on — ''(I) strong evidence from at least 1 well-designed and well-implemented experimental study; (II) moderate evidence from at least 1 well-designed and well-implemented quasi-experimental study; or ''(III) promising evidence from at least 1 well-designed and well-implemented correlational study with statistical controls for selection bias; or ''(ii)(I) demonstrates a rationale based on high-quality research findings or positive evaluation that such activity, strategy, or intervention is likely to improve student outcomes or other relevant outcomes."

(ii) In their 2016 Non-Regulatory Guidance document "Using Evidence to Strengthen Education Investments", the Office of Elementary and Secondary Education provides the following definition and example for the term: "A quasi-experimental study (as known as a quasi-experimental design study or QED)… means a study using a design that attempts to approximate an experimental design by identifying a comparison group that is similar to the treatment group in important respects. These studies, depending on design and implementation, can meet What Works Clearinghouse Evidence Standards [for high-quality research]. An example of a QED is a study comparing outcomes for two groups of classrooms matched closely on the basis of student demographics and prior mathematics achievement, half of which are served by teachers who participated in a new mathematics professional development (PD) program, and half of which are served by other teachers. This study uses a nonequivalent group design by attempting to match or statistically control differences between the two groups." (OESE, 2016, pg. 11)

(iii) In their Procedures Handbook, the What Works Clearinghouse provides the following rationale and definition: "In general, to improve the comparability of effect size estimates across studies, the WWC uses student-level standard deviations when computing effect sizes, regardless of the unit of assignment or the unit of intervention. … For continuous outcomes, the WWC has adopted the most commonly used effect size index, the standardized mean difference known as Hedges' g, with an adjustment for small samples. It is defined as the difference between the mean outcome for the intervention group and the mean outcome for the comparison group, divided by the pooled within-group standard deviation of the outcome measure." (IES, 2017b, pg. 14)

(iv) Relying on the 2013 technical report on the STAAR scale scores from the Texas Education Agency, the decision was made to combine results for both English and Spanish into a single grade-level mean scale score. From the 2013 STAAR Vertical Scale Technical Report from the TEA's Student Assessment Division: "Under Texas Education Code (TEC) §39.036, the Texas Education Agency (TEA) is required to develop a vertical scale for assessing student performance in grades 3–8 for reading and mathematics. A vertical scale is a scale score system that allows for direct comparison of student test scores across grade levels within a content area. Vertical scaling refers to the process of placing test scores that measure similar content areas but at different grade levels onto a common scale. A vertical scale was developed for the following grades and subjects: STAAR English grades 3–8 mathematics, STAAR English grades 3–8 reading, STAAR Spanish grades 3–5 reading. Although there is a Spanish version of STAAR mathematics assessments in grades 3–5, a separate vertical scale was not developed because the same scale is used for both language versions. Use of the same scale is possible because Spanish mathematics items are transadapted from the English items. Spanish reading passages and items are uniquely developed to maintain the authenticity of the Spanish assessment." (Student Assessment Division, 2013, pg. 3)

(v) From the American Statistical Association (ASA): "Informally, a p-value is the probability under a specified statistical model that a statistical summary of the data (e.g., the sample mean difference between two compared groups) would be equal to or more extreme than its observed value… The smaller the p-value, the greater the statistical incompatibility of the data with the null hypothesis, if the underlying assumptions hold." (Wasserstein & Lazar, 2016)

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Appendix A: Teacher Incentive Fund

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education (the Department) has supported human capital strategies for teachers and school leaders, "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science and math. While the specific programming supported through the TIF grant program has evolved since 2006 (Miller et al., 2015), TIF projects are supported by the Department to develop and implement sustainable performance-based compensation systems (PBCSs) for teachers, principals, and other personnel in high-need schools in order to increase educator effectiveness and student achievement. HISD was awarded over $43 million as part of the first and third cohorts of TIF grantees – $11.8 million in 2006, and $31.3 million in 2010. A recap of these program activities is available on HISD's website (Price & Stevens, 2017).

In September 2012, HISD was awarded a TIF grant for $15.9 million over five years (OESE, 2012b) — one of just six STEM projects funded among the fourth cohort of awards (TIF4-STEM): HISD, plus Calcasieu Parish (LA), National Institute for Excellence in Teaching (IA), Orange County (FL), Washoe County (NV), and the South Carolina Department of Education.

These grantees committed to the two Absolute Priorities required of all TIF grantees, as well as a third Priority that was specific to STEM programming:

- **Priority 1 (all grantees):** "An LEA-wide human capital management system (HCMS) with educator evaluation systems at the center that (a) is aligned with the local education agency's (LEA's) vision of instructional improvement and (b) uses information generated by the evaluation system to inform key human capital decisions, such as recruitment, hiring, placement, dismissal, compensation, professional development, tenure, and promotion."
- **Priority 2 (all grantees):** "An LEA-wide educator evaluation system based, in significant part, on student growth. The frequency of evaluation must be at least annually and the evaluation rubric should include at least three performance levels and (a) two or more observations during each evaluation period, (b) student growth for the evaluation of teachers at the classroom level, and (c) additional factors determined by the LEA. In addition, the evaluation system must generate an overall evaluation rating based, in significant part, on student growth and the evaluation system must be implemented within the timeframe specified in Priority 2."
- **Priority 3 (STEM grantees):** "Improving STEM achievement by developing a corps of skilled STEM master teachers by providing additional compensation to teachers who (a) receive an overall evaluation effectiveness rating of effective or higher under the evaluation system, (b) are selected based on criteria that are predictive of the ability to lead other teachers, (c) demonstrate effectiveness in one or more STEM subjects, and (d) accept STEM-focused career ladder positions. In addressing this priority, each LEA needs to identify and develop the unique competencies that, based on evaluation information or other evidence, characterize effective STEM teachers. Projects also need to identify hard-to-staff STEM subjects and use the HCMS to attract effective teachers, leverage community support and expertise to inform the implementation of its plan, ensure that financial and non-financial incentives are adequate to attract and retain persons with strong STEM skills in high-need schools, and ensure that students have access to and participate in rigorous and engaging STEM coursework."

See http://www2.ed.gov/programs/teacherincentive/2012-374ab.pdf for the full text of the application package for TIF4 (OSEA, 2012a).

Appendix B: Identification of Homogenous School Clusters

Excerpt of Analysis by Dr. Yu-Ting Chang of the HISD Research and Accountability Department.

MEMORANDUM April 9, 2014

TO: Chief School Officers

FROM: Carla J. Stevens
Assistant Superintendent, Research and Accountability

SUBJECT: **IDENTIFICATION OF HOMOGENOUS SCHOOL CLUSTERS**

The Department of Research and Accountability was asked to perform a non-hierarchical cluster analysis of elementary, middle, and high schools using demographic data. The purpose of this analysis was to develop clusters, or groups, of comparable schools, for the purpose of comparing student performance on the STAAR reading and mathematics assessments for elementary and middle schools, and on the STAAR EOC assessments for high schools within each cluster.

A non-hierarchical, partitioning model, formally known as "K-Means," was performed using STATA (a data and statistical software program). K-Means is a multivariate learning model that processes and classifies an assortment of fairly homogenous variables into sub populations known as "clusters." Schools were then classified into one of several clusters, developed at each level (elementary, middle, and high), based on the relationships between the schools on each of the variables.

In this analysis, the nine variables used were: enrollment, percent economically disadvantaged, percent at risk, percent zoned, percent mobility, percent ELL, percent African American, percent Hispanic, and percent White.

Due to the algorithmic structure of K-Means, each of the nine variables had to be standardized to prevent unequal weighting. For example, if enrollment was not standardized, it would have a much larger scale compared to the other variables, leading to inaccurate cluster results. […]

A total of 35 middle schools were analyzed in this analysis, resulting in six school clusters. A total of 161 elementary schools were analyzed in this, analysis resulting in eight school clusters. A total of 214 HISD schools and 5 NFISD [North Forest ISD] schools were assigned to a cluster based on the characteristics, or pattern of relationships, each school exhibited on the nine variables.

Some schools were omitted from the analysis for various reasons, which include: no mobility rate, no zoned rate, multi-level grade schools, early childhood centers, and specialized schools. […]

Should you have further questions, please contact my office in the Department of Research and Accountability at (713) 556-6700.

cc: Superintendent's Direct Reports, Chief School Officers
School Support Officers, School Office Directors
Lupita Hinojosa

Appendix C: 148 Schools in Sample, by Homogeneous Cluster and Treatment/Comparison Assignment

	Treatment	Comparison		Treatment	Comparison
56 Elementary Schools in Cluster E1					
Anderson		1	Lewis		1
Barrick		1	Lyons		1
Benavidez		1	Martinez, R.		1
Benbrook		1	McNamara		1
Berry		1	Moreno		1
Bonham		1	Neff		1
Bonner		1	Northline		1
Braeburn	1		Park Place		1
Brookline		1	Patterson		1
Burbank		1	Pilgrim Acad.		1
Coop		1	Piney Point		1
Crespo		1	Port Houston		1
Cunningham		1	Robinson		1
De Chaumes		1	Rodriguez		1
DeAnda		1	Rucker		1
Durkee	1		Sanchez		1
Eliot	1		Scarborough		1
Franklin		1	Scroggins		1
Gallegos		1	Seguin		1
Golfcrest		1	Shearn		1
Harris JR		1	Sherman		1
Harris RP		1	Southmayd	1	
Henderson JP		1	Stevens		1
Herrera	1		Sutton		1
Hines-Caldwell		1	Tijerina		1
Janowski		1	Wainwright		1
Kennedy		1	White		1
Ketelsen		1	Whittier		1
			No. in Cluster E1	**5**	**51**
10 Elementary Schools in Cluster E2					
Almeda		1	Garden Villas		1
Cornelius		1	Lantrip		1
Elrod		1	Law	1	
Emerson		1	Roosevelt		1
Garcia		1	Tinsley		1
			No. in Cluster E2	**1**	**9**
21 Elementary Schools in Cluster E3					
Briscoe		1	Helms		1
Browning		1	Jefferson		1
Burnet		1	Looscan	1	
Cage		1	Love		1
Carrillo		1	Memorial		1
Crockett		1	Pugh	1	
Davila		1	Red		1
DeZavala		1	Rusk		1
Durham		1	Sinclair		1
Field		1	Wharton		1
Gregg		1	**No. in Cluster E3**	**2**	**19**

	Treatment	Comparison		Treatment	Comparison
25 Elementary Schools in Cluster E5					
Askew		1	Isaacs		1
Bastian		1	Kelso		1
Bell		1	Martinez, C.		1
Bruce		1	Milne	1	
Cook		1	Montgomery	1	
Daily		1	Paige		1
Dogan		1	Peck		1
Foerster		1	Shadowbriar		1
Fondren		1	Smith, K.		1
Grissom	1		Valley West		1
Gross		1	Walnut Bend		1
Highland Heights		1	Windsor Village		1
Hobby		1	**No. in Cluster E5**	**3**	**22**
24 Elementary Schools in Cluster E6					
Alcott		1	MacGregor		1
Atherton		1	Mading	1	
Blackshear	1		McGowen	1	
Burrus	1		Osborne		1
Codwell	1		Pleasantville		1
Foster	1		Reynolds		1
Frost		1	Ross	1	
Hartsfield		1	Thompson		1
Henderson NQ		1	Wesley		1
Kashmere Gardens		1	Whidby		1
Lockhart		1	Woodson PK-8		1
Longfellow		1	Young		1
			No. in Cluster E6	**7**	**17**
7 Middle Schools in Cluster M1					
Attucks		1	Thomas		1
Cullen		1	Welch		1
Fleming	1		Williams		1
Key		1	**No. in Cluster M1**	**1**	**6**
5 Middle Schools in Cluster M6					
Deady		1	Long		1
Fondren	1		Sugar Grove	1	
Henry		1	**No. in Cluster M6**	**2**	**3**

Number of Schools, by Level and by Group			
	Treatment	Comparison	*Level Total*
Elementary	18	114	*132*
Middle	3	13	*16*
Group Total	**21**	**127**	***148***

As outlined in Step 2 of the section “Research Design”, three schools that participated in the TIF4 grant programming were excluded from the analytic sample in this study: Garden Oaks Montessori and Wilson Montessori (K–8) were both dropped from the analytic sample because they did not have comparable schools in HISD. Dodson Elementary was dropped from the sample because it did not have three years of student data: it was closed after 2013, and its zoned students incorporated into the nearby TIF4 school Blackshear Elementary.

Appendix D: Using "A Better Picture of Poverty" to Assess Sample Balance

"Leaders at every level of the school system are being challenged to think and act differently to address the effects of income inequality on academic performance. The majority of schools within Houston ISD are located in high-poverty areas, so it is important to understand which may need the most help – and what kind of help would be most useful. However, simple proxies for poverty, like the proportion of students who receive free and reduced lunch, fail to capture the volume and nature of the challenges that many Houston schools face. Inspired by the November 2014 research report, *A Better Picture of Poverty*, by the Center for New York City Affairs, we identified 23 school and neighborhood risk factors that contribute to chronic absenteeism and low student performance. When the factors are displayed using [color-coding] there emerges a very clear picture of both the kinds of and the volume of educational disadvantage associated with that location; a "heat map" of educational disadvantage."

Excerpt, Campus Risk Load Profiles Fall 2015 (Reeves, McCarley, Mosier, & Carney, 2015)

Risk Factors for Chronic Absenteeism at the TIF4 Project Schools

Overall, the 2015 *Risk Load* report showed two things – that HISD schools are facing complex issues, but that some schools are showing success even with a heavy "risk load." The same is true of the TIF4 project schools. Figure B-1 shows the "heat map" of each school's total risk factors, chronic absenteeism, and the 22 factors associated with it. The sources and definitions of these variables are found in the rest of this Appendix. The median number of Risk Factors facing a TIF4 school is 11, compared to a median of just 8 for all other HISD schools serving grades K–8.

Figure D-1. 2015 Family, School, and Neighborhood Risk Factors for Chronic Absenteeism

Total Number of Risk Factors 2015 Rating		School Name	Chronic Absenteeism	Free Lunch Eligible	Students in Temp. Housing	Special Ed. Students	Black or Hispanic	ELL Students	Students Not Ident. as GT	Immigrant Students	Refugee Students	Principal Turnover	Teacher Turnover	Teacher Vacancy	Student Mobility	Student Transfers	Student Suspensions	Student Safety Issues	CPS Involvement	Child Poverty	Poverty Rate	HS Education or Below	Lack of Adult Professionals	Male Unemployment	Public Housing	Homeless Shelter
18	IR	Sugar Grove MS	-0.100	0.100	1.270	-0.566	-1.089	-1.268	-1.458	-0.758	-1.829	-2.000	-1.079	-2.000	-0.459	-2.000	-0.100	-1.169	-1.143	-0.431	-0.313	-0.308	0.568	0.696	2.000	-2.000
	MET	Fleming MS	0.420	-1.557	-1.105	-0.882	-1.907	0.629	-1.648	1.656	-0.145	-0.111	-0.210	-1.219	-0.392	-2.000	-1.605	0.100	2.000	-1.814	-2.000	-1.119	-0.607	-0.906	2.000	-2.000
17	IR	Blackshear ES	-0.567	-0.390	0.100	-0.143	-1.626	1.152	-1.160	1.793	-0.173	-2.000	-2.000	2.000	-0.748	-2.000	-2.000		2.000	-1.407	-1.428	-0.100	-1.526	-0.823	-2.000	-2.000
		Fondren MS	-0.469	0.313	0.312	-0.286	-0.308	-0.920	-1.690	0.335	-1.890	-0.111	-1.778	-0.810	-0.596	-2.000	-1.239	-0.179	2.000	-0.769	-0.568	0.201	-0.377	-0.314	2.000	-2.000
15	MET	Grissom ES	0.100	-1.467	-2.000	0.321	-1.528	-0.415	-0.573	1.186	2.000	-1.216	-1.507	2.000	0.251	-2.000	-0.100		-2.000	-0.289	-0.238	-0.490	-1.070	-0.606	2.000	2.000
		McGowen ES	0.112	-0.735	-0.657	-0.977	-1.921	1.856	-0.857	1.867	2.000	-0.100	-0.738	2.000	0.111	-2.000	-1.258		-2.000	-0.200	-0.100	-0.838	-2.000	-2.000	2.000	2.000
14	IR	Mading ES	-1.061	-0.100	-0.305	-1.534	-1.784	1.530	-1.509	1.906	2.000	-1.216	-1.138	2.000	-0.100	2.000	-1.611		2.000	-0.500	-0.143	-0.649	-2.000	-2.000	2.000	2.000
13	IR	Foster ES	-1.963	-1.592	0.709	-1.024	-1.764	1.973	-1.775	2.000	2.000	-0.100	0.515	2.000	-0.232	-2.000	-2.000		2.000	-1.054	-0.939	-0.421	-1.539	-0.668	2.000	2.000
	MET	Looscan ES	-0.460	-0.986	2.000	-1.163	-1.843	-0.237	-0.596	1.633	2.000	-0.100	-2.000	2.000	0.109	-2.000	-0.296		2.000	-1.607	-0.921	-0.956	-0.882	0.273	2.000	2.000
		Durkee ES	0.678	-0.641	2.000	-1.441	-1.685	-0.439	-0.612	1.671	2.000	-0.100	-0.151	2.000	0.361	-2.000	0.263		2.000	-1.319	-1.653	-1.726	-0.149	-0.370	2.000	2.000
		Pugh ES	0.684	-1.446	2.000	-1.116	-1.784	-0.285	-0.787	0.346	2.000	-0.100	-0.873	2.000	0.510	2.000	-0.242		2.000	-0.542	-0.407	-1.422	-0.502	-0.565	2.000	2.000
11	IR	Burrus ES	-0.100	-0.850	-0.101	0.738	-1.587	1.867	-1.266	1.630	2.000	2.000	-0.668	2.000	-0.148	2.000	0.773		2.000	-0.764	-0.802	-0.459	-0.100	-0.509	2.000	2.000
	MET	Eliot ES	0.875	-1.415	1.512	-1.395	-1.843	-0.189	-0.435	0.685	2.000	-0.100	-0.873	2.000	-0.310	-2.000	0.846		2.000	0.100	-0.167	-1.808	0.815	1.014	2.000	2.000
10	IR	Montgomery ES	-0.770	-0.349	-2.000	-0.097	-1.626	0.143	-0.647	0.499	1.383	2.000	0.284	2.000	0.317	-2.000	-0.272		2.000	0.175	0.303	-0.489	-0.478	-0.248	2.000	2.000
		Ross ES	0.739	-0.464	0.100	0.599	-1.626	1.072	-0.751	2.000	2.000	-1.216	-0.100	2.000	0.100	2.000	0.623		2.000	-0.926	-0.825	-0.985	-0.302	-0.249	2.000	2.000
	MET	Southmayd ES	0.177	-1.153	1.607	-0.375	-1.862	-0.487	0.318	1.837	2.000	-0.100	0.529	2.000	0.347	-2.000	1.765		2.000	-0.100	-0.252	-1.051	0.167	0.157	-2.000	2.000
		Herrera ES	0.703	-1.760	2.000	-0.560	-1.508	-0.424	-0.488	1.799	2.000	2.000	-0.181	-1.195	0.872	2.000	1.935		2.000	-0.201	-0.514	-1.645	0.969	1.051	2.000	2.000
		Braeburn ES	1.426	-1.728	1.091	0.182	-1.705	-1.593	-0.477	-0.966	-0.339	2.000	0.812	2.000	0.624	-2.000	0.318		2.000	-1.224	-1.151	-0.362	0.299	0.680	2.000	2.000
9	IR	Milne ES	-1.084	-1.070	2.000	-0.606	-1.390	0.831	-0.855	1.670	2.000	-0.100	-0.380	2.000	-0.197	-2.000	-1.211		2.000	0.338	0.152	0.762	0.160	0.325	2.000	2.000
	MET	Law ES	-0.234	-0.600	1.617	-0.560	-1.331	0.420	-0.392	1.921	2.000	2.000	-0.104	2.000	-0.308	-2.000	1.103		2.000	1.045	1.162	0.591	-0.100	-0.523	2.000	2.000
7	IR	Codwell ES	-1.450	-0.328	0.906	0.135	-1.725	1.856	-1.218	2.000	2.000	-0.100	0.830	2.000	0.163	2.000	-1.790		2.000	0.116	0.446	0.100	-1.060	-0.322	2.000	2.000

Sorted by count of school's factors below HISD average (0.00). Showing bounded Z-Scores. Elementary and secondary schools not compared to each other. White cell indicates data unavailable.

-2.000 2.000

Risk Factors Balance between Treatment and Comparison Schools

Appendix Table 1 shows the descriptive statistics of these risk factors for both the TIF4 and Comparison schools: both group means and standard deviations, and the standardized mean difference (Hedges' **g**, or effect size).

Appendix D Table 1. 2014–2015 Risk Load Factors for Treatment and Comparison Schools

Demographic Variable	Treatment (T)		Comparison (C)		|g|
	Mean	SD (Pts)	**Mean**	SD (Pts)	
Student Variables					
Free/Reduced Lunch Eligible	**88.2**	7.7	**85.8**	9.4	0.27
Black or Hispanic	**97.9**	1.9	**95.1**	6.4	0.47
English Language Learner	**28.7**	19.5	**40.0**	19.9	0.57
Immigrant	**1.9**	3.3	**3.3**	3.7	0.39
Asylee/Refugee	**0.70**	1.7	**0.60**	1.9	0.05
Special Education	**7.9**	2.3	**7.1**	3.1	0.27
Gifted/Talented	**7.9**	3.9	**12.5**	7.3	0.67
Family Variables					
Child Protective Services	**0.06**	0.2	**0.01**	0.0	0.57
Homeless/Housing Insecure	**1.3**	3.2	**0.7**	0.8	0.44
Student Mobility	**27.3**	5.3	**25.9**	6.7	0.21
School Environment Variables					
Chronically Absent	**8.1**	4.6	**5.6**	3.8	0.65
Suspended Once or More	**8.9**	11.1	**5.2**	8.2	0.43
If Ss left > Ss transferred in (1/0)	**0.71**	0.5	**0.66**	0.5	0.11
Student Safety Score †	**64.3**	9.8	**64.2**	17.3	0.00
Teacher Turnover, 2014 to 2015	**33.9**	12.7	**26.6**	13.2	0.56
Mid-Year Teacher Vacancies	**0.01**	0.0	**0.01**	0.0	0.18
Principals (Count), 2011 to 2015	**2.1**	0.9	**2.0**	0.9	0.10
Neighorhood Variables					
Children in Poverty	**46.2**	11.4	**41.1**	14.7	0.35
HS Grad or Less	**64.7**	11.9	**60.4**	19.5	0.23
Neighborhood Poverty	**31.6**	8.1	**28.6**	10.0	0.31
Adults in Workforce	**87.2**	4.0	**89.4**	4.3	0.51
Unemployed Men, Age 20-64	**12.6**	5.3	**10.3**	4.9	0.45
If Public Housing in Zone	**0.10**	0.3	**0.15**	0.4	0.15
If Homeless Shelter In Zone	**0.19**	0.4	**0.23**	0.4	0.09
Number of Schools Per Group					
Elementary	18		114		132
† Secondary	3		13		16
Total	21		127		148

Data Source Abbreviations in "A Better Picture of Poverty"

- ACS: American Community Survey 5 Year Estimates, 2010–2014, from the US Census Bureau (Tract)
- City: The City of Houston's Housing and Community Development Department.
- HRIS: Houston ISD's Human Resource Information Systems.
- PEIMS Snapshot: The Public Education Information Management System (PEIMS) encompasses all data requested and received by TEA about public education, including student demographic and academic performance, personnel, financial, and organizational information. Data from the October 31, 2014 "PEIMS Snapshot".
- TAPR: Texas Academic Performance Report (TAPR) 2014–2015.
- SIS: Student Information System, called Chancery. SIS "At Risk" Report from HISD Federal and State Compliance Department.
- YourVoice: A customer satisfaction survey conducted by HISD vendor RDA (2013, 2014, 2015). Student survey items must have a 50% response rate to be included and reported.

Student Variables in "A Better Picture of Poverty"

1. Free/Reduced Lunch Eligible. Percentage of school's students enrolled at the PEIMS snapshot who received free or reduced-price lunch subsidies under the Richard B. Russell National School Lunch Act, or are considered to be economically disadvantaged by the Texas Education Agency. Source: TAPR 2014–2015, from PEIMS Snapshot.
2. Black or Hispanic. Percentage of school's students enrolled at the PEIMS snapshot who are identified as belonging to one of the following groups: African American, or Hispanic. Source: TAPR 2014–2015, from PEIMS Snapshot.
3. English Language Learner (ELL). Percentage of school's students enrolled at the PEIMS snapshot identified as participating in programs for English language learners (ELL). Students are identified as ELL by the Language Proficiency Assessment Committee (LPAC). Source: TAPR 2014–2015, from PEIMS Snapshot.
4. Immigrant. Percentage of school's students enrolled at the PEIMS snapshot identified as Immigrants. Source: PEIMS Snapshot.
5. Asylee/Refugee (Secondary only). Percentage of school's students enrolled at the PEIMS snapshot whose initial enrollment in a school in the United States in grades 7 through 12 was as an unschooled asylee or refugee per Texas Education Code (TEC) Section 39.027(a-1). Source: PEIMS Snapshot.
6. Special Education. Percentage of school's students enrolled at the PEIMS snapshot identified as students with disabilities. Students are placed in special education by their school's Admission, Review, and Dismissal (ARD) committee. Source: TAPR 2014–2015, from PEIMS Snapshot.
7. Students NOT identified as Gifted/Talented: Percentage of school's students enrolled at the PEIMS snapshot who are NOT identified and served in state-approved gifted and talented programs. Source: TAPR 2014–2015, from PEIMS Snapshot.

Family Variables in "A Better Picture of Poverty"

8. Child Protective Services. Percentage of students removed from the school by Department of Family and Protective Services (a.k.a. Child Protective Services) during the school year. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.
9. Homeless/Housing Insecure. Percentage of school's students enrolled at the PEIMS snapshot who are qualified for at-risk status due to either being flagged as homeless or having residential placement. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.
10. Student Mobility. Percent of school's students who have been in membership at a school for less than 83% of the school year (missed six or more weeks). Source: TAPR 2014–2015.
11. Chronically Absent. Percentage of school's students enrolled at the PEIMS snapshot who missed 18 or more days of school. Source: Barbara Bush Foundation for Family Literacy, 2014–2015 Data.
12. Suspended Once or More. Percentage of school's students enrolled at the PEIMS snapshot who attend at least one day in a school who received at least one In-School Suspension or Out-of-School Suspension during the school year. Source: SIS "At Risk" Report from HISD Federal and State Compliance Department.
13. If Ss left > Ss transferred in. A binary variable (1/0) capturing whether (1) or not (0) more students left the school than joined the school throughout the year. Source: HISD Demographer in Student Support Services.

14. Student Safety Score (*Secondary only*). Percentage of student respondents who "agree" or "strongly agree" with the statement, *"Overall, I am satisfied that my school is safe and secure".* Source: YourVoice Survey.
15. Teacher Turnover, 2014 to 2015. Percentage of teachers *not* retained at the same campus from the 2013–2014 school year to the 2014–2015 school year. Source: HRIS.
16. Mid-Year Teacher Vacancies. Percentage of teaching positions vacant at the campus on December 1, 2015, as a percentage of total possible teacher population for that campus. Source: HRIS.
17. Principals (Count), 2011 to 2015. Number of unique principals at the school over the previous five years. Source: HRIS.

Neighborhood Variables in "A Better Picture of Poverty"

18. Children in Poverty. Percentage of school's zoned census tract residents ages 18 and younger who live in households below the federal poverty level. Source: ACS.
19. HS Grad or Less. Percentage of school's zoned census tract residents ages 25 and older who attained less than or equal to high school graduation (i.e., no additional formal education after high school). Source: ACS.
20. Neighborhood Poverty. Percentage of school's zoned census tract residents (all ages) who live in households below the federal poverty level. Source: ACS.
21. Adults in Workforce. Percentage of school's zoned census tract residents ages 16 and older who are employed in the civilian labor force. Source: ACS.
22. Unemployed Men, Age 20-64. Percentage of school's zoned census tract male residents ages 20 to 64 who are not employed. Source: ACS.
23. If Public Housing in Zone. Binary variable capturing whether (1) or not (0) a school has Public Housing zoned for attendance. Source: City.
24. If Homeless Shelter in Zone. Binary variable capturing whether (1) or not (0) a school has a homeless shelter zoned for attendance. Source: City.

Appendix E: More on the Methods

Limitations

As illustrated in **Table 1, Table 2,** and **Appendix D Table 1,** the two groups of schools (TIF4, and Comparison) are unequal at baseline along several variables that could affect student outcomes. This does somewhat constrain the generalizability of the findings. Some of these variables were included as controls in the model assessing causal impact (see below). The small sample size for schools serving grades 6–8 (*n*=21) and the resulting degrees of freedom limited the possibilities of adding covariates to the regression model to better account for these baseline differences.

STAAR Performance Levels and STAAR Scale Scores

The first analysis in this report addresses the trends in students' performance levels over the grant period. The cut scores for these performance levels are determined annually by the Texas Education Agency (TEA), and reflect a student's mastery of the content for their current grade level. Under the category definitions revised for 2016–2017 and published in April 2017, the TEA's definitions indicate the following for STAAR in grades 3–8:

- Masters Grade Level (previously Level III: Advanced): "Performance in this category indicates that students are expected to succeed in the next grade or course with little or no academic intervention. Students in this category demonstrate the ability to think critically and apply the assessed knowledge and skills in varied contexts, both familiar and unfamiliar."
- Meets Grade Level (previously Level II: Satisfactory at Final Standard). "Performance in this category indicates that students have a high likelihood of success in the next grade or course but may still need some short-term, targeted academic intervention. Students in this category generally demonstrate the ability to think critically and apply the assessed knowledge and skills in familiar contexts."
- Approaches Grade Level (previously Level II: Satisfactory Phase-In 1 and Level II: Satisfactory 2016). "Performance in this category indicates that students are likely to succeed in the next grade or course with targeted academic intervention. Students in this category generally demonstrate the ability to apply the assessed knowledge and skills in familiar contexts."
- Did Not Meet Grade Level (previously Level I: Unsatisfactory): "Performance in this category indicates that students are unlikely to succeed in the next grade or course without significant, ongoing academic intervention. Students in this category do not demonstrate a sufficient understanding of the assessed knowledge and skills." (Student Assessment Division, 2017)

In consultation with technical assistance providers, HISD's TIF4 project staff determined that the STAAR performance levels were insufficiently rigorous for an investigation of the causal impact of TIF4 because these cut scores changed each year (Shakman, Wogan, Finster, & Milanowski, 2016). Nevertheless, the per-school category counts (or percentages) of students were important to the TIF4 programming for specific purposes: in addition to being used in each school's annual accountability measures from TEA, they were used in the project measures reported annually to USDE.

After considering two other possible dependent variables (Index 2 Student Progress scores from campus-level TEA accountability, and TEKS-level analysis of student achievement), the decision was made to examine the scale scores that underpin the TEA's annual cut scores for performance levels. Consequently the findings of the causal impact analyses were not affected by the TEA's changes in cut scores. For more information on scale scores, see the *STAAR Vertical Scale Technical Report* (Student Assessment Division, 2013).

Modeling the Causal Impact of TIF4 on Math and Science

The model used to evaluate the causal impact of the TIF4 program can be expressed as follows:

$$y_{jt} = \beta_{0j} + \beta_{1t} + \beta_{2t}TIF_j + \beta_{3t}X_{jt} + \varepsilon_{jt}$$

In this model,

- y_{jt} is the average STAAR score in science or mathematics at school *j* in year *t*;
- β_{0j} is a fixed effect for school *j*;
- β_{1t} is a fixed effect for year *t*;
- TIF_j is an indicator variable that equals 1 if school *j* is a participant in the TIF4 program and 0 if school *j* is a comparison school; and
- X_{jt} is a vector of characteristics of school *j* in year *t*.

Note that the coefficients β_{2t} and β_{3t} are year-specific. Of particular interest are the coefficients β_{2t}, which measure the impact of participation in TIF4 in year *t*. Since the TIF4 program had not been implemented in the baseline year (2013), we constrain β_{2t} to equal zero in that year (i.e., $\beta_{2,2013}$ = 0). Consequently, the interpretation of β_{2t} in years after the baseline year (i.e., the interpretation of $\beta_{2,2014}$, $\beta_{2,2015}$, $\beta_{2,2016}$, and $\beta_{2,2017}$) is the cumulative impact of the TIF4 program over the course of its having been implemented for (*t* - 2013) years. For example, the coefficient $\beta_{2,2016}$ is the impact on student achievement of a school having participated in the TIF4 program for three years.

The model is estimated by regressing y_{jt} on a full set of school dummies; a set of year dummies with the baseline year (2013) omitted; interactions between TIF4 status and year dummies (with baseline year omitted); and interactions between school characteristics and year dummies (with baseline year included if the school characteristic is time-variant, omitted if time-invariant). This approach produces estimates of the cumulative impact of TIF4 one year ($\beta_{2,2014}$), two years ($\beta_{2,2015}$), three years ($\beta_{2,2016}$), and four years ($\beta_{2,2017}$) after baseline. The significance of these can be tested individually ($\beta_{2,2014} = 0$, $\beta_{2,2015} = 0$, etc.) or jointly ($\beta_{2,2014} = \beta_{2,2015} = \beta_{2,2016} = \beta_{2,2017} = 0$).

The regression is estimated by ordinary least squares over data sets that are separate by grade and subject but pooled across years. A total of eight regressions are estimated: two in which the outcome variable y_{jt} is average science STAAR score (one each for grades five and eight, the grades in which science is tested); and six in which y_{jt} is average mathematics STAAR score (one each for grades three through eight). The data sets over which each of these eight regressions are estimated include a separate observation for each school for each year from 2013 to 2017. Coefficient standard errors are estimated with clustering by school.

When the outcome variable y_{jt} is average STAAR science or mathematics scores in grades three through five, the school characteristics in X_{jt} include, by school and year:

- average STAAR reading scores by school for that grade and year;
- percent African-American by school and year,
- percent limited English proficient by school and year,
- percent students with disabilities by school and year,
- percent economically disadvantaged by school and year; and,
- percent of students immigrant by school.

Of these, all but the percentage of immigrant students are measured yearly and are time-variant. (See **Appendix D** for details on the sources of these variables.)

When the outcome variable y_{jt} is average STAAR science or mathematics scores in grades six through eight, the school characteristics vector X_{jt} is made up of a more parsimonious set of variables:

- average STAAR reading score by school and year,
- percent African-American by school and year, and

- percent limited English proficient by school and year.

In these grades, the data set is substantially smaller, both in terms of the number of TIF4 schools (3) and the number of comparison schools (13). Including the full set of control variables in these grades substantially reduced the precision of the estimated impacts of TIF4, usually without substantively changing the point estimates.

Average STAAR scores in science, mathematics, and reading are normalized using the mean and standard deviation of STAAR scores across students in Texas by subject, grade, and year. This improved the comparability of the outcome variable y_{jt} from one year to the next. It also produced more easily interpreted estimates of the β_{2t} coefficients that are measured in standard deviations of student-level achievement.

When the outcome variable is STAAR mathematics, the year 2015, which was the first year of a transition to new state mathematics standards, is omitted from the data set. As a result, we do not estimate the impact of TIF4 on mathematics outcomes in 2015, two years out. This does not affect the ability to measure the impact of TIF4 one year (2014) or three or four years (2016, 2017) after implementation.

Technical Details on Specific Grade/Subject Models

Fifth Grade Science

In fifth-grade science, the improvement in science STAAR scores among students in TIF4 schools is statistically significant. We can reject at the .003 level the hypothesis that there is no impact from TIF4 over the four years of implementation. The fifth-grade result is robust to changing the specification of the model to include no variables at all, to including only average STAAR reading scores, and to only including school characteristics other than STAAR reading scores in X_{jt}. In all of these specifications, we can reject the hypothesis of no impact from TIF4 at the .025 level or better.

Eighth Grade Science

The evidence in eighth-grade science is less compelling, even given the substantive point estimate of the impact of the TIF4 program. This is because the sample of schools is sufficiently small that even a substantive measured impact is not necessarily statistically significant. The *p*-value of an *F*-test of the hypothesis that there is no effect from TIF4 on eighth-grade science achievement is p=0.09. This means that, if there were no effect from the TIF4 program at all, the probability that there would be a difference in achievement between students in TIF4 schools and in non-TIF schools of the size that we observe in the data is about nine percent. This does not meet the conventional significance threshold of $p \leq 0.05$, although it does meet the more permissive threshold of $p \leq 0.10$. While this level of statistical significance is not as compelling, these results are nonetheless suggestive that the TIF4 program had an impact on eighth-grade science achievement.

As mentioned above, the eighth-grade model includes a more parsimonious set of school characteristics than the fifth-grade model. More specifically, the fifth-grade model includes percent free and reduced-price lunch, percent students with disabilities, and percent immigrant, while the eighth-grade model does not. Adding these variables to the eighth-grade model yields point estimates of the impact of TIF4 similar to those from the more parsimonious model presented in Figure 1. However, it also increases the *p*-value of the hypothesis of no impact from TIF4 to p=0.37, which is not statistically significant at any conventional level. The combination of a substantially lower *p*-value but not substantively different point estimates suggests that the estimated eighth-grade science model with additional school characteristics is too imprecise to yield useful information about the robustness of the more parsimonious model's estimate of the impact of the TIF4 program.

In contrast, simplifying the specification of the eighth-grade science model to include only average STAAR reading scores produces similar point estimates with a *p*-value of .04, and removing all variables also produces similar point estimates with a *p*-value of 0.02. Both of these *p*-values are sufficiently low to reject the hypothesis of no impact from TIF4 at conventional levels, although both results also do not control for any improvements over time among schools with specific characteristics relative to other schools, or for the effects of any changes over time in the characteristics of TIF4 schools relative to non-TIF4 schools.

Sixth Grade Mathematics

As shown in **Figure 16**, the point estimates suggest a substantive impact in sixth-grade mathematics — a cumulative impact over the four years of about a fifth of a standard deviation. However, the estimates are not sufficiently precise to be statistically significant at conventional levels; an F-test of the hypothesis that the impact of TIF4 in all four years is zero has a *p*-value of 0.42.

Seventh Grade Mathematics

The TIF4 program in seventh grade mathematics has an immediate effect of about one-fifth of a standard deviation of student achievement starting in its first year, which increases slightly to about a quarter of a standard deviation in the third year of TIF4. (Recall that we do not measure the effect in the second year, given that we do not include 2015 mathematics scores as an outcome due to the change in mathematics standards at that time.) In the fourth year, the cumulative impact of the TIF4 program ticks upward to about half of a standard deviation of student achievement. This would be a very large impact: a half-standard-deviation increase would improve the achievement of a student at the 25th percentile to the 43rd percentile; that of a student at the 50th percentile to the 69th percentile; and that of a student at the 75th percentile to the 88th percentile. An impact this great may in part be the result of randomness, which is evidenced by the wide two-standard-error confidence intervals around the point estimates of the impact. One way to check this is to see if this uptick persists into the following year; however, given that test scores and statewide documentation for 2018 were not available, we cannot know if this is the case or not.

Regardless, it is unlikely that the impact of TIF4 on seventh-grade mathematics achievement is zero. We can reject the hypothesis that all of the TIF4 program effects across years are zero at the 0.001 level. This result is robust to four different specifications:

- to removing all school characteristics from the model;
- to including only average STAAR reading scores;
- to including all school characteristics described above other than average STAAR reading scores; and
- to adding the school characteristics included in the elementary school models but not in the middle school models (percent students with disabilities, percent free- and reduced-price lunch, and percent immigrant).

In all these specifications, the point estimates of the impact of TIF4 are substantially positive and statistically significant (i.e., we can reject the hypothesis that the TIF4 programs had no effect at the $p \leq 0.005$ level).

Eighth Grade Mathematics

In eighth grade mathematics, we see achievement dip among TIF4 schools relative to non-TIF schools in the first year, only to recover in the third year to a level of about one-quarter of a standard deviation higher among TIF4 schools than among non-TIF schools, and to further improve to about four-tenths of a standard deviation higher in the fourth year.

An additional variable, equal to the percentage of eighth-grade students attempting the algebra assessment in lieu of the eighth-grade mathematics assessment, is added to X_{jt} when the outcome variable y_{jt} is average STAAR mathematics scores in grade eight. This is to adjust for the distortionary effect on measured eighth-grade mathematics scores that takes place when a disproportionately high proportion of

students do not take the eighth-grade assessment in favor of algebra. The percentage of students taking the algebra exam enters the regression linearly. Entering this percentage into the regression as a quadratic or cubic rather than solely as a linear term does not have a substantive effect on the estimate.

We cannot reject the hypothesis that TIF4 had no effect (p=0.01). This test attributes to TIF4 not only the higher achievement among TIF4 schools in the third and fourth years, but also the lower achievement among TIF4 schools in the first year (2014); this is because it is not a test that TIF4 has a *positive* effect, but more broadly a test that TIF4 has a *nonzero* effect over the four years.

Notably, this 2014 result may also have been impacted by a policy change in testing from 2013 to 2014. In 2013, advanced students in grade 7 who took the Pre-AP math courses were tested in the grade 8 math STAAR. However, in 2014, policy was changed to have them take their grade-level assessment (grade 7 math). This policy change had a positive impact on the grade 7 mathematics results and an adverse impact on the grade 8 results in 2014. (Sondhi, Huang, McCarley, Sage, & Stevens, 2014) It is possible that the TIF4 schools were affected more by this policy change than the Comparison schools, contributing to the 2014 effect.

However, the fourth-year (2017) effect, which has a point estimate of 0.39 and measures the cumulative impact of the TIF4 program over all four years, is statistically significant at conventional levels; testing its significance using a t-test yields a p-value of 0.04. This suggests that, while we do not measure any positive immediate effect in the first year of TIF4, we do measure a substantive and significant cumulative effect by the end of its fourth year. It is useful to note that this result, while suggestive, is not especially robust. In particular, adding percent students with disabilities, percent free- and reduced-price lunch, and percent immigrant reduces the fourth-year effect of TIF4 from a statistically significant point estimate of 0.39 to a statistically non-significant point estimate of 0.07.

Appendix F: Tables

Appendix F Table 1. STAAR Math, Grades 3–5: Mean Scale Score, Std. Deviation, Student Count

	Grade 3 Math		Grade 4 Math		Grade 5 Math	
	TIF4	Comp.	TIF4	Comp.	TIF4	Comp.
2013	1398.0	1438.3	1456.8	1514.8	1514.7	1554.7
	(46.7)	(50.8)	(45.7)	(53.6)	(37.8)	(50.5)
	1,407	10,646	1,498	10,087	1,377	9,675
2014	1405.8	1445.6	1484.2	1531.0	1545.9	1580.6
	(49.1)	(58.1)	(50.1)	(57.2)	(43.7)	(54.9)
	1,406	11,179	1,449	10,225	1,322	9,648
2016	1390.1	1424.0	1491.0	1524.4	1533.9	1567.2
	(34.3)	(51.3)	(48.5)	(54.1)	(46.1)	(54.0)
	1,561	12,059	1,558	10,922	1,498	10,919
2017	1407.6	1442.4	1504.3	1542.5	1562.5	1596.8
	(49.0)	(54.9)	(62.9)	(56.8)	(44.3)	(54.2)
	1,459	11,693	1,581	11,302	1,477	10,724

- Mean campus scale scores were calculated by year and grade for the STAAR 3–5 mathematics tests. Campus, subject, and grade-level results with fewer than five testers were excluded. Results from first administration English and Spanish test versions were used to calculate the mean campus scale scores. Prior to 2016, the following test versions were excluded from mean campus scale scores: STAAR-L, M, Accommodated, Alternate, and Alternate 2. The scale scores of all students with "S" codes were used. In 2016, the test versions STAAR-L, Accommodated, and Alternate 2 were excluded from mean campus scale scores. In 2017, the STAAR Alt. 2 test version was excluded from mean campus scale scores. (McCarley, Ye, Selig, & Stevens, 2013, 2014; Reeves, Bigner, & Stevens, 2016, 2017; Reeves, Carney, & Stevens, 2015)
- 2015 STAAR Math scores are not shown since they were not used in this analysis

Appendix F Table 2. STAAR Science, Grades 5 and 8: Mean Scale Score, Std. Deviation, Student Count

	Grade 5 Science		Grade 8 Science	
	TIF4	Comp.	TIF4	Comp.
2013	3506.4	3671.3	3547.0	3718.9
	(104.6)	(160.9)	(159.9)	(278.5)
	1,414	9,773	570	1,972
2014	3555.1	3662.7	3501.3	3763.2
	(130.3)	(181.0)	(122.8)	(424.6)
	1,355	9,747	561	2,159
2015	3533	3622	3480	3632
	(159.4)	(155.7)	(90.1)	(343.8)
	1,430	10,121	577	2,183
2016	3625	3676	3630	3657
	(110.3)	(167.7)	(101.7)	(392.4)
	1,495	10,897	672	2,242
2017	3664	3735	3612	3663
	(145.4)	(183.6)	(140.5)	(411.4)
	1,475	10,737	674	2,169

- Mean campus scale scores were calculated by year and grade for the STAAR science tests for grades 5 and 8. Campus, subject, and grade-level results with fewer than five testers were excluded. Results from first administration English and Spanish test versions were used to calculate the mean campus scale scores. Prior to 2016, the following test versions were excluded from mean campus scale scores: STAAR-L, M, Accommodated, Alternate, and Alternate 2. The scale scores of all students with "S" codes were used. In 2016, the test versions STAAR-L, Accommodated, and Alternate 2 were excluded from mean campus scale scores. In 2017, the STAAR Alt. 2 test version was excluded from mean campus scale scores. (McCarley, Ye, Selig, & Stevens, 2013, 2014; Reeves, Bigner, & Stevens, 2016, 2017; Reeves, Carney, & Stevens, 2015)

Appendix Table 3. Math, Grades 6–8: Mean Scale Score, Std. Deviation, Student Count

	Grade 6 Math		Grade 7 Math		Grade 8 Math	
	TIF4	Comp.	TIF4	Comp.	TIF4	Comp.
2013	1533.3	1566.4	1516.1	1559.4	1620.0	1635.3
	(31.9)	(61.9)	(8.7)	(27.5)	(9.9)	(37.8)
	568	2,107	482	1,610	584	1,964
2014	1551.6	1578.4	1556.4	1570.1	1607.5	1633.5
	(22.2)	(75.4)	(22.7)	(32.0)	(27.0)	(36.6)
	588	2,026	586	2,116	534	1,797
2016	1584.5	1582.0	1580.8	1586.8	1630.0	1597.0
	(44.9)	(72.2)	(24.9)	(58.5)	(21.3)	(39.3)
	773	2,122	720	2,151	627	1,924
2017	1567.2	1557.5	1623.4	1587.6	1647.3	1599.2
	(44.4)	(67.8)	(39.3)	(56.9)	(64.5)	(36.8)
	741	2,270	760	2,028	617	1,905

- Mean campus scale scores were calculated by year and grade for the STAAR 6–8 mathematics tests. Campus, subject, and grade-level results with fewer than five testers were excluded. Results from first administration English and Spanish test versions were used to calculate the mean campus scale scores. Prior to 2016, the following test versions were excluded from mean campus scale scores: STAAR-L, M, Accommodated, Alternate, and Alternate 2. The scale scores of all students with "S" codes were used. In 2016, the test versions STAAR-L, Accommodated, and Alternate 2 were excluded from mean campus scale scores. In 2017, the STAAR Alt. 2 test version was excluded from mean campus scale scores. (McCarley, Ye, Selig, & Stevens, 2013, 2014; Reeves, Bigner, & Stevens, 2016, 2017; Reeves, Carney, & Stevens, 2015)
- 2015 STAAR Math scores are not shown since they were not used in this analysis

HOUSTON INDEPENDENT SCHOOL DISTRICT

RESEARCH

Educational Program Report

TEACHER INCENTIVE FUND STEM GRANT IN HOUSTON ISD: A HUMAN CAPITAL APPROACH TO IMPROVING STEM EDUCATION

HISD | Research and Accountability

ANALYZING DATA, MEASURING PERFORMANCE.

2018 BOARD OF EDUCATION

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Teacher Incentive Fund STEM Grant in Houston ISD: A Human Capital Approach to Improving STEM Education

Executive Summary

Program Description

The fourth cohort of the Teacher Incentive Fund federal grant competition ("TIF4") included special consideration for projects that would identify, develop, and utilize master teachers as leaders of STEM education. In September 2012, HISD was awarded a TIF4 grant for $15.9 million to implement a human capital approach to improving STEM education. The TIF4 project schools were among the HISD schools serving grades K–8 with the highest student economic disadvantage and the most risk factors for chronic absenteeism. A human capital approach to strengthening STEM education addressed the TIF4 project schools' need for high-quality supports for student learning, and the systemic challenges to teacher retention, development, and recruitment in hard-to-staff subjects.

The first report in this series provided a descriptive overview of the grant-funded activities and interventions unique to the TIF4 project schools, setting the context for a meaningful discussion of programmatic impact. The second report in the series addressed student outcomes for State of Texas Assessments of Academic Readiness (STAAR) Mathematics (grades three through eight) and STAAR Science (grades five and eight), during the grant period of 2012–2013 to 2016–2017. This report overviews the performance-based compensation strategies implemented through the TIF4 grant, and situates the TIF4 schools in the context of HISD's historic challenges for new teacher retention, effective teacher retention, and the retention of math and science teachers.

Highlights

Key findings in this third report include:

- Overall, HISD paid about ten $5,000 teacher retention bonuses for each $10,000 teacher recruitment bonus (178 Retention vs. 18 Recruitment). In Years Three, Four, and Five, the TIF4 schools retained 75% of their Effective and Highly Effective math and science teachers.
- During the grant period, HISD directed $3,330,781 of federal, state, and local resources into the ASPIRE Award at the TIF4 project schools. Over a thousand (1,012) ASPIRE Awards were paid to educators at the TIF4 campuses during this time. Every TIF4 school had at least one educator who received an ASPIRE Award during the grant.
- By the start of their third year, 46% of new teachers had left the HISD school where they were initially hired. This attrition rate is higher for new math (60.8%) and new science (61.2%) teachers.
- During this period, the top ten percent of HISD schools (90th percentile and upward) annually retained over 80% of all their Effective and Highly Effective teachers, regardless of subject area or years of experience.

This suggests that effective math and science teachers find retention bonuses to be meaningfully more compelling than recruitment bonuses that are twice as expensive and require a longer time commitment. Critically, these are teachers who have already shown success in meeting the needs of students at HISD's hard-to-staff schools. Taken together, these findings strongly suggest that the high turnover among HISD's math and science teachers can be mitigated through investment in retention bonuses for effective and highly effective teachers already working at specific campuses.

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Introduction

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education (USDE) has supported human capital strategies "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science and math. Responding to the national agenda to improve STEM education, in 2012, the fourth cohort of the Teacher Incentive Fund federal grant competition (TIF4) included special consideration for projects designed to improve STEM education by identifying, developing, and utilizing master teachers as leaders of broader improvements (OESE, 2012a).

In September 2012, Houston Independent School District (HISD) was awarded a TIF4 grant for $15.9 million over five years (Award #S374B120011). The human capital strategies supported through TIF4 in Houston continue the successes and strategies of HISD's previous TIF grants (Price & Stevens, 2017), and resemble the strategies undertaken by the other 35 TIF4 grant recipients nationwide (OII, 2015). For more information about the Teacher Incentive Fund grant, see **Appendix A** (p. 25).

HISD was one of six TIF4 grantees to support a "comprehensive approach to improving STEM instruction" as part of their overall human capital strategy (OESE, 2012b). These STEM-specific TIF4 grants were frequently described by USDE staff as TIF4-STEM grantees. A human capital approach to strengthening STEM education addressed the project schools' need for high-quality supports for student learning, and the systemic challenges to teacher retention, development, and recruitment in hard-to-staff subjects. Through the TIF4 grant, HISD supported some activities that addressed teaching and learning across all content areas, and some activities that addressed teaching and learning only within the STEM content areas.

This report is the third in a series, each assessing an aspect of the TIF4 programming at the project schools. The first report provided a descriptive overview of activities and interventions unique to the TIF4 project schools, setting the context for a meaningful discussion of programmatic impact (Price, Provencher, & Stevens, 2018). Under the assumptions guiding the TIF grant program, student outcomes are a function of human capital management inputs — educator recruitment, retention, selection, assessment, professional development and supports, and performance-based compensation (Miller et al., 2015) — as mediated by teaching and learning behaviors. Therefore, the second report addressed student outcomes for the State of Texas Assessments of Academic Readiness, or STAAR, Mathematics (grades three through eight) and STAAR Science (grades five and eight), during the grant period of 2012–2013 to 2016–2017 (Price, Christian, & Stevens, 2018).

This report overviews the performance-based compensation strategies implemented through the TIF4 grant, as well as situates that work in the context of HISD's challenges for teacher retention and mobility. Several factors inform a teacher's decision about where and what to teach — compensation, working conditions, and student characteristics such as race, prior achievement, and economic disadvantage status (Hanushek, Kain, & Rivkin, 2002; Hanushek & Rivkin, 2007). Among the major factors influencing teachers' decisions in the labor market, *compensation* is one of the inputs that can be manipulated programmatically by school or district leadership. Performance-based compensation systems (abbreviated to PBCS in TIF grant documentation) are designed to recognize and financially reward teachers for student metrics associated with their instruction. Compensation strategies are an important component of achieving the district's goals around teacher retention and development.

Within education, it is generally accepted that on average, a more experienced teacher should be considered a more effective educator than a teacher with less experience (Hanushek, Kain, & Rivkin, 2004).

In this context, the exit of an experienced teacher from a specific school will ripple outward to other schools: if experienced teachers do not stay in HISD, then they are often replaced by less-experienced or new teachers. These new teachers, in turn, may not remain in HISD long enough to become experienced teachers themselves, resulting in a cycle where even the highest-need students may frequently be taught by individuals who do not have sufficient expertise to meet their instructional needs. The final components of this report delve into these specific outcomes: new teacher retention, effective teacher retention, and the retention of math and science teachers.

Methods

In July 2012, HISD leadership identified specific schools to receive STEM programming through the TIF4 grant (HISD, 2012). Located in almost every quadrant of Houston (see **Appendix Figure 1**, p. 26), each year, these schools served approximately 7,500 students from pre-kindergarten through eighth grade. Like most of the schools in HISD, the TIF4 project schools were considered "high-need" under the definitions in the U.S. Department of Education's Request for Application (OESE, 2012a). Additionally, the TIF4 project schools each had a persistent track record of underperforming on the science STAAR exams required under the Elementary and Secondary Education Act (NCLB, 2002). Their inclusion in the TIF4 grant was intended to address student learning and achievement in both math and science. The TIF4 project schools were identified based on their need for supports, rather than randomly. Consequently, HISD project staff were precluded from conducting randomized controlled trials, which is considered the most rigorous research design for making causal inferences (Murnane & Willett, 2011).

As a result, these analyses serve as descriptive models of historical behavior, and as explorations of existing trends. None of these analyses are appropriate for supporting causal inference statements about the impact of the TIF4 grant. The datasets, methodology, limitations, and findings for each of these components are described in each section below.

Performance Based Compensation at TIF4 Schools

As part of the grant, specific performance-based compensation strategies for recruitment and retention were implemented for STEM teachers at the TIF4 campuses. These represented a major investment of public resources, and they were an important aspect of the comprehensive TIF4–STEM programming at the project schools that yielded such remarkable effects for student achievement in math and science as presented in the second report of this series.

ASPIRE Award

In January 2007, the Houston Independent School District (HISD) inaugurated the Teacher Performance-Pay Model 2005–2006, becoming the first school district in the nation to implement a performance-pay system of this magnitude based on individual teacher effectiveness. The experience gained in the first year and consultations with national experts and teachers provided the impetus for recommending the improvement and enhancement of the model, which became the ASPIRE Award under the "Recognize" component of the district's comprehensive education-improvement model, Accelerating Student Progress Increasing Results and Expectations (Hui, Mosier, & Bigner, 2018). The HISD Research and Accountability team published an annual program overview and evaluation of the ASPIRE Award during the TIF4 grant period (Zimmerman, Hui, & Mosier, 2017a, 2017b; Zimmerman, Hui, Mosier, & Chang, 2015; Zimmerman, Mosier, & O'Brien, 2014). From 2007 through 2016, the ASPIRE Award program was available to educators, school leaders, and support staff at all HISD schools. The model underwent updates over the years, staying relevant to changes in state assessments, state accountability measures, and available

metrics of teacher performance. For the 2016–2017 school year, this Award was available only to educators and school leaders at HISD schools participating in the TIF4 grant.

The outcomes of the ASPIRE Award program at the TIF4 schools can be measured three ways: in cumulative number of awards, in the consistency with which a school had an award paid, and in the sum of performance-based compensation received by educators at TIF4 project schools.

While the schools represent a wide range of performance along this metric, every TIF4 school had at least one educator who received an ASPIRE Award during the grant period. Over a thousand[i] (1,012) ASPIRE Awards were paid to educators at the TIF4 campuses during this time. This represents an average of 44 Awards per school. As shown in **Figure 1** (p. 7), nine schools saw a more-than-average number of Awards during this period: Garden Oaks Montessori (105), Braeburn ES (102), Southmayd ES (100), Fondren MS (95), Eliot ES (83), Herrera ES (78), Wilson Montessori (67), Burrus ES (50), and Fleming MS (50). The other schools had fewer Awards than the group average of 44. (See **Appendix Table 1**, p. 27, for details.)

The TIF4 grant period covered five ASPIRE Awards. On average, a specific school saw an ASPIRE Award in 3.7 years, or 75% of the time. In none of these five years did an educator at every TIF4 school earn an Award; the number of schools with an Award ranged from 14 schools for 2016–2017 to 20 schools for 2014–2015. A measure of a school's consistency in earning ASPIRE Award-level-metrics, then, is the fraction of these five years in which at least one their educators earned an ASPIRE Award. Thirteen schools were above this group average.

- At 100%, 11 Schools with Awards in five years: Braeburn ES, Burrus ES, Eliot ES, Fleming MS, Fondren MS, Foster ES, Garden Oaks Montessori, Herrera ES, Southmayd ES, Sugar Grove Academy, Wilson Montessori
- At 80%, two schools with Awards in four years: Durkee ES and Law ES

The remaining ten project schools were below the 75% group average in terms of consistency. Not surprisingly, many of the schools whose educators consistently earned an ASPIRE Award are also above the group's per-school average of 44 Awards during the project period. The notable exceptions with below-average performance and above-average consistency are Foster ES (32 Awards in 5 years), Looscan ES (24 Awards in 5 years) and Sugar Grove Academy (14 Awards in 5 years).

As illustrated in **Figure 2** (p. 7), cumulative ASPIRE Award payouts at each school over the five-year grant period range from $403,350 and $330,854 (Fondren MS and Southmayd ES, respectively) to $16,500 and $3,750 (Codwell ES and Mading ES, respectively). Details on each school's payout for each year can be found in **Appendix Table 2** (p. 28). The HISD Research and Accountability team published extensive details on the Awards payout for each year of the TIF4 grant (Hui & Carney, 2016; Hui & Mosier, 2015; Hui, Mosier, & Bigner, 2017, 2018; Mosier & LaSage, 2014). The 2018 analysis covered exclusively the TIF4 project schools.

During the grant period, HISD directed $3,330,781 of federal, state, and local resources into the ASPIRE Award at the TIF4 project schools. As shown in **Figure 3** (p. 8), these resources varied by Award year — from $265,625 in Year Four to $933,508 in Year Two. Aggregated across the five ASPIRE Award payouts, three percent came from state funds ($100,517 from the District Awards for Teacher Excellence Program, or DATE, for Award 2012–2013), 31.2% from federal funds ($1,038,467 from TIF4), and 65.8% from local district funds ($2,191,797 from HISD's general fund). This breakdown is cumulative across all five years, and it does not reflect the sum of HISD's locally funded investment in the TIF4-STEM project.

Figure 1. Cumulative Count of ASPIRE Awards at TIF4 Project Schools, 2012–2013 to 2016–2017

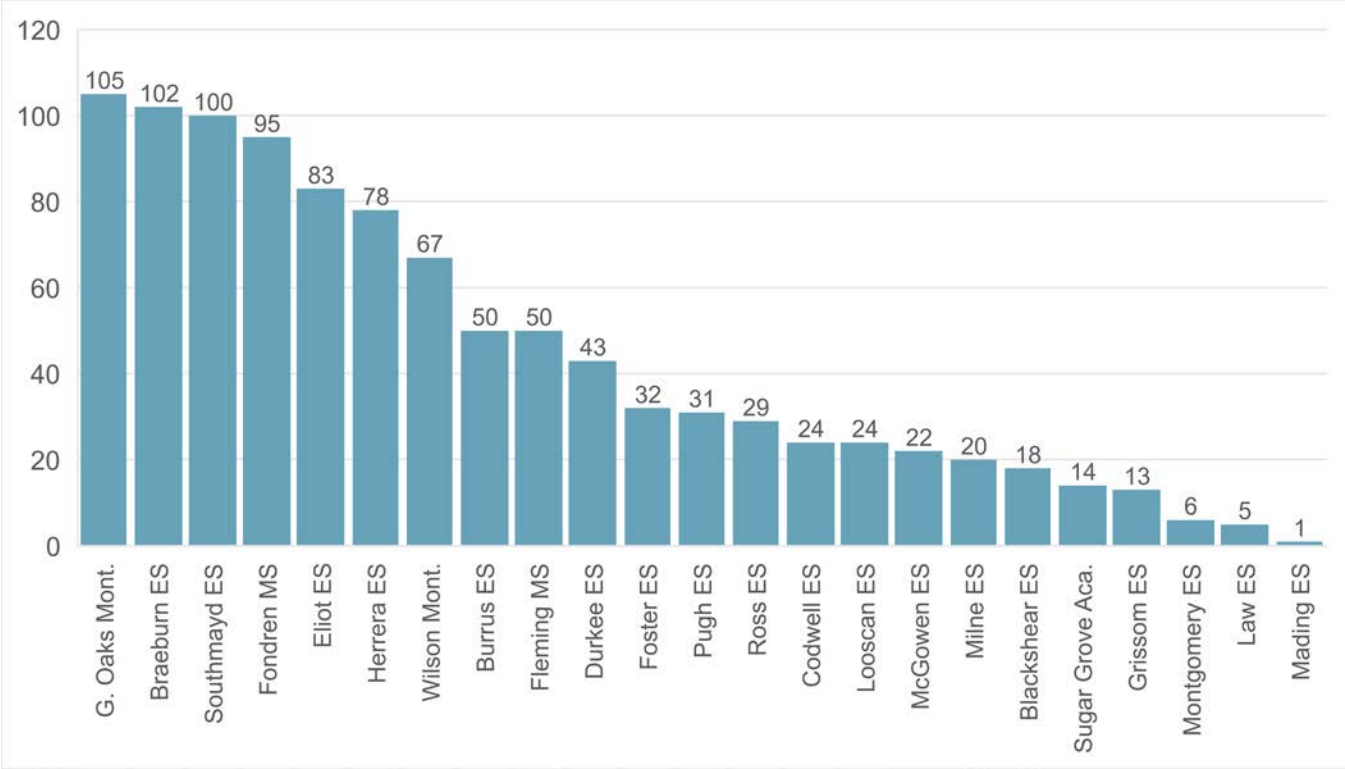
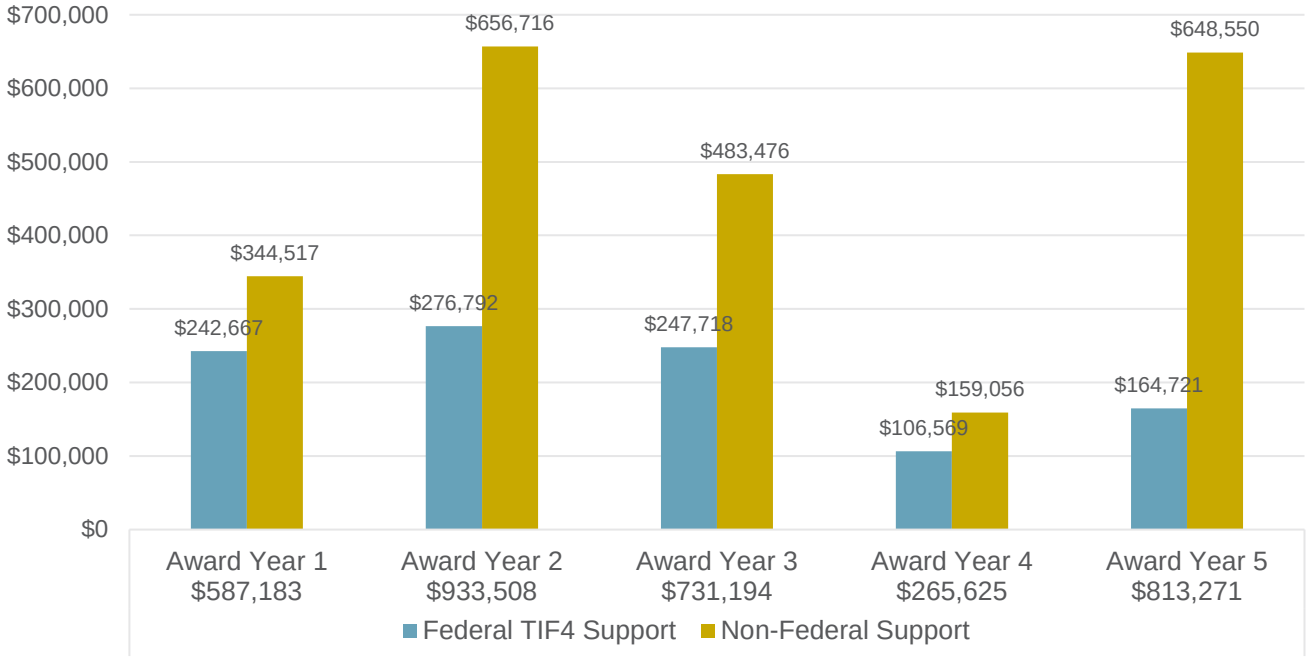


Figure 2. Cumulative ASPIRE Award Payout at TIF4 Project Schools, Awards 2013–2017

Figure 3. Cost Division of ASPIRE Awards at TIF4 Project Schools, Awards 2012–2017



Note: These totals include neither the fringe benefits on this compensation, nor the payout of ASPIRE Awards to campus-based support staff who were not eligible for TIF4 funding. See Appendix B (p.27).

Recruitment and Retention Bonuses for STEM Teachers at TIF4 Project Schools

As noted above, HISD was one of just six TIF4 grantees to support a "comprehensive approach to improving STEM instruction" as part of their overall human capital strategy (OESE, 2012b) — including recruitment and retention bonuses paid to qualifying math and science teachers.

Teachers already at a specific TIF4 project school were eligible for a retention bonus of up to $5,000 if the teacher returned to the same TIF4 campus by the first duty day of the following fall semester; ***and,***

- The teacher was scheduled to teach core foundation courses[ii] for either math or science or both in a STAAR or End of Course (EOC) tested grade and subject for the following academic year; ***and,***
- The teacher was considered Effective or Highly Effective according to the HISD Teacher Appraisal and Development System (TADS) for the most recently available data; this summative rating must include measures of Student Performance; ***and,***
- The teacher had a Student Growth (Education Value-Added Assessment System, or EVAAS) Cumulative Gain Index score for either math or science at or above 1.0 for the most recently available academic year in a STAAR/EOC tested grade and subject; ***or,*** the teacher has at least one teacher-level Comparative Growth metric in the top two quintiles for math or science for the Academic Year 2015–2016 in a STAAR/EOC tested grade and subject (Year Five only).

Teachers working in HISD at a school other than a TIF4 campus were eligible for a Recruitment bonus of up to $10,000 by (a) moving to a TIF4 campus as of the first duty day of the following academic year, (b) meeting the three criteria outlined above, and (c) making a verbal commitment to work at the campus for a five-year period.

Due to the timing of metrics availability vis-à-vis the hiring cycle, new science and math teachers would not have the student-level data required for bonus eligibility until after the conclusion of their second full year in the classroom. To illustrate: in March 2016, HISD administrators identified and notified those HISD

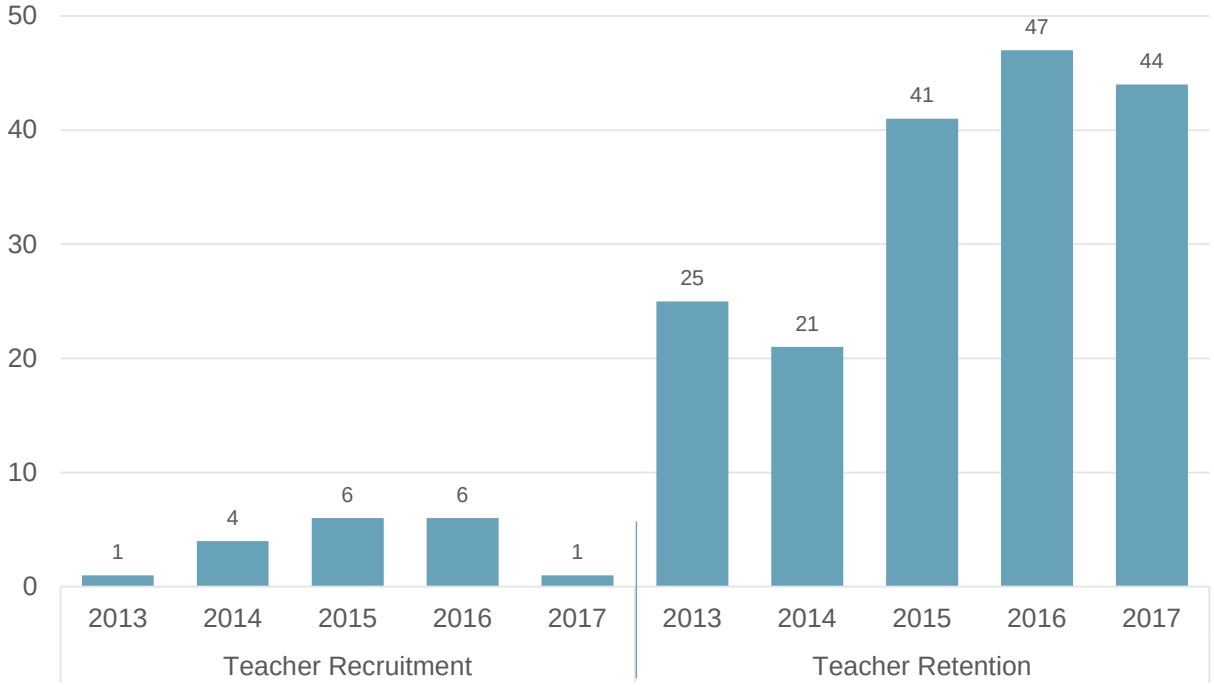
teachers whose documented effectiveness and evaluation criteria indicated they would be eligible for a bonus should they return to their TIF4 campus to teach for the 2016–2017 school year. These teachers were identified before TADS or EVAAS metrics for the current school year were completed, but in time to be relevant to their decisions about where to teach in the following school year. Consequently, the bonuses paid in September 2016 were based on the most recent data available at the time of the identification in March 2016: data from 2014–2015 (finalized in December 2015 for all HISD teachers). Performance metrics from the 2015–2016 school year drove the bonuses paid to teachers identified in March 2017, for bonuses to be paid in September 2017 in support of staffing for the 2017–2018 school year.

In the first two annual cycles of the bonus program, a total of five recruitment and 46 retention bonuses were paid through the TIF4 grant (**Figure 4**). These numbers were meaningfully higher in Years Three, Four, and Five:

- In September 2015, HISD paid six Recruitment and 41 Retention bonuses to eligible TIF4 teachers, or retention of 74.5% of the 55 eligible teachers.
- In September 2016, HISD paid six Recruitment and 47 Retention bonuses to eligible TIF4 teachers, or retention of 85.5% of the 55 eligible teachers.
- In September 2017, HISD paid one Recruitment and 44 Retention bonuses to eligible TIF4 teachers, or retention of 74.6% of the 59 eligible teachers.

Overall, HISD paid about ten retention bonuses for each recruitment bonus (178 vs. 18). Project staff have attributed the relative later success to the realignment of the cycle calendar that took place early in Year Three. Principals at project schools received the names of teachers who would be eligible for a retention bonus if they returned for the following year, as well as the names of all HISD teachers who would be eligible for a recruitment bonus if they were successfully recruited for the following year. Additionally, the teachers currently at TIF4 schools received a communication directly notifying them of their bonus eligibility, should they return for the following year. (See **Appendix C**, p. 29, for a sample.) In Year Three, this direct notification went out in May, in Year Four in April, and in Year Five in March.

Figure 4. TIF4 Recruitment (18) and Retention (78) Bonuses, September 2013 to September 2018



Teacher Retention and Mobility During the TIF4 Grant Period

How long do new teachers stay in HISD?

One of the goals of the TIF4 grant was to improve district-level human capital management systems — consequently, an assessment of district-wide measures is necessary to contextualize the human capital outcomes of the specific TIF4 schools. Project staff conducted a descriptive analysis that followed three cohorts of first-year[iii] teachers in HISD, from their entry into HISD during the 2012–2013, 2013–2014, and 2014–2015 school years. These cohorts of first-year teachers were followed from their first fall semester until the beginning of the 2018–2019 school year. Cohort 1 (originally n=1,581) first entered HISD in 2012–2013, Cohort 2 (originally n=1,666) first entered HISD in 2013–2014, and Cohort 3 (n=1,757) first entered HISD in 2014–2015. This gives a district-level perspective on the three types of movement available to newly hired teachers:

- Returned to Same School Next Year: These individuals were listed as teachers on the same HISD school's employee roster in the fall semester of the following academic year.
- Moved Schools for Next Year: These "mover" individuals were listed as teachers on a different HISD school's employee roster in the fall semester of the following academic year.
- Left District for Next Year: These "leaver" individuals were not listed as teachers on any HISD school's employee roster in the fall semester of the following academic year.

This methodology does obscure those movements that are the result of career development — for example, a teacher who takes on a new role at the same campus as an Assistant Principal is treated as a "leaver". This analytical choice was deliberate because from the district-wide perspective, the promotion creates a vacancy in an instructional position that would otherwise have been filled; even though the promotion may be a positive development for the teacher and for the campus, it is a negative development for the district-wide measures. This is one of the ways in which district-level goals for teacher retention and career development can be in tension with campus-level goals.

Table 1 (p. 11) shows how many cohort-member teachers were employed at the start of each year, and where they appeared in the following year's staffing data. This table can be interpreted as follows: for Cohort 1 in 2012–2013, there were 1,581 first year teachers in HISD. For example, for the year following their first full year of teaching, 1,209 teachers from Cohort 1 returned to teach in the same HISD school, 105 moved to a different school in HISD, and 267 were not employed as teachers on the roster of any HISD school.

These data can also be used to calculate the percentage of teachers in each cohort who returned in the following year to the school where they were initially hired. **Table 2** (p. 11) shows the cohorts' same-school retention for each additional year of their career. For example, 76.47% of teachers hired in the 2012–2013 cohort returned to teach in the same school in 2013–2014. This analysis presents HISD with several trends:

- One year after hiring, an average of 72% of teachers returned to the school where they were initially hired. Inversely, by the start of their second year, nearly 30% of teachers had left the school where they were initially hired.
- Two years after hiring, an average of 54% of teachers returned to the school where they were initially hired. Inversely, by the start of their third year, 46% or nearly half of teachers had left the school where they were initially hired.
- On average, a school that hires a teacher with no years of teaching experience who is also new to HISD has just slightly better than a 50/50 chance of benefiting from that teacher's third year of teaching.
- Across all three cohorts, teacher mobility retention leveled out four years after the initial hire.

These results are presented graphically below in **Figure 5** (p. 12), outlining the magnitude of the challenge at hand.

Table 2 (below) and **Figure 5** (p. 12) do not make the distinction between a teacher's promotion, a teacher's leave of HISD, and a teacher's movement to another school within HISD. While these are relevant distinctions for district-level objectives, from the school's perspective, they are all equally problematic since they each create a vacancy in an instructional position that would otherwise have been filled. This is another example of how campus-level and district-level goals for teacher retention and career development are not always in tight alignment.

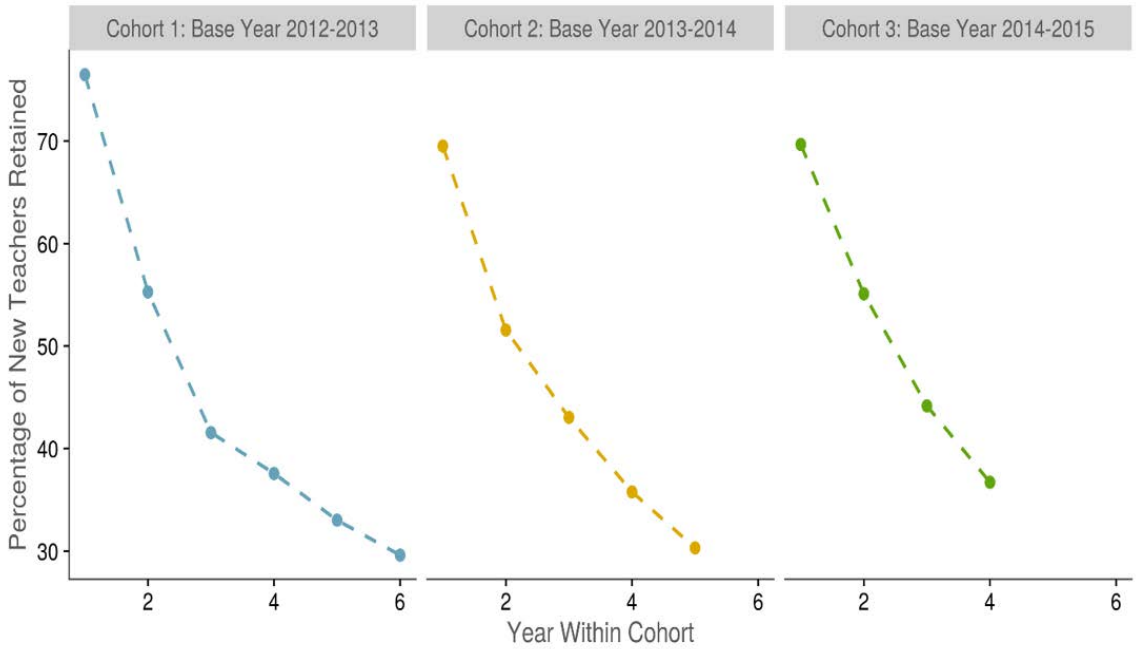
Table 1. Retention and Movement in HISD for Three Cohorts of New Teachers

School Year	Cohort	Count at Beginning of Year	Returned to Same School Next Year	Moved Schools for Next Year	Left Tchr. Roster for Next Year
2012–2013	1	1,581	1,209	105	267
2013–2014	1	1,274	874	111	289
2014–2015	1	930	657	94	179
2015–2016	1	753	594	59	100
2016–2017	1	672	522	54	96
2017–2018	1	572	468	34	70
2013–2014	2	1,666	1,158	120	388
2014–2015	2	1,205	859	116	230
2015–2016	2	973	717	70	186
2016–2017	2	785	596	70	119
2017–2018	2	662	505	63	94
2014–2015	3	1,757	1,224	162	371
2015–2016	3	1,296	968	79	249
2016–2017	3	1,045	776	73	196
2017–2018	3	834	645	68	121

Table 2. Same-School Retention of New Teachers in Three Cohorts, By Year

Years After Hire	Average Cohort SS Retention	Cohort 1 (2012–2013)	Cohort 2 (2013–2014)	Cohort 3 (2014–2015)
1 Year After Hire (a.k.a., start of 2nd year)	72.0%	76.47% (1,209/1,581)	69.51% (1,158/1,666)	69.66% (1,224/1,757)
2 Years After Hire (a.k.a., start of 3rd year)	54.0%	55.28% (874/1,581)	51.56% (859/1,666)	55.09% (968/1,757)
3 Years After Hire (a.k.a., start of 4th year)	42.9%	41.56% (657/1,581)	43.04% (717/1,666)	44.17% (776/1,757)
4 Years After Hire (a.k.a., start of 5th year)	36.7%	37.57% (594/1,581)	35.77% (596/1,666)	36.71% (645/1,757)
5 Years After Hire (a.k.a., start of 6th year)	31.7%	33.02% (522/1,581)	30.31% (505/1,666)	--
6 Years After Hire (a.k.a., start of 7th year)	--	29.60% (468/1,581)	--	--

Figure 5. Within-School Retention of New Teachers in HISD, for Three Cohorts



How long do new math and science teachers stay in HISD?

Research on the STEM teaching workforce has suggested that math and science teaching positions are more difficult to staff than other subject-specific roles. Each year of the TIF4 grant period, the Texas Education Agency (TEA) supported this conclusion by formally naming mathematics and science as "teacher shortage" areas (TEA, 2012, 2013, 2014, 2015, 2016). The next step of analysis repeated the analysis described above, focusing on new math and science teachers, districtwide.

Initial screening for math and science teachers relied solely on job coding in HISD's human resources information system. However, this excluded multi-subject teachers from elementary grades, and over-reported the outcomes of secondary math and science teachers. Ultimately, these teachers were identified by the content area of their courses, as listed in the district's student information system (Chancery). This approach did not exclude elementary teachers, and therefore provided a more comprehensive view of STEM instruction across the district than the initial strategy. There were two tradeoffs: (1) teachers assigned math *and* science courses (e.g., self-contained) were counted in both analyses, even though they only occupy one position, and; (2) the final course assignments for spring semester of 2018–2019 were not yet available, and so the overall analysis period excludes 2018–2019.

Overall, the retention for new math and science teachers is meaningfully less successful than the district-wide average for all subjects (outlined in previous section). The numbers in **Table 3** (p. 13) and **Table 4** (p. 13) show the percentage of new math and science teachers who returned to the same school and subject. Each year, the average cohort retention rate for math and for science teachers is nearly 10 percentage points lower than the cohort's overall same-school retention rate. Three years after hiring, a little over a quarter of the cohort's initial math teachers are still teaching math at their initial school. The rates are similar for new science teachers: less than a third are still teaching science at their original school.

However, even if they stay in the same school, it is possible that a person who is teaching math in their first year is teaching other subject areas in their later years. The school benefits from retaining the teacher in a different role, even if this mobility is considered a loss for subject-specific retention. Consequently, project

Table 3. Same-School and Same-Role Retention of New Math Teachers, by Cohort/Year

Years After Hire	Average Cohort Retention	Cohort 1 (2012–2013)	Cohort 2 (2013–2014)	Cohort 3 (2014–2015)
1 Year After Hire (a.k.a., start of 2nd year)	57.8%	62.91% (380/604)	54.59% (357/654)	56.00% (392/700)
2 Years After Hire (a.k.a., start of 3rd year)	39.2%	42.22% (255/604)	35.47% (232/654)	39.86% (279/700)
3 Years After Hire (a.k.a., start of 4th year)	28.8%	26.99% (163/604)	28.13% (184/654)	31.14% (218/700)
4 Years After Hire (a.k.a., start of 5th year)	23.3%	23.68% (143/604)	22.94% (150/654)	--
5 Years After Hire (a.k.a., start of 6th year)	--	22.85% (138/604)	--	--

Table 4. Same-School and Same-Role Retention of New Science Teachers, by Cohort/Year

Years After Hire	Average Cohort Retention	Cohort 1 (2012–2013)	Cohort 2 (2013–2014)	Cohort 3 (2014–2015)
1 Year After Hire (a.k.a., start of 2nd year)	57.7%	61.43% (336/547)	55.27% (341/617)	56.37% (376/667)
2 Years After Hire (a.k.a., start of 3rd year)	38.8%	40.77% (223/547)	36.14% (223/617)	39.58% (264/667)
3 Years After Hire (a.k.a., start of 4th year)	29.0%	27.79% (152/547)	29.01% (179/617)	30.28% (202/667)
4 Years After Hire (a.k.a., start of 5th year)	29.0%	23.95% (131/547)	21.07% (130/617)	--
5 Years After Hire (a.k.a., start of 6th year)	--	19.56% (107/547)	--	--

staff looked at both kinds of retention for math and science teachers: same-school and same-role, as well as same-school and different role. **Figure 6** (p. 14) shows the same-school retention of those individuals who taught math in their first year who taught math in the following years, while **Figure 7** (p. 14) shows the same-school same-role retention of new science teachers. In both, the rate shown is for Cohort 1. The rates of same-school retention regardless of content area are described in **Appendix Tables 3–4** (p. 30).

Same-school retention for new teachers is relatively low, but this is also the case for more experienced teachers. We also calculated the average number of years any HISD teacher who appeared in the data window stayed at any one school during that time. As shown in **Table 5** (p. 14), the average duration of a teacher's stay at one school over the five-year period was less than three years (2.51), and lower for math and science teachers. Note that this does not mean the average teacher in this window left in the middle of their second year. Rather, it means that the average teacher left either two or three years after initial hiring (for both math and science, more often two years rather than three).

Since project staff did not incorporate information on where the experienced teachers were employed before the beginning of the observation period, these figures underestimate the true total duration of the average HISD teachers' time in one school. However, this does suggest that the average HISD teacher moves relatively frequently, within a given five-year period, and therefore suggests that the stability of the faculty at the typical HISD campus is relatively low. This may hinder a school's ability to build a cohesive faculty that functions as a professional learning community.

Figure 6. Same-School Same-Role Retention for Three Cohorts of New Math Teachers

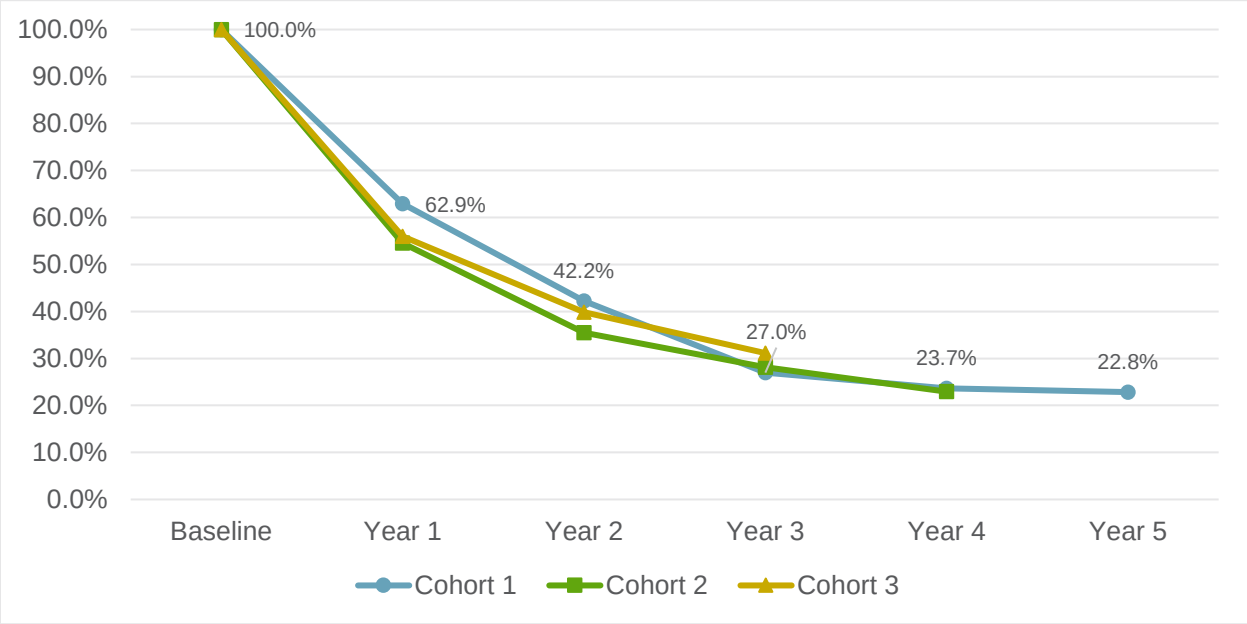


Figure 7. Same-School Same-Role Retention for Three Cohorts of New Science Teachers

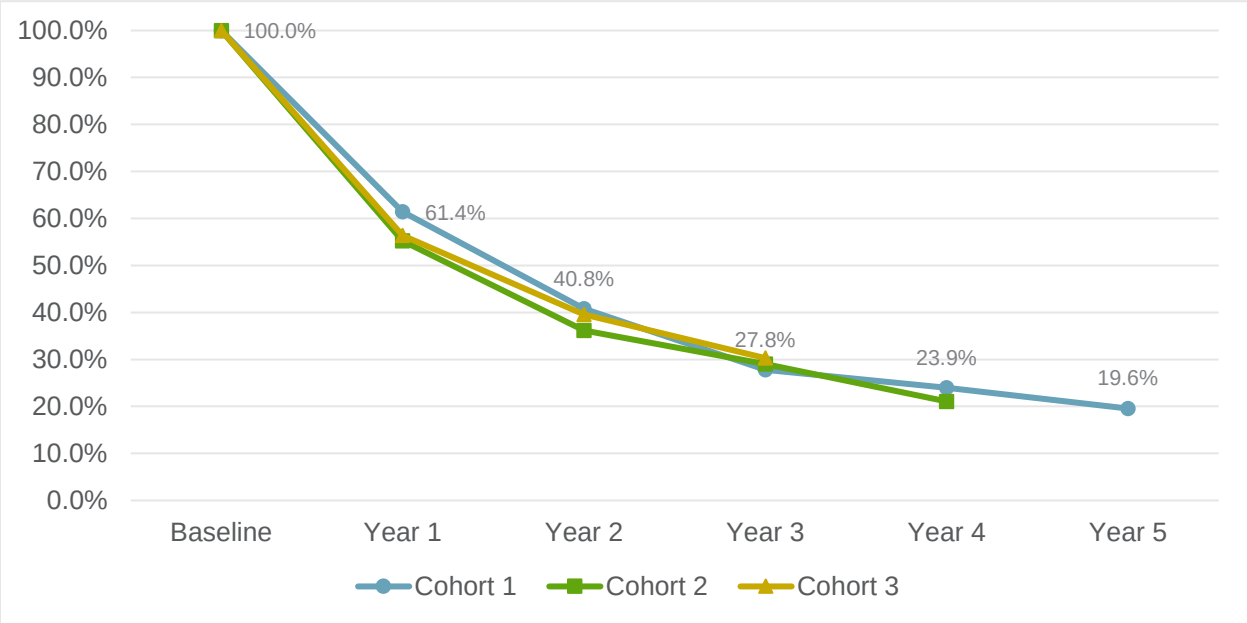


Table 5. Average Number of Years at Same School for HISD Teachers, 2012-2013 to 2017-2018

All Teachers	Math Teachers	Science Teachers
2.51 / 5	2.36 / 5	2.33 / 5

Which HISD schools are especially good at retaining their top teachers?

Teacher turnover has been shown to be detrimental to the quality of instruction, especially in low performing schools (Hanushek, Rivkin, & Schiman, 2016; Ronfeldt et al, 2013). While turnover is likely to be somewhat of an issue in most schools, there may be some schools in HISD that are substantially better at retaining the most effective teachers, even after controlling for those factors outside schools' control that influence teacher turnover. The former can provide HISD leadership with possible models for emulation, while the latter could be targeted for additional support. This is important because not all turnover has the same impact on instruction — because "if effective teachers are less likely to leave than less effective teachers, however, then high levels of teacher attrition may improve rather than decrease the overall quality of the teaching workforce" (Guarino, Santibanez, & Daley, 2006).

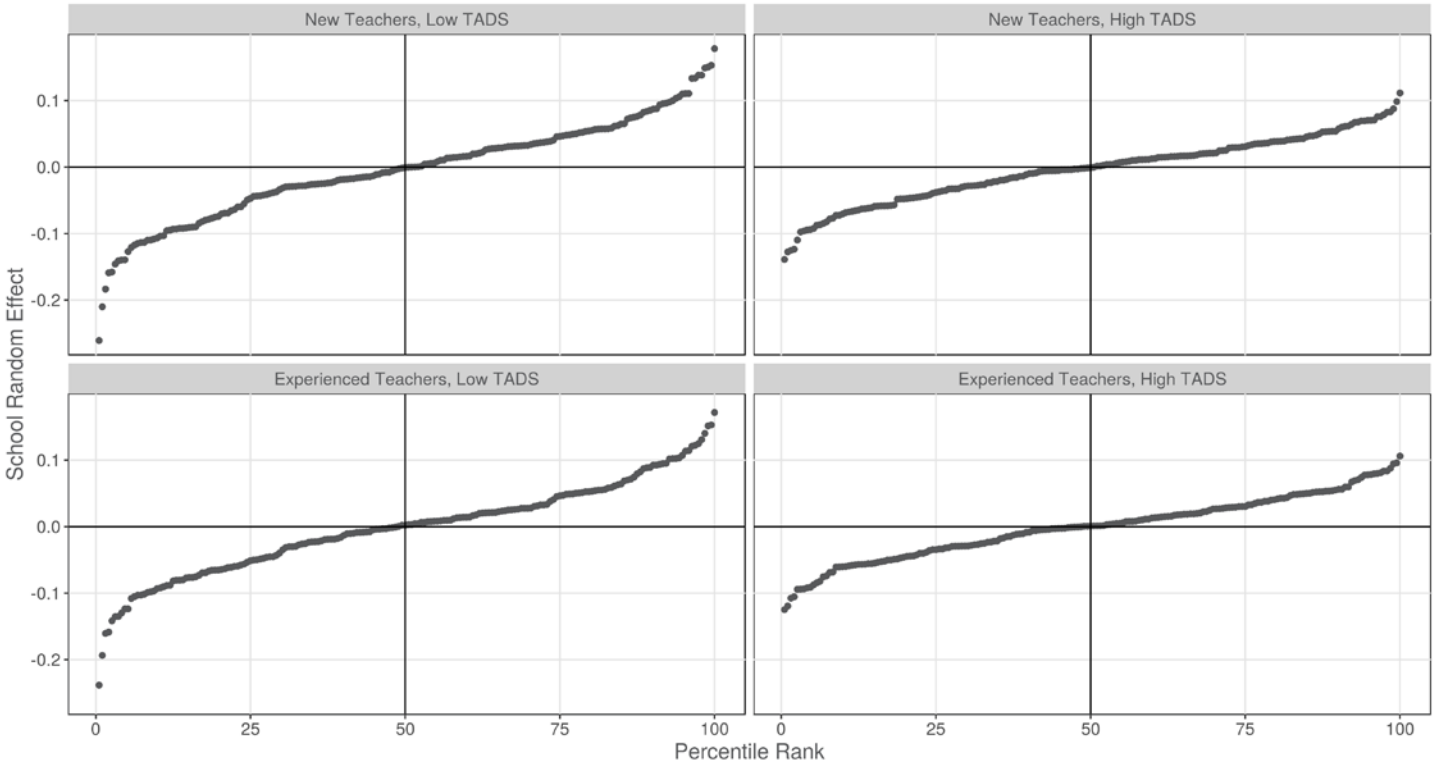
To identify which schools are better than expected at the task of retaining their effective and highly effective teachers, project staff first used five years of employee rosters, school demographics, and teacher appraisal (TADS) data to develop a quantitative model estimating the likelihood that a teacher is retained in that school the following year, given school (percent Hispanic, percent African American, percent economic disadvantage) and teacher (TADS rating, experience level) characteristics that are known from other research to influence teacher turnover (e.g., Borman & Dowling, 2008). This model estimated the unique contribution of the school to teacher retention after removing the effects of year to year variation[iv], and after controlling for the school's student characteristics known from other research to influence teacher turnover — the school's percentage of economically disadvantaged students, Black, Hispanic, Asian, and White students.

The school's random effect, then, is the school's distance from the expected level of retention for schools with similar student populations. Model results were used to derive an estimate of how schools compared to each other in terms of retaining each of the four categories of teachers: New and High TADS, New and Low TADS, Experienced and HIGH TADS, as well as Experienced and Low TADS. (For definitions of each term, see **Appendix E**, p. 31.) This modeling showed that HISD schools do differ substantially in their retention of teachers within each category. **Figure 8** (p. 16) shows the individual schools' random effect on retention, for each of the teacher types:

- Each school is represented on each panel by one dot. These dots are ordered by the size of the effect (vertical axis) and arranged visually from left to right according to their percentile rank (horizontal axis).
- Schools to the right of the 50th percentile on the horizontal axis had a positive effect on teacher retention — meaning that they retained that category of teachers at a higher rate than what was expected.
- Schools to the left of the 50th percentile had a negative effect on teacher retention — meaning that they retained that category of teachers at a lower rate than what was estimated for them.
- At the 50th percentile, the school effect is equal to zero — meaning that those schools retained that category of teacher at the same rate that was estimated for a school with their student characteristics.

Note that there is a greater difference between schools at or above the 75th percentile and those at or below the 25th percentile in retention of low TADS teachers compared to high TADS teachers — in both rows, the dots in the right-hand graphic (High TADS) are more tightly clustered than the dots in the left-hand (Low TADS) graphics.

Figure 8. Same-School Retention for Four Teacher Categories, School Effect and Percentile Rank



Additional analysis showed substantial variation of teacher retention across schools at most levels of these school characteristics, especially at high percentages of economic disadvantage, all percentages of Hispanic students, and low percentages of African American students. These findings are illustrated in **Appendix Figures 2**, **3,** and **4** (**Appendix E**, pp. 31–32). Schools whose dots are above the district-wide trend line are retaining teachers at a higher rate than expected for that demographic factor; schools below the trend line are retaining teachers at a lower rate than expected.

The district-wide trend line in **Appendix Figure 2** (p. 31) shows regardless of whether they are low or high TADS, new teachers are increasingly unlikely to be retained as economic disadvantage rate increases (negative slope), whereas this factor appears to have almost no relation to the retention of experienced high TADS teachers (minimal or totally flat slope). The district-wide trend line in **Appendix Figure 3** (p. 32) shows that the retention of teachers becomes less likely with the increase of each school's percentage of Hispanic students. This is true for all four categories of teachers (four negative slopes).

The district-wide trend lines in **Appendix Figure 4** (p. 32) show a different pattern: the school's percentage of African-American students has a weak relationship to the retention of new and low TADS teachers (minimal or totally flat slope), and a positive relationship to the retention of the three other categories of teacher (three positive slopes).

The left-hand columns of **Table 6** (p. 17) show the eight TIF4 project schools that are above the district average (50th percentile) for their retention of experienced high TADS teachers, as ranked by their estimated school effect on retention. The right-hand columns of the table show the six TIF4 project schools that are above the district average (50th percentile) for their retention of new high TADS teachers, when ranked by their estimated school effect on retention. These schools are represented among the dots above the 50th percentile line in the two High TADS graphs in **Figure 8** (above).

Table 6. Retention of High TADS Teachers: TIF4 Schools Above HISD Average (50th Percentile)

Experienced High TADS Teachers			New High TADS Teachers		
TIF4 School	Effect	Percentile	TIF4 School	Effect	Percentile
Burrus ES	0.043	80.7%	Ross ES	0.068	92.7%
Foster ES	0.035	76.0%	Fleming MS	0.047	84.9%
Ross ES	0.029	72.4%	Foster ES	0.045	84.4%
Law ES	0.029	71.9%	Wilson ES	0.025	70.3%
Braeburn ES	0.028	71.4%	Burrus ES	0.011	57.8%
Codwell ES	0.027	70.3%	Codwell ES	0.008	54.7%
Wilson ES	0.013	59.9%			
Blackshear ES	0.006	54.7%			

Table 7. HISD's Average Estimated Retention Rate by Year, TADS Rating, and Teacher Experience

	Low TADS		High TADS	
Year	Experienced Teachers	New Teachers	Experienced Teachers	New Teachers
2012–2013	0.68	0.69	0.82	0.75
2013–2014	0.64	0.53	0.80	0.72
2014–2015	0.57	0.55	0.79	0.73
2015–2016	0.60	0.56	0.82	0.76
2016–2017	0.63	0.59	0.82	0.75

Table 7 (above) shows the average estimated retention rate by low and high TADS and experienced and new teachers for each year. Overall, the average retention rate is higher for high TADS teachers in all years for both experienced and new teachers. Between experienced and new teachers, there are no measurable differences in the estimated retention rate between low and high TADS teachers. Additionally, the estimated retention rates do not vary significantly by year.

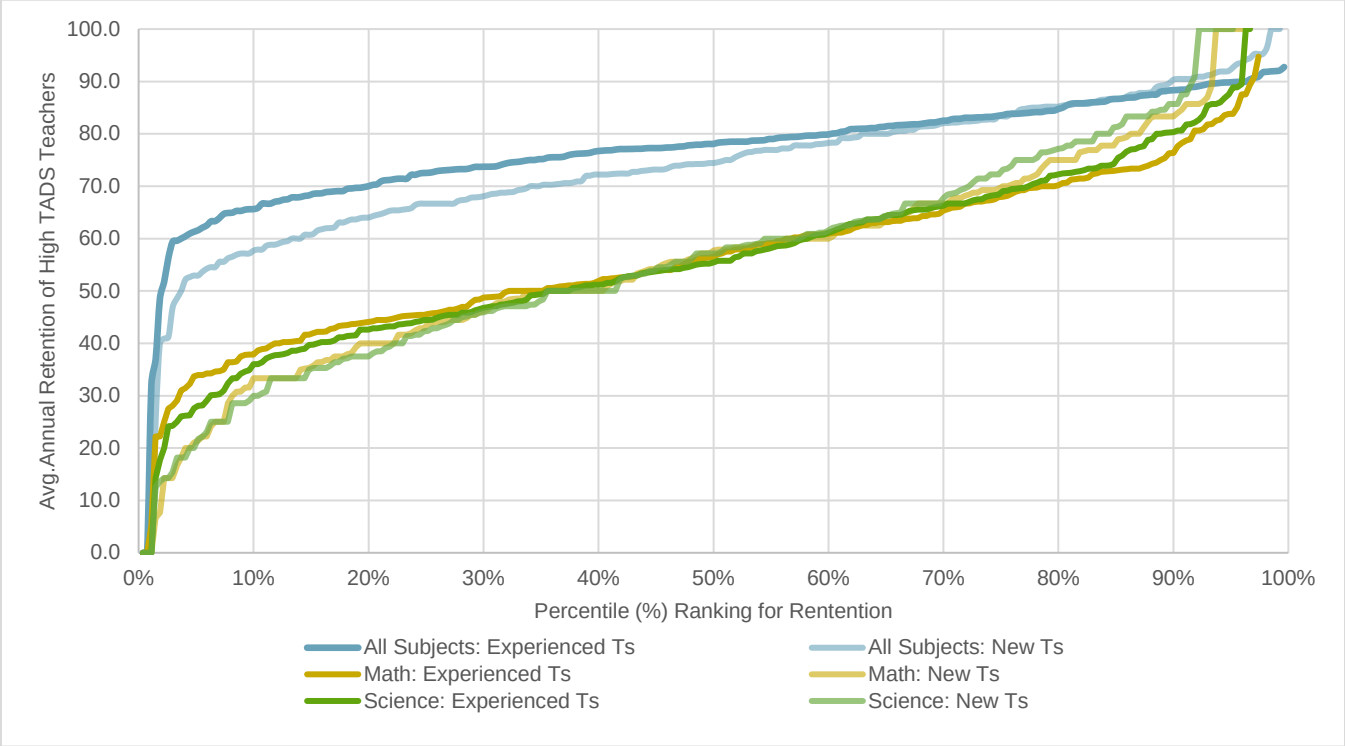
Which HISD schools are especially good at retaining their math and science teachers?

Earlier analysis of teacher mobility (reported above) required the identification of each school's average annual retention of effective and highly effective teachers across all subject areas during the five-year observation window. (See Appendix E for definitions.) This also yielded numbers for each school's average annual retention rates for effective and highly effective math and science teachers. In **Figure 9** (p. 18), these rates have been sorted from low to high (vertical axis), ranked as percentiles (horizontal axis), and plotted close together. The resulting dots illustrate the distribution of retention rates across the district:

- During this period, the top ten percent of HISD schools (90th percentile and upward) annually retained over 75% of all their high TADS teachers, regardless of subject area or years of experience.
- Nearly two-thirds (64%) of HISD's schools demonstrated an annual average retention over 50% for all six groups of high TADS teachers.

In most of HISD's schools, new and high TADS teachers were retained at a lower rate for each of the subject areas than their more experienced counterparts (the light lines are lower than the dark lines for all three subjects until near the 70% mark). This lends further support to the conclusion suggested by **Table 5**: even within the overall challenge of turnover, a school is more likely to experience turnover of their High TADS teachers for math and science than for a general subject.

Figure 9. Historical Retention of New and Experienced Teachers, Comparing Across Subjects



As with the retention of all teachers, the retention of both math (**Appendix Figure 5**, p. 32) and science (**Appendix Figure 6**, p. 33) teachers showed significant variation in the lowest and highest school effects. Again, while student demographics influenced retention, as shown in **Appendix Figures 7–12** (pp. 34–36), there was considerable variation in the retention estimates especially at high levels of school percentage of free/reduced price lunch, low levels of the percentage of African American students, and variation at all levels of Hispanic students. This again suggests that some schools are better at retaining High TADS math and science teachers even when school demographics are similar.

Table 8 (below) shows the nine TIF4 schools above the district average for their retention of experienced, high TADS mathematics teachers, as ranked by their estimated school effect on retention. The right-hand columns of the table show the five TIF4 project schools above the district average for their retention of new high TADS mathematics teachers, also ranked by school effect. **Table 9** (p. 19) shows the same for science.

Table 8. Retention of High TADS Mathematics Teachers: TIF4 Schools Above 50th Percentile

Experienced High TADS Math Teachers			New High TADS Math Teachers		
TIF4 School	**Effect**	**Percentile**	**TIF4 School**	**Effect**	**Percentile**
Eliot ES	0.106	85.0%	**Eliot ES**	0.140	94.7%
Codwell ES	0.093	82.9%	**Southmayd ES**	0.113	89.8%
Garden Oaks	0.067	74.9%	**Ross ES**	0.081	80.2%
Fondren MS	0.053	67.9%	**Garden Oaks**	0.069	76.5%
Sugar Grove Aca.	0.045	64.7%	**Fondren MS**	0.063	74.3%
Ross ES	0.038	61.5%			
Blackshear ES	0.036	59.4%			
Southmayd ES	0.009	55.1%			
Braeburn ES	-0.003	50.3%			

Table 9. Retention of High TADS Science Teachers: TIF4 Schools Above 50th Percentile

Experienced High TADS Science Teachers			New High TADS Science Teachers		
TIF4 School	Effect	Percentile	TIF4 School	Effect	Percentile
Fleming MS	0.124	87.0%	Eliot ES	0.125	95.1%
Sugar Grove Aca.	0.109	83.7%	Sugar Grove Aca.	0.107	88.6%
Codwell ES	0.107	81.5%	Fleming MS	0.107	88.0%
Ross ES	0.077	72.8%	Garden Oaks	0.056	72.8%
Garden Oaks	0.044	66.3%	Ross ES	0.056	72.3%
Burrus ES	0.013	57.1%	Burrus ES	0.048	67.9%
Eliot ES	0.002	51.6%	Herrera ES	0.047	67.4%
			Codwell ES	0.017	58.2%
			Southmayd ES	0.006	53.8%

Fifteen of the 23 TIF4 project schools appear on at least one of these six "above average" lists. As a point of interest, participation in the TIF4 grant might be expected to cause retention of math and science teachers to vary even among schools with similar student demographics. Since the TIF4 project focused on STEM teaching, providing performance-based compensation and retention bonuses to math and science teachers in tested grades and subjects in the grants schools, we might expect that if these interventions influenced math and science teachers' retention decisions, the TIF4 schools would have, on average, larger, more positive school effects.

We found that the differences between the average school random effects on the retention rate for high TADS of TIF4 and non-TIF4 schools were small, and in favor of the TIF4 schools only for math and science teachers with three or fewer years of experience. **Table 10** (below) shows the average school effects in percentage points for high TADS new and experienced teachers. A positive difference shows where TIF4 schools on average had higher retention, a negative difference shows where TIF4 schools had lower retention than non-TIF4 schools.

Note that this analysis is not a specific test of the effect of the TIF intervention on retention. An analysis at the teacher level (rather than the school level) might show different results for several reasons. First, schools are weighted the same regardless of size. Second, the retention rate includes both teachers that have received retention bonus or performance-based pay and those that did not. Third, this analysis does not control for other teacher-level characteristics that might affect retention, such as age or gender. While the present analysis does suggest that, over the years studied, TIF schools did not on average have very different retention rates than non-TIF schools, more analysis would be needed to estimate specific TIF4 effects on individual teacher retention.

Table 10. TIF4 and Non-TIF4 Average Effects on Retention: High TADS Math/Science Teachers

	TIF4 Schools	Non-TIF4 Schools	Difference
New Math Teachers	0.1%	-0.2%	0.3%
Experienced Math Teachers	-1.2%	0.2%	-1.0%
New Science Teachers	0.5%	-0.2%	0.7%
Experienced Science Teachers	-2.2%	0.1%	-2.3%

Another point of interest is whether schools' overall tendency to retain teachers varies by TADS ratings or teacher experience. First, we examined whether schools that tend to retain new teachers also retain experienced teachers. We found that there was a substantial correlation between schools' relative effects on retention for new and experienced teachers, both high TADS and low. **Table 11** (p. 20) shows the

correlations of school effects for new and experienced teachers, for all teachers, math teachers, and science teachers at both performance levels. The positive correlations show that on average schools that are good at retaining inexperienced high TADS teachers are also good at retaining experienced high TADS teachers. It also seems that schools that retain inexperienced low TADS teachers also retain experienced low TADS teachers.

Table 11. Correlation of School Effects on the Retention of New and Experienced Teachers

Correlation of School Retention Effects for New and Experienced Teachers		
	High TADS	**Low TADS**
All Teachers	0.54	0.85
Math Teachers	0.72	0.60
Science Teachers	0.73	0.53

Another point of interest is whether schools' overall tendency to retain teachers varies by TADS ratings. Ideally, schools that are good at retaining high TADS teachers would also be good at exiting low TADS teachers, so that in such schools, retention rates for low TADS teachers would be lower. Correlations between retaining high and low TADS teachers would thus be negative. We found that, overall, correlations were substantial and positive, as shown in **Table 12** (below).

These correlations suggest that schools that are better at retaining high TADS teachers are likely also to be better at retaining low TADS teachers. This suggests that some schools are generally more likely to exit less effective teachers, regardless of the experience. This seems especially true of new math teachers. It is possible that if schools have a difficult time finding qualified math teachers, they may find it more expedient to retain less effective teachers and try to develop them rather than to try to hire new ones that are more effective.

Taken together, these correlations show that many schools are generally better or worse at retention, notwithstanding teacher effectiveness or experience. This seems especially true of retention of effective (high TADS) and less than effective (low TADS) math and science teachers.

Table 12. Correlation of School Effects on the Retention of Low TADS and High TADS Teachers

Correlation of School Retention Effects for High and Low TADS Teachers		
	New Teachers	**Experienced Teachers**
All Teachers	0.62	0.64
Math Teachers	0.88	0.80
Science Teachers	0.70	0.80

Conclusion

HISD staff and school leadership are grateful for the investment of federal TIF4 resources that enabled teachers and students to experience a comprehensive approach to improving STEM education. While we recognize that there are areas for continued improvement when it comes to the retention of math and science teachers across all experience levels, the lessons learned through the implementation of the TIF4 grant will continue to shape HISD's strategies moving forward. In this context, the district can point to three specific takeaways from the human capital approach to improving STEM education.

First, every TIF4 school had at least one educator who received an ASPIRE Award during the grant period. During the grant period, over a thousand ASPIRE Awards (1,012) were paid to educators at the TIF4

campuses. This illustrates HISD's commitment to identify and recognize teachers whose students are exceeding expectations; it reflects the reality that high-quality teaching happens in every school across HISD.

Second, for three consecutive years, the TIF4 schools retained 75% of their Effective and Highly Effective math and science teachers. Project staff attribute this in part to the realignment of the bonus calendar — by providing bonus-eligible teachers with relevant communications about their eligibility before most teacher choices were finalized. Additionally, anecdotal evidence collected by project staff suggests that teachers were also incentivized to stay in the TIF4 schools because of the meaningful STEM instructional resources and job-embedded professional supports provided through the grant.

Third, across the grant period, the TIF4 schools paid out about ten retention bonuses for each recruitment bonus. This suggests that effective math and science teachers find retention bonuses to be meaningfully more compelling than recruitment bonuses that are twice as expensive and require a longer time commitment. Critically, these are teachers who have already shown success in meeting the needs of students at HISD's hard-to-staff schools. Taken together, these two findings strongly suggest that the high turnover among HISD's math and science teachers can be mitigated through investment at specific campuses.

Whatever the exact reason for the increased retention among math and science teachers at TIF4 schools, the students of the TIF4 project schools were the ultimate beneficiaries of these teachers' decisions to stay — generating statistically significant and meaningful gains in their math and science achievement during the grant period (Price, Christian, & Stevens, 2018). HISD staff and school leadership look forward to building on these takeaways as we continue to serve the diverse needs of our students and families.

Endnotes

(i) Note that the figures in this report do not include ASPIRE Awards earned by campus-based support staff whose Awards were not supported by TIF4 funding. See details in Appendix B, Tables 1 and 2.

(ii) For the purposes of this STEM incentive, "Core Foundation Courses" included ONLY those courses identified by the Texas Education Agency under the Core Foundation areas of Mathematics and Science at the elementary and middle school level, and those math and science Core Foundation courses required for graduation credit in the 4x4 Recommended or Distinguished High School Diploma programs.

(iii) These individuals were identified by their contract type and their years of previous experience: a probationary contract, with zero years of experience.

(iv) In the model, the estimates are statistically "shrunk" towards the mean across the five-year window — this reduces the distortion that is possible from a single year that is very strong or very weak.

(v) While HISD's educator evaluation system makes a distinction between the two levels, both levels are considered "Ineffective" under the federal TIF grant reporting guidance.

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Appendix A: Teacher Incentive Fund in HISD

Since established by an Appropriations Act in 2006, the Teacher Incentive Fund (TIF) competitive grant program in the U.S. Department of Education (the Department) has supported human capital strategies for teachers and school leaders, "to ensure that students attending high-poverty schools have better access to effective teachers and principals, especially in hard-to-staff subject areas" such as science, math, and STEM (Science, Technology, Engineering, and Mathematics). While the specific programming supported through the TIF grant program has evolved since 2006 (Miller et al., 2015), TIF projects are supported by the Department to develop and implement sustainable performance-based compensation systems (PBCSs) for teachers, principals, and other personnel in high-need schools in order to increase educator effectiveness and student achievement. Houston Independent School District (HISD) was awarded over $43 million as part of the first and third cohorts of TIF grantees – $11.8 million in 2006, and $31.3 million in 2010. A recap of these program activities is available on HISD's website (Price & Stevens, 2017).

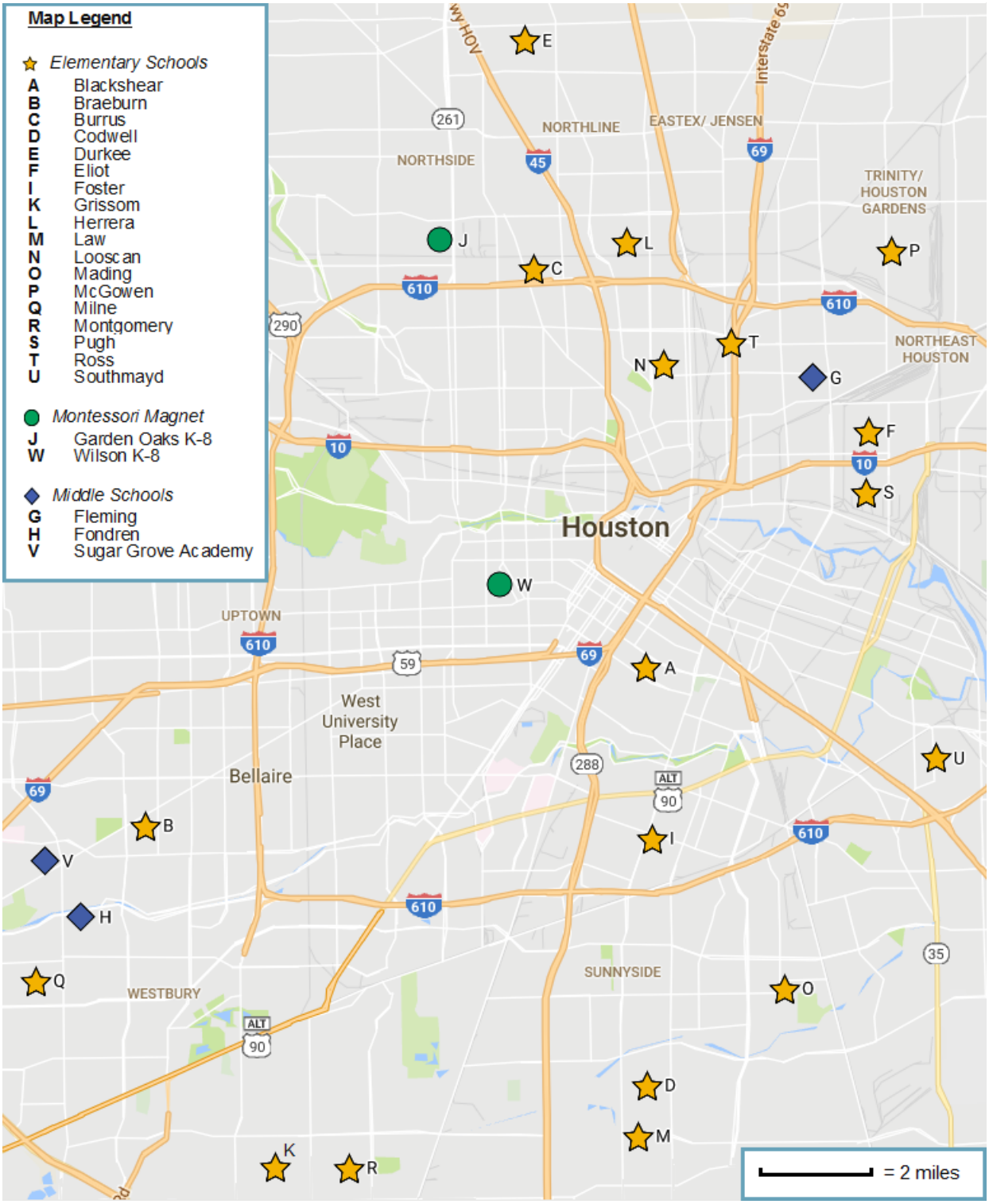
In September 2012, HISD was awarded a TIF grant for $15.9 million over five years (OESE, 2012b) — one of just six STEM projects funded among the fourth cohort of awards (TIF4-STEM): HISD, plus Calcasieu Parish (LA), National Institute for Excellence in Teaching (IA), Orange County (FL), Washoe County (NV), and the South Carolina Department of Education.

These grantees committed to the two Absolute Priorities required of all TIF grantees, as well as a third Priority that was specific to STEM programming:

- **Priority 1 (all grantees):** "An LEA-wide human capital management system (HCMS) with educator evaluation systems at the center that (a) is aligned with the local education agency's (LEA's) vision of instructional improvement and (b) uses information generated by the evaluation system to inform key human capital decisions, such as recruitment, hiring, placement, dismissal, compensation, professional development, tenure, and promotion."
- **Priority 2 (all grantees):** "An LEA-wide educator evaluation system based, in significant part, on student growth. The frequency of evaluation must be at least annually and the evaluation rubric should include at least three performance levels and (a) two or more observations during each evaluation period, (b) student growth for the evaluation of teachers at the classroom level, and (c) additional factors determined by the LEA. In addition, the evaluation system must generate an overall evaluation rating based, in significant part, on student growth and the evaluation system must be implemented within the timeframe specified in Priority 2."
- **Priority 3 (STEM grantees):** "Improving STEM achievement by developing a corps of skilled STEM master teachers by providing additional compensation to teachers who (a) receive an overall evaluation effectiveness rating of effective or higher under the evaluation system, (b) are selected based on criteria that are predictive of the ability to lead other teachers, (c) demonstrate effectiveness in one or more STEM subjects, and (d) accept STEM-focused career ladder positions. In addressing this priority, each LEA needs to identify and develop the unique competencies that, based on evaluation information or other evidence, characterize effective STEM teachers. Projects also need to identify hard-to-staff STEM subjects and use the HCMS to attract effective teachers, leverage community support and expertise to inform the implementation of its plan, ensure that financial and non-financial incentives are adequate to attract and retain persons with strong STEM skills in high-need schools, and ensure that students have access to and participate in rigorous and engaging STEM coursework."

See http://www2.ed.gov/programs/teacherincentive/2012-374ab.pdf for the full text of the application package for TIF4 (OESE, 2012a).

Appendix Figure 1. Geographic Location of the TIF4 Project Schools



Appendix B: Detailed Breakdown, ASPIRE Award at TIF4 Project Schools

Appendix Table 1. Count of ASPIRE Awards Paid at Each TIF4 Project School, 2012–2017

Number of Awards	2012–2013 n=18	2013–2014 n=18	2014–2015 n=20	2015–2016 n=16	2016–2017 n=14	*Total n=23*
Blackshear ES	12 + 5		1			**18**
Braeburn ES	6	29	18	3	46	**102**
Burrus ES	8	2	16	4	20	**50**
Codwell ES			24			**24**
Durkee ES	2	4	34	3		**43**
Eliot ES	23	23	3	4	30	**83**
Fleming MS	7	22	11	1	9	**50**
Fondren MS	2	9	11	33	40	**95**
Foster ES	9	3	3	3	14	**32**
Garden Oaks Montessori	25	28	34	9	9	**105**
Grissom ES			12		1	**13**
Herrera ES	33	2	3	2	38	**78**
Law ES	1	1	2	1		**5**
Looscan ES	17	7				**24**
Mading ES			1			**1**
McGowen ES		2	18		2	**22**
Milne ES	18	1	1			**20**
Montgomery ES		3		3		**6**
Pugh ES		16	14	1		**31**
Ross ES	10			1	18	**29**
Southmayd ES	32	26	1	15	26	**100**
Sugar Grove Academy	2	3	4	3	2	**14**
Wilson Montessori	12	26	23	5	1	**67**
Total Awards	**224**	**207**	**234**	**91**	**256**	**1,012**

Notes: The 12 Awards paid to Dodson staff in 2012–2013 are included in the cell with the five Awards to Blackshear ES. These counts do not include individuals who were not eligible for TIF4 funding. The ASPIRE groups eligible for TIF4 funding include Group 1, Group 2, Group 3, Group 4, Group 1L, and Group 2L. The ASPIRE groups not eligible for TIF4 funding included Group 5, Group 6, and Group 7. For more details about the ASPIRE Award groups, please see additional HISD reporting on the ASPIRE Award (e.g., Hui, Mosier, & Bigner, 2018; Zimmerman, Hui, & Mosier, 2017).

Appendix Table 2. Sum of ASPIRE Award Payout at Each TIF4 Project School, 2012–2017

ASPIRE Award Payout	2012–2013 n=18	2013–2014 n=18	2014–2015 n=20	2015–2016 n=16	2016–2017 n=14	*Total n=23*
Blackshear ES	$61,000.00		$7,500.00			$68,500.00
Braeburn ES	$8,000.00	$109,066.67	$56,212.50	$10,833.33	$111,125.00	$295,237.50
Burrus ES	$45,500.00	$10,000.00	$24,750.00	$13,125.00	$61,875.00	$155,250.00
Codwell ES			$16,500.00			$16,500.00
Durkee ES	$15,000.00	$25,000.00	$155,775.00	$15,000.00		$210,775.00
Eliot ES	$52,000.00	$122,333.33	$18,750.00	$15,833.33	$78,000.00	$286,916.67
Fleming MS	$55,000.00	$128,500.00	$57,956.25	$5,000.00	$35,000.00	$281,456.25
Fondren MS	$15,000.00	$56,575.00	$60,525.00	$91,625.00	$179,625.00	$403,350.00
Foster ES	$4,500.00	$13,500.00	$15,000.00	$4,583.33	$49,875.00	$87,458.33
Garden Oaks Montessori	$19,500.00	$110,750.00	$98,850.00	$27,125.00	$25,833.33	$282,058.33
Grissom ES			$27,000.00		$5,000.00	$32,000.00
Herrera ES	$109,100.00	$15,000.00	$22,500.00	$7,500.00	$125,375.00	$279,475.00
Law ES	$10,000.00	$10,000.00	$7,500.00	$1,666.67		$29,166.67
Looscan ES	$18,500.00	$12,250.00				$30,750.00
Mading ES			$3,750.00			$3,750.00
McGowen ES		$10,700.00	$19,500.00		$5,750.00	$35,950.00
Milne ES	$14,000.00	$10,000.00	$3,750.00			$27,750.00
Montgomery ES		$20,000.00		$12,500.00		$32,500.00
Pugh ES		$34,000.00	$27,000.00	$5,000.00		$66,000.00
Ross ES	$5,000.00			$5,000.00	$63,375.00	$73,375.00
Southmayd ES	$119,083.33	$113,500.00	$7,500.00	$29,583.33	$61,187.50	$330,854.17
Sugar Grove Academy	$15,000.00	$15,000.00	$26,250.00	$10,000.00	$10,000.00	$76,250.00
Wilson Montessori	$21,000.00	$117,333.33	$74,625.00	$11,250.00	$1,250.00	$225,458.33
Total Award Payout	**$587,183**	**$933,508**	**$731,1934**	**$265,625**	**$813,2701**	**$3,330,781**

Note: Total Award Payments (bottom row) are rounded to the nearest dollar. These figures do not include the fringe benefits on this compensation. These figures combine federal (TIF4), local (cost-sharing match, and local supplement), and state funds ($100,517 from the District Awards for Teacher Excellence program, or DATE, for ASPIRE 2012–2013). The monetary value of the 12 Awards paid to Dodson staff for 2012–2013 are included in the cell with the five Awards to Blackshear ES. Also, these figures do not include ASPIRE Awards paid from local funds to individuals who were not eligible for TIF4 funding. The ASPIRE groups eligible for TIF4 funding include Group 1, Group 2, Group 3, Group 4, Group 1L, and Group 2L. The ASPIRE groups not eligible for TIF4 funding included Group 5, Group 6, and Group 7. For more details about the ASPIRE Award groups, please see additional HISD reporting on the ASPIRE Award (e.g., Hui, Mosier, & Bigner, 2018; Zimmerman, Hui, & Mosier, 2017).

Appendix C: Sample Notice of Initial Eligibility for STEM Bonus

The following message was sent to the 59 teachers at TIF4 project schools who were notified in March 2017 that they met eligibility criteria for the STEM retention bonus supported by the TIF4 grant. Fields in `fixed width font` and enclosed with double-angle quotation marks indicate the MS Excel fields that were merged in MS Word to generate and send individual communications.

Email Date: March 24, 2017

Email Title: Notice of Initial Eligibility: STEM Bonus for «TEACHERNAME»

Email Body:

Dear «TEACHERNAME» («TITLE» at «SCHOOL1516»):

Thanks to a federal grant, select teachers in HISD can receive a STEM Retention bonus in September 2017 by meeting specific eligibility criteria. You are receiving this email because records show that you meet initial eligibility criteria for this bonus. (See Table below.)

Should you return to a TIF4 project school to teach there for the 2017–2018 academic year, you will meet all criteria to receive a bonus of up to $5,000. Please take this into consideration as you make your plans!

Teacher ID # «EMPL-ID»: Records

Employed at TIF4-STEM School for 2016–2017	☑ «SCHOOL1516»
2016 Summative Rating in TADS is 3 or 4	☑ «TADS1516»
2016 Subject is STEM-related	☑ «SUBJECT»
2016 Comparative Growth metric in the top quintile for math or science	☑ «CMPGRO1516»

Download and view the full award eligibility criteria here. Details about quintiles can be found at the [link], and information on Comparative Growth can be found at [link].

These retention incentives will be paid out on or before September 30, 2017.

Please note that Principal «P-LASTNAME» has also received this information about your initial eligibility. Let me know if you have any questions!

Thank you,

Lauren E. Price
Grant Manager, TIF4

** NOTE: Please note that the exact amount of any post-tax award will depend on your own individual financial situation — as bonuses can be taxed differently than other compensation. Also, this notice of bonus eligibility does not confirm or contradict any current or future offer of employment with HISD.

Appendix D: Retention and Mobility of New Math and Science Teachers

Appendix Table 3. Mobility and Retention in Three Cohorts of New Math Teachers

School Year	Cohort	Count at Start	Came Back Next Year in ___ Role:		Moved Schools Next Year in ___ Role:		Left District's Teacher Roster
			Same	*Different*	*Same*	*Different*	
2012–13	1	604	380	71	24	12	101
2013–14	1	487	255	63	20	16	115
2014–15	1	356	163	70	20	16	79
2015–16	1	284	143	76	16	8	36
2016–17	1	259	138	65	9	4	29
2017–18	1	225	-	-	-	-	-
2013–14	2	654	357	70	23	13	156
2014–15	2	464	232	82	25	15	97
2015–16	2	371	184	84	14	7	72
2016–17	2	299	150	69	13	8	48
2017–18	2	257	-	-	-	-	-
2014–15	3	700	392	74	32	20	147
2015–16	3	518	279	93	22	12	97
2016–17	3	420	218	80	18	10	77
2017–18	3	338	-	-	-	-	-

Appendix Table 4. Mobility and Retention in Three Cohorts of New Science Teachers

School Year	Cohort	Count at Start	Came Back Next Year in ___ Role:		Moved Schools Next Year in ___ Role:		Left District's Teacher Roster
			Same	*Different*	*Same*	*Different*	
2012–13	1	547	336	61	27	11	98
2013–14	1	435	223	73	23	9	94
2014–15	1	330	152	72	16	15	67
2015–16	1	267	131	76	8	13	36
2016–17	1	236	107	70	10	6	30
2017–18	1	203	-	-	-	-	-
2013–14	2	617	341	81	20	13	133
2014–15	2	456	223	84	23	17	95
2015–16	2	357	179	79	13	7	72
2016–17	2	286	130	79	8	9	48
2017–18	2	241	-	-	-	-	-
2014–15	3	667	376	70	32	19	143
2015–16	3	497	264	92	22	12	95
2016–17	3	404	202	81	16	12	78
2017–18	3	319	-	-	-	-	-

Appendix E: Same-School Teacher Retention and Student Demographics

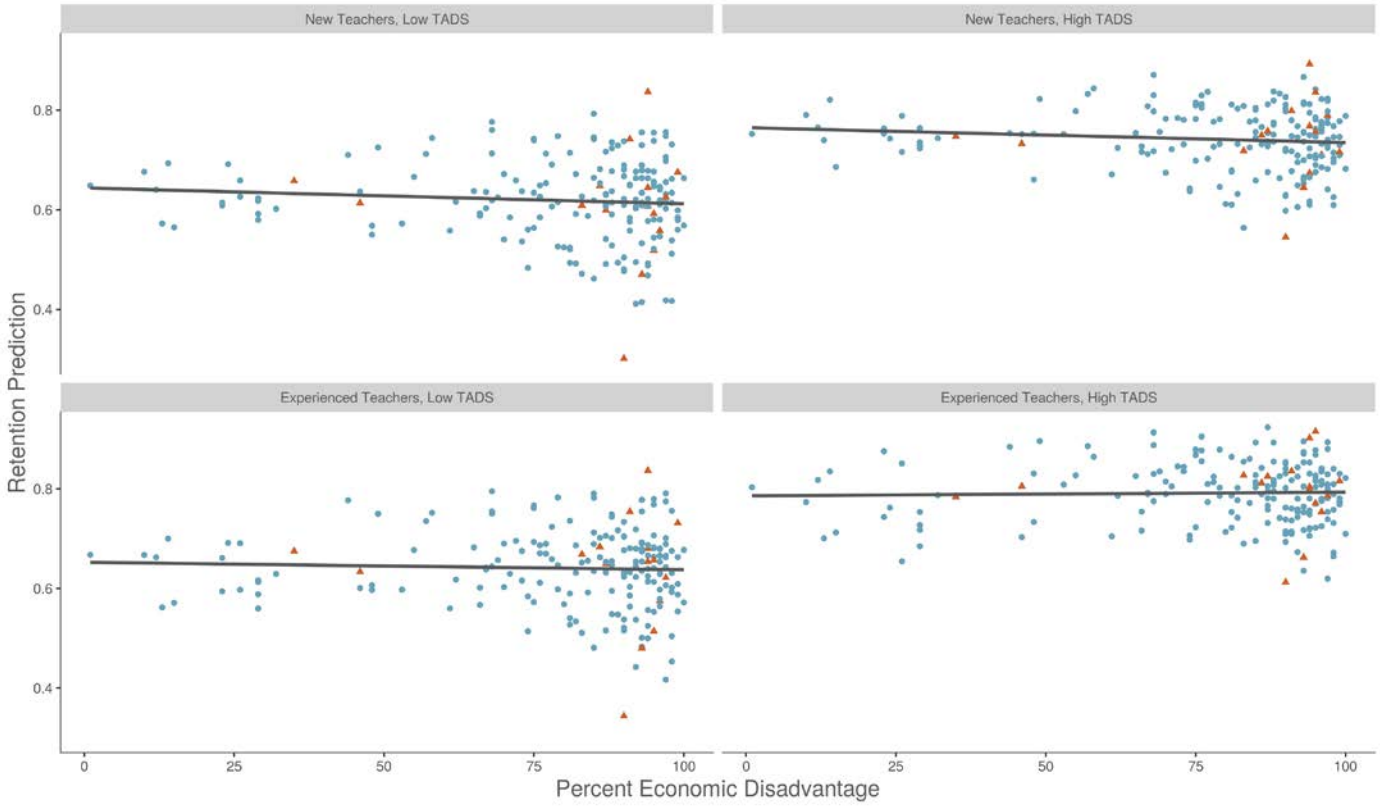
The school's random effect is the school's distance from the expected level of retention for schools with similar student populations. These model results were used to derive an estimate of how schools compared to each other in terms of in retaining each group: New and High TADS, New and Low TADS, Experienced and High TADS, as well as Experienced and Low TADS:

- *Teacher:* Coded in the human resources dataset as teachers according to their job function and salary plan (PeopleSoft, and SAP OneSource),
- *New*: Three or fewer years of teaching experience for a given year.
- *Experienced*: Four or more years of teaching experience for a given year.
- *High TADS:* Summative appraisal score of 3 or 4 in the TADS final dataset for the specific year.
- *Low TADS:* Summative appraisal score of 1 or 2 in the TADS final dataset for the specific year.[v]

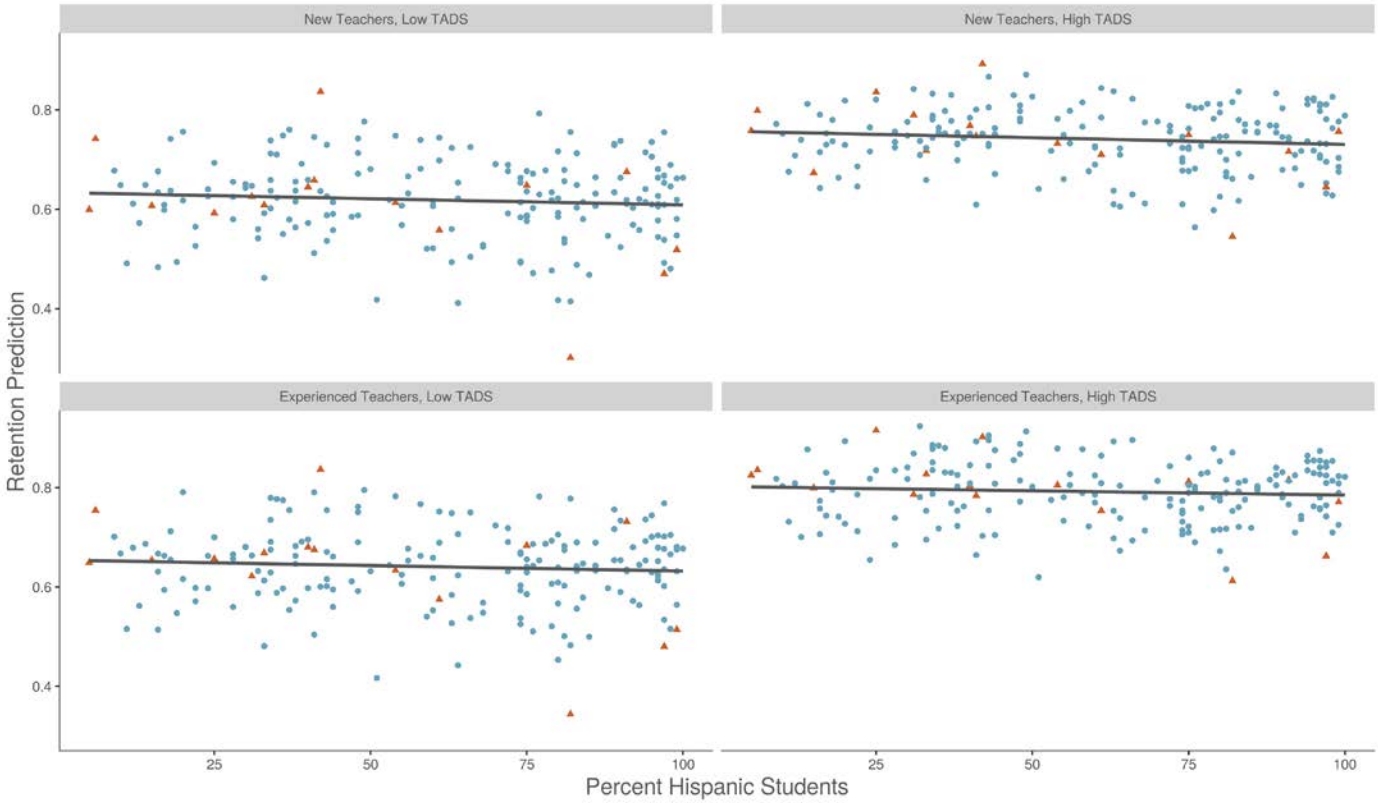
In each of these figures, the dark line represents the district-wide relationship between the likelihood that a teacher will return to the same campus for the following year, as a function of the school's demographics. Schools whose dots are above the district-wide trend line are retaining teachers at a higher rate than expected for that demographic factor; schools below the trend line are retaining teachers at a lower rate than expected. **Appendix Figures 2–4** (p. 31–32) address the retention of all teachers, while **Appendix Figures 5–12** (pp. 33–36) address math and science.

Schools participating in the TIF4 grant are represented by red triangles. All other schools are represented by blue dots.

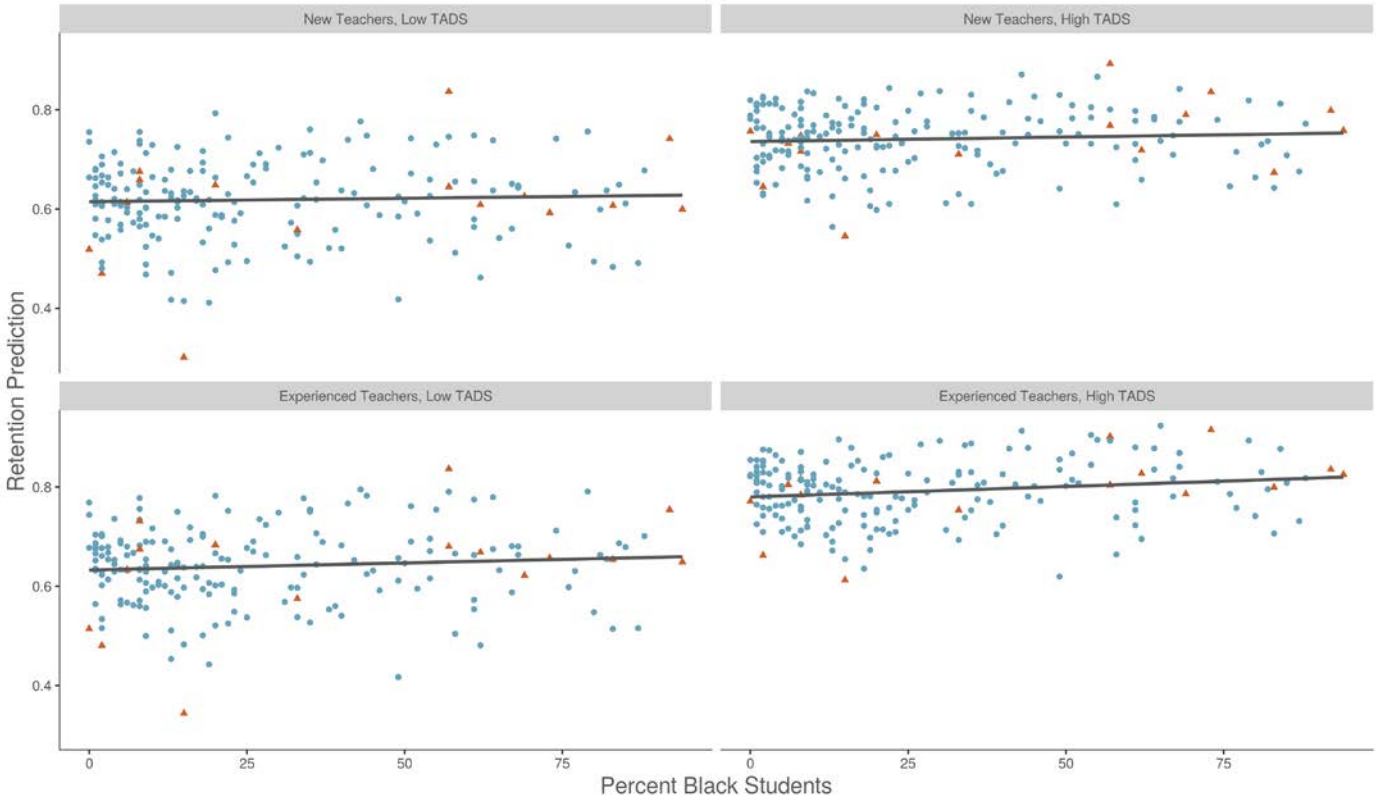
Appendix Figure 2. Same-School Retention for Four Teacher Categories, by School's Economic Disadvantage



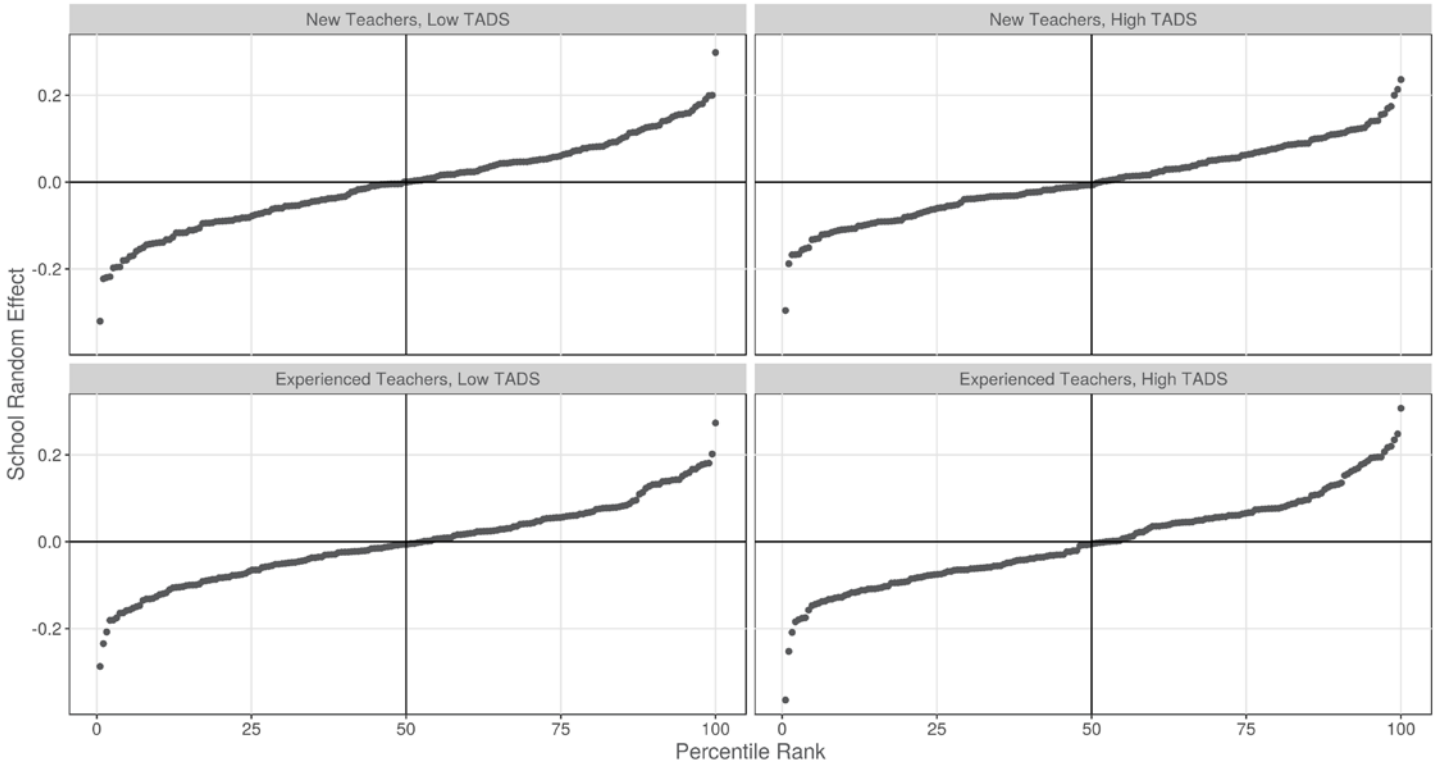
Appendix Figure 3. Same-School Retention for Four Teacher Categories, by School's Percent Hispanic



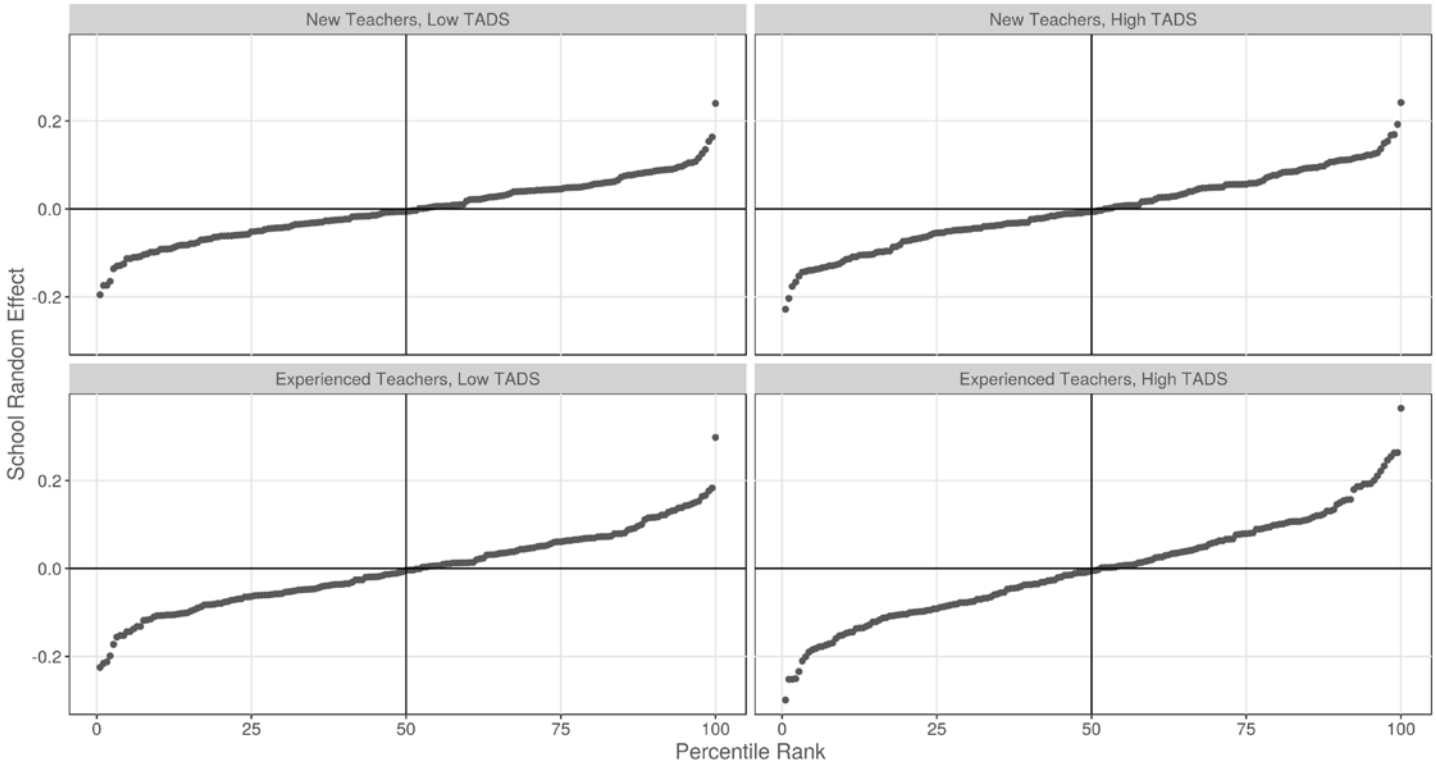
Appendix Figure 4. Same-School Retention for Four Teacher Categories, by School's Percent African-American



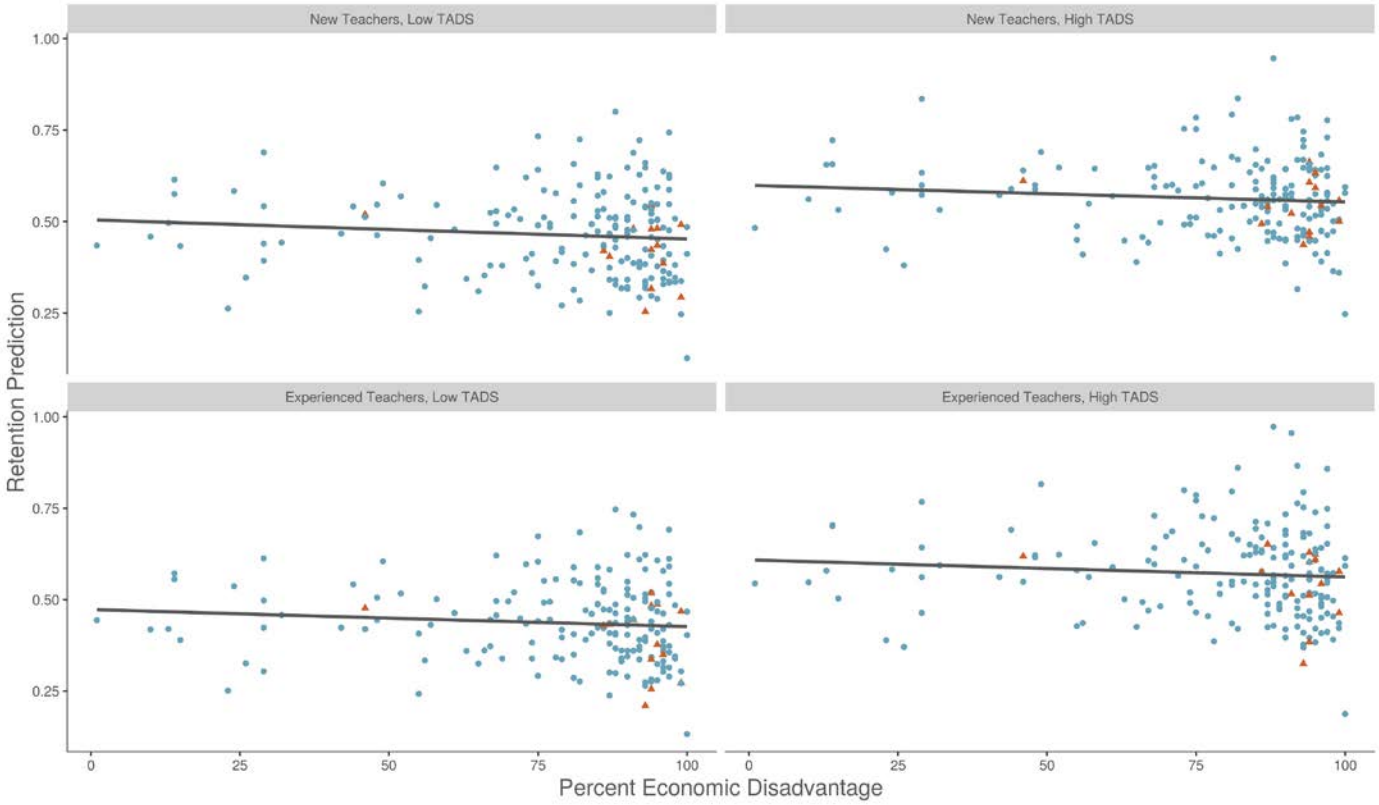
Appendix Figure 5. Math Teacher Retention for Four Categories, by School Effect and Percentile Rank



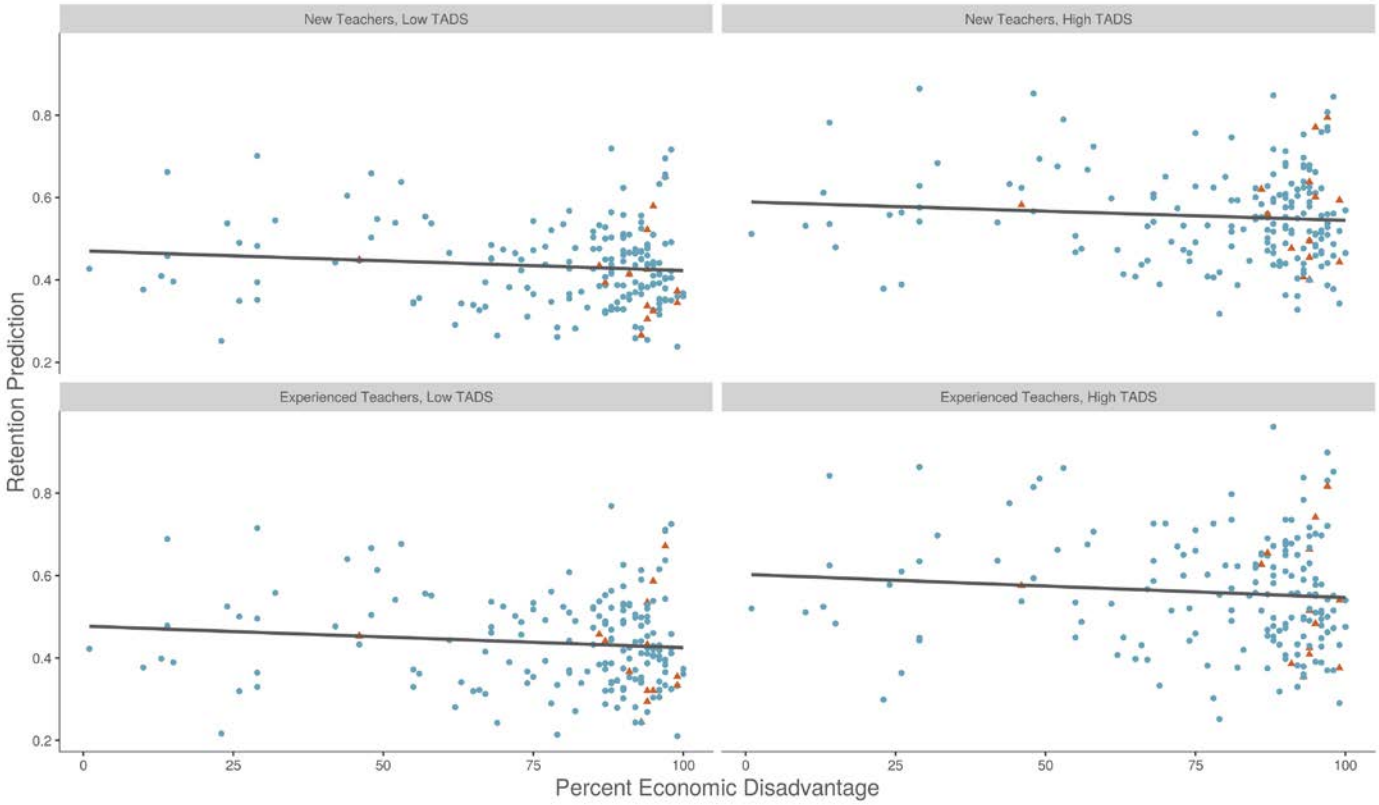
Appendix Figure 6. Science Teacher Retention for Four Categories, by School Effect and Percentile Rank



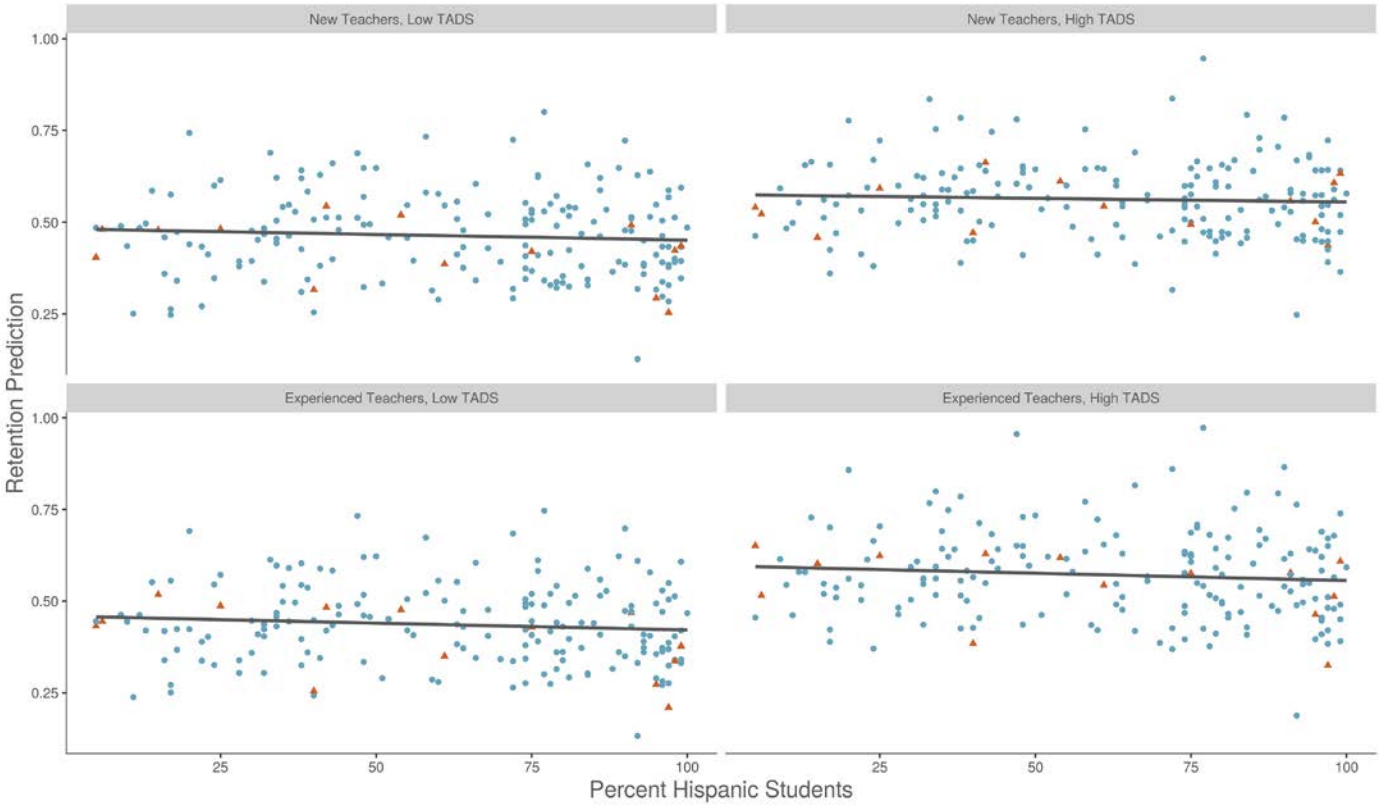
Appendix Figure 7. Math Teacher Retention for Four Categories, by School's Percent Economic Disadvantage



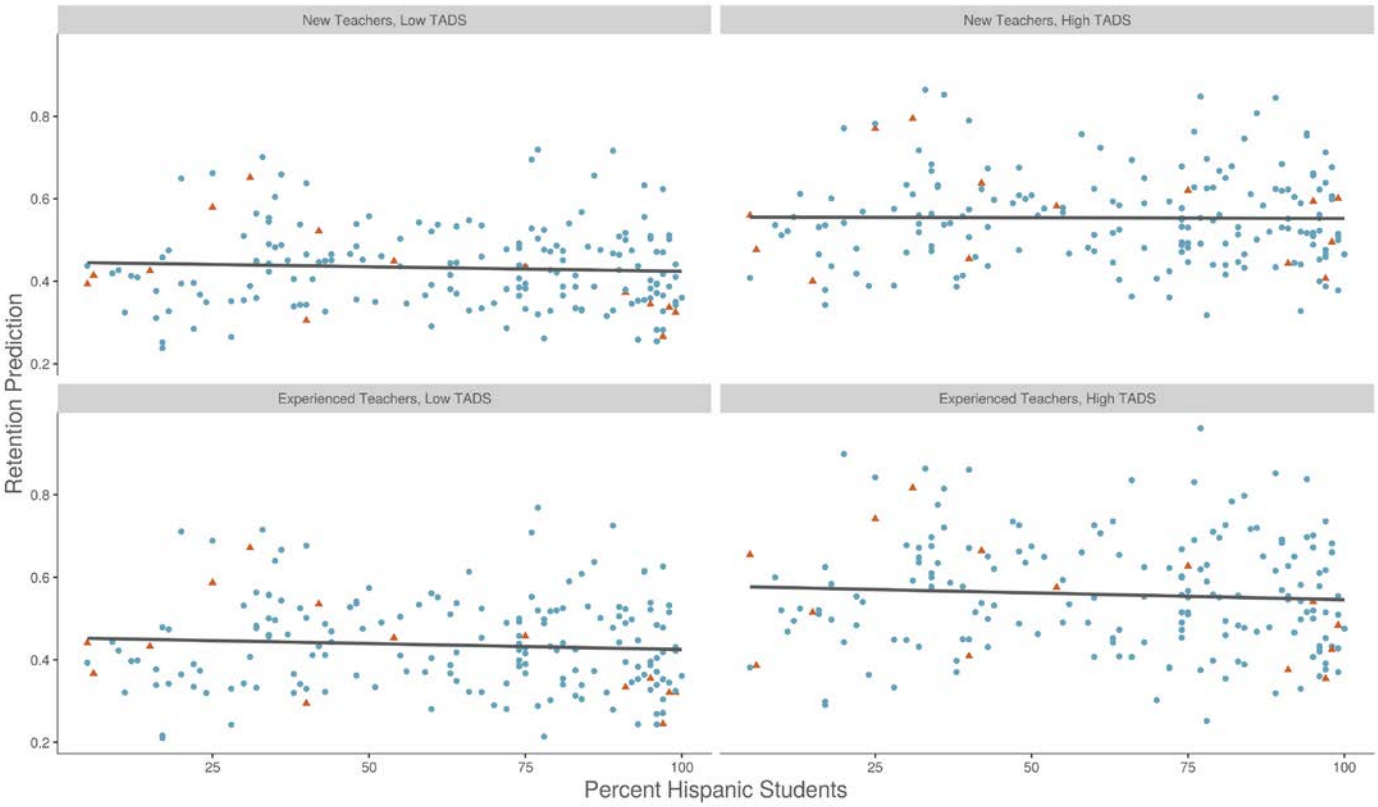
Appendix Figure 8. Science Teacher Retention for Four Categories, by School's Percent Economic Disadvantage



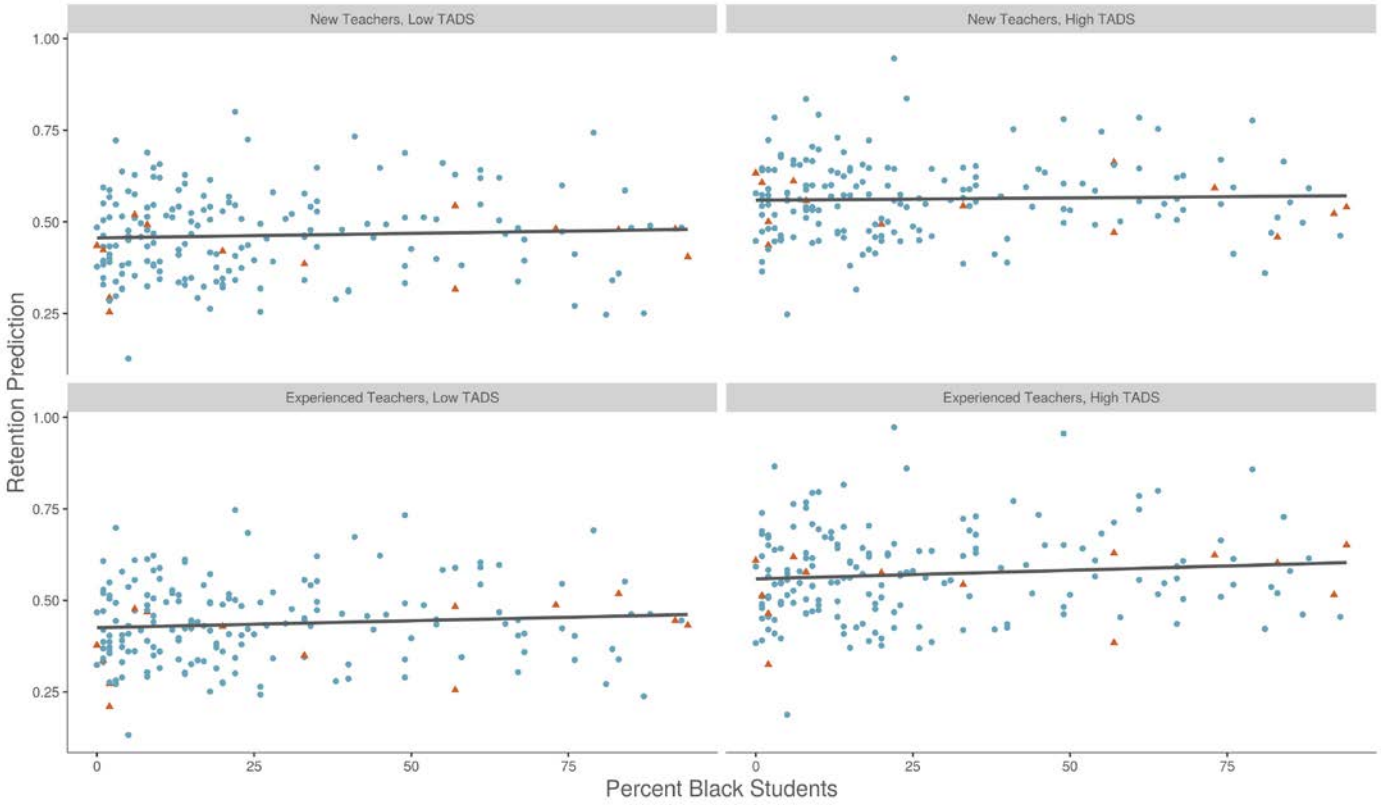
Appendix Figure 9. Math Teacher Retention for Four Categories, by School's Percent Hispanic



Appendix Figure 10. Science Teacher Retention for Four Categories, by School's Percent Hispanic



Appendix Figure 11. Math Teacher Retention for Four Categories, by School's Percent African-American



Appendix Figure 12. Science Teacher Retention for Four Categories, by School's Percent African-American