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

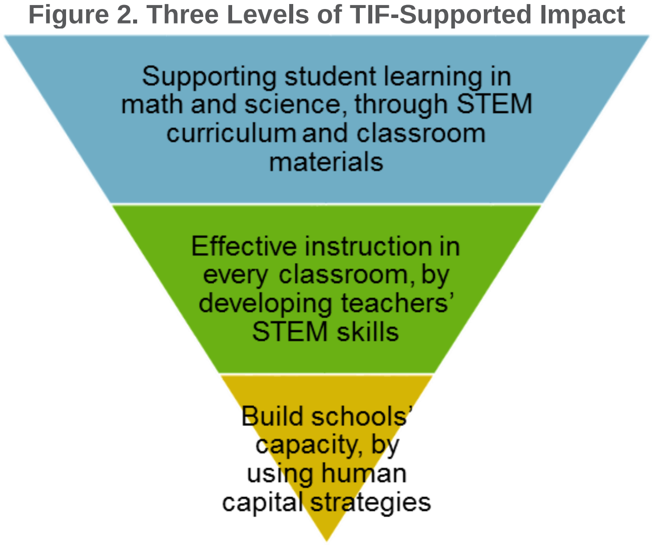
Since 2011, the number of STEM-related jobs, types of STEM degrees granted, and the level of student interest in STEM fields all continue to increase across the country (Neuhauser, 2015). But the national racial gaps identified in 2011 have persisted (Neuhauser & Cook, 2016). The ongoing confluence of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

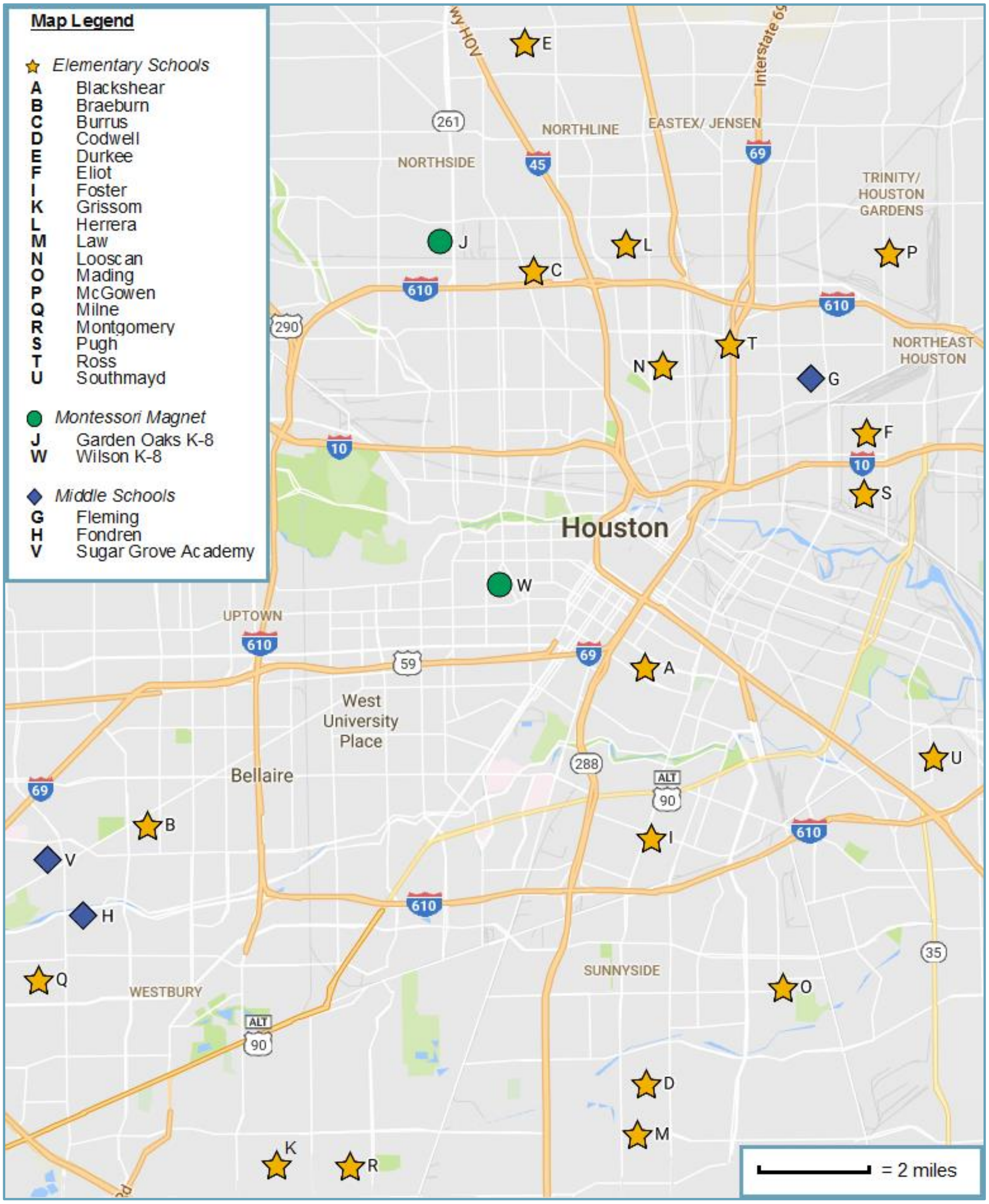
**Figure 2. Three Levels of TIF-Supported Impact**



## 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).

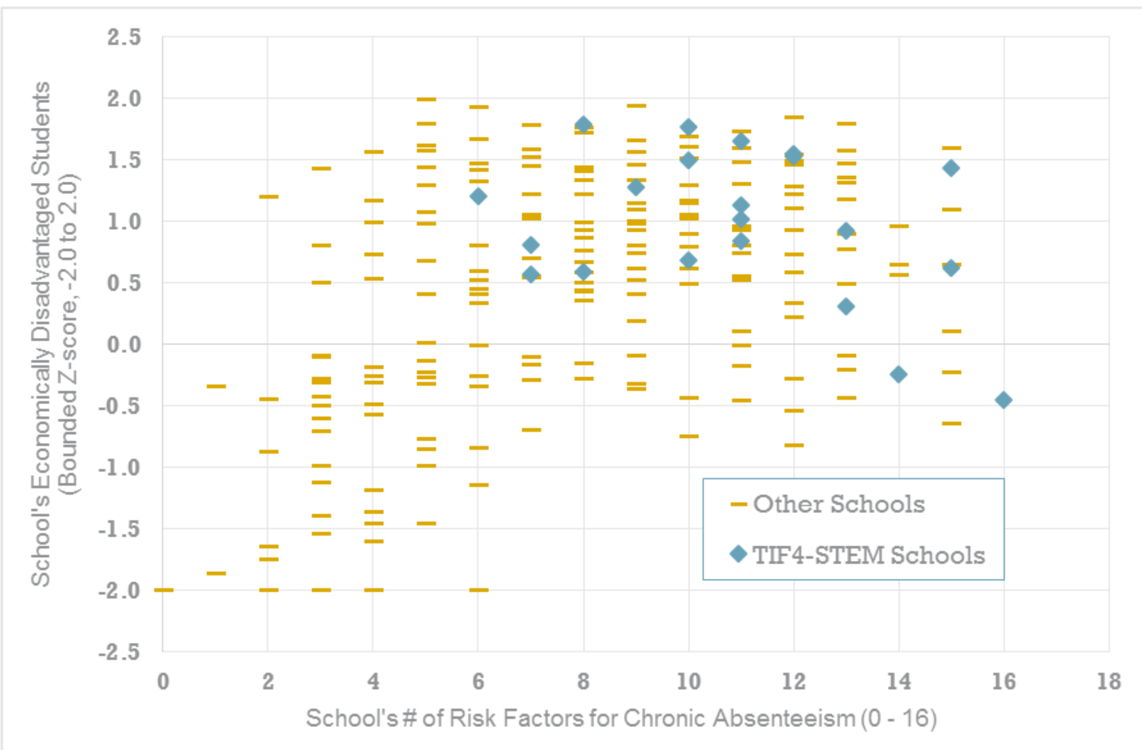
**Figure 3. Geographic Location of the TIF4 Project Schools**



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**<br>*Ten FTE per year*<br>*See Appendix C* | Hired August 2013 | Continued | Continued | Contracts concluded August 2017 |
| **TDS Team Lead (1 FTE)**<br>*Lead 1, 2013—2015;*<br>*Lead 2, 2015—2017* | Hired June 2013 | Continued | Staff transition July 2015 | Contract concluded August 2017 |
| **Curriculum Manager (1 FTE)**<br>*Created Design Challenges,*<br>*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**<br>*Supports for individual teachers, and campus-wide as requested* | Began | Continued | Continued | Continued |
| **The "STEM Cadre"**<br>*A cohort model for professional learning across campuses* | Began | Continued | Continued (With stipend) | Continued (With stipend) |
| **Support for Other STEM Funding Opportunities**<br>*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.

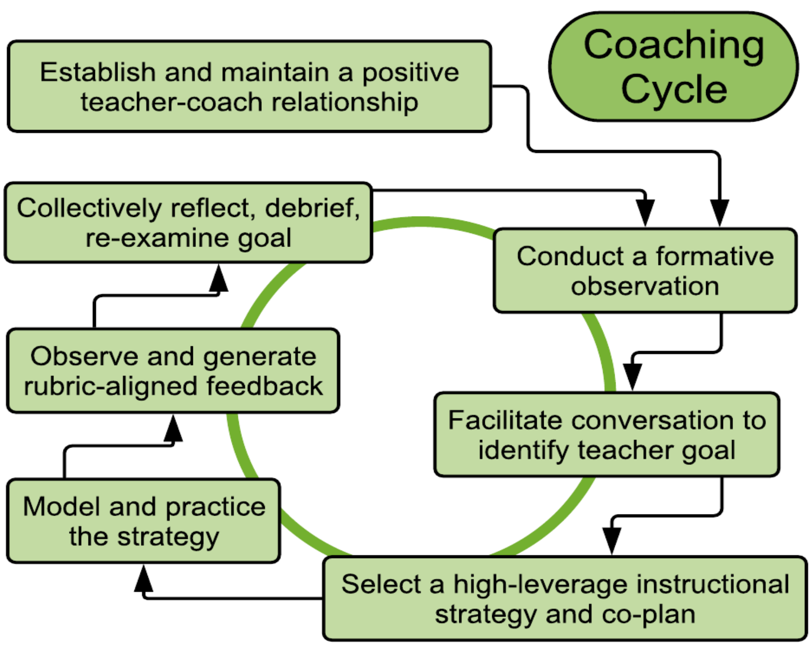
Although their work during the initial years was exclusively on the TIF4 project schools, in the final two years of the grant, the TDS team also delivered trainings to share their content area expertise with other

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.

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*“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)*

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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 T³ 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).

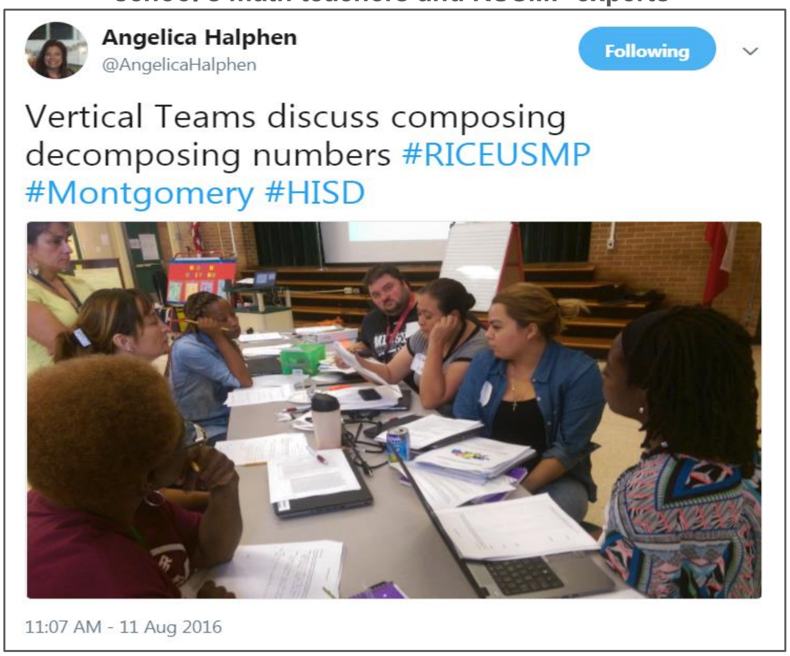


**Figure 7. A STEM Master Teacher tweets about work with her school's math teachers and RUSMP experts**

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**<br>*Grades 4 through 8* | - | - | - | Available across HISD |
| **Grading Rubrics**<br>*Grades K through 8*<br>*Supporting district-wide initiatives around authentic assessment* | - | - | Available across HISD | Available across HISD |
| **Code.org**<br>*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**<br>*Classroom Walk-Through*<br>*School Walk-Through* | - | - | Available as Word and PDF documents | Tools digitized with Kickup through pilot |
| **Games Robots Play**<br>*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).

Figure 10

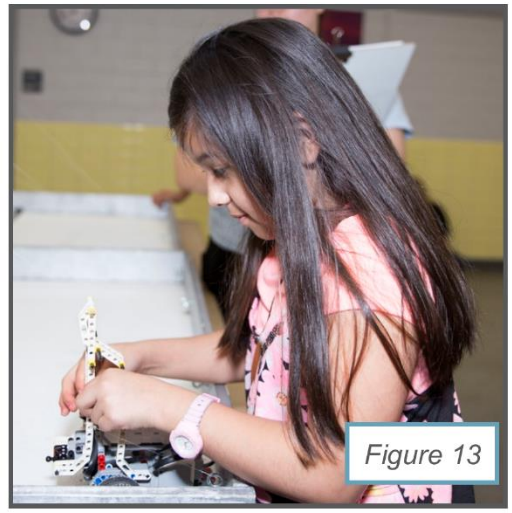

Figure 13

Figure 11

Figure 12

Figure 14

**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.

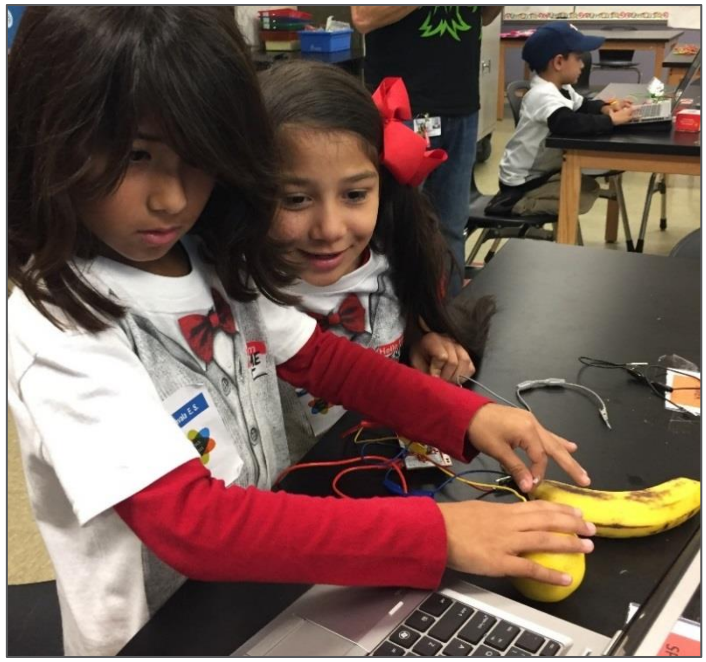

**Figure 20. Students from Herrera Elementary use Makey Makeys to take on coding and circuits at "Crack The Code", December 2016. (Photo: Sabrina Provencher)**

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.

Scale: -2.000 to 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)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>Q (Science) |
| **Fondren MS** | D (Math)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>Q (Science) |
| **Sugar Grove MS** | D (Math)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>H (Science) | L (Math)<br>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:
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## 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 Spac**e 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.*