INTRODUCTION

Harmony Public Schools ("Harmony" or "HPS") is a charter management organization currently operating 54 high-quality charter schools across Texas, with two more campuses opening in fall of 2018. HPS schools, grounded in a science, technology, engineering, and math (STEM) model, provide exceptional learning opportunities for nearly 33,000 students. Taken as a whole, the HPS student body is generally representative of local districts, but is more ethnically and racially diverse and less white overall than the state (86.1% vs. 71.9% non-white). HPS serves a significant population of students identified as "high-need" such as those living in poverty (60% of students are eligible for Free and Reduced Lunch), English Language Learners (24% of students classified as ELL), and attending high-minority schools.

Harmony has an 18-year track record of supporting high-need students to achieve outstanding academic results, transforming the way Texas students, especially disadvantaged populations, engage with math and science. Harmony schools have consistently earned national recognition, with multiple schools appearing annually on lists such as U.S. News & World Report's "Best High Schools in the Nation" and The Washington Post's "Challenge Index."

High school graduates with a strong STEM foundation are in high demand both in Texas and across the country (see Significance section). HPS is uniquely positioned to cultivate a pipeline of knowledgeable, skilled, diverse students in the STEM sector, supported by knowledgeable, skilled, diverse teachers—the focus of this project—because its large network already:

- Serves a truly diverse student body across its high-quality schools;
- Serves all grade levels (Pre-K through 12), with its feeder schools in close physical proximity to enable seamless progression through the grades;
- Continuously refines its STEM focus and rigorous project-based learning (PBL) curriculum

in response to data;

- Prioritizes investments in teaching and learning that personalize student learning and increase educators' capacity to provide high-impact instruction; and
- Has a history of developing resources that improve achievement outcomes, both for students within Harmony and those who attend other schools who use Harmony's materials.

This project, "Launching Elementary Academic Foundations to STEM" (LEAF to STEM) is a natural continuation of work HPS began under a 2012 Race to the Top-District (RTT-D) grant to *deepen personalized learning* through a PBL-based approach for each middle and high school student in the Harmony system. HPS plans to extend the program to elementary classrooms, building younger students' foundational skills, confidence, and ability to engage in deeper learning in STEM. This project also leverages Harmony's work to *enable quality instruction* across the system. Through a 2016 Teacher Incentive Fund (TIF) grant, Harmony has invested in a robust Human Capital Management System (HCMS) to attract, retain, and grow strong educators. The HCMS will be a foundation for this project, supporting PBL elementary instruction to reshape the K-12 STEM learning experience for HPS students.

A. SIGNIFICANCE

LEAF to STEM is a project designed to address Absolute Priority 1 (Moderate Evidence) and Absolute Priority 3 (Promoting Science, Technology, Engineering, and Mathematics (STEM) education) by expanding the successful HPS middle and high school STEM-focused PBL and personalized learning model (Sahin et al., 2017a, 2017b, Sahin and Top, 2015) to grades K-5. HPS will achieve this using three strategies that build elementary teachers' competence and confidence in delivering high-quality STEM instruction:

1. Adapt Harmony's proven, effective STEM Students on Stage ("STEM SOS") PBL

curriculum and supplemental resources for teachers to implement in grades K-5;

2. Launch a professional development institute for elementary teachers, focused on delivering Harmony's PBL inquiry-based STEM curriculum with fidelity; and
3. Introduce unique STEM-focused peer-to-peer mentoring programs for elementary teachers.

These three strategies are evidence-based and aligned with the recommendations of the National Academies of Science (NAS) for K-12 STEM education. The NAS recommendations emphasized both increasing STEM literacy for all students and expanding and diversifying the number of students with long-term interest (academically and professionally) in STEM through rigorous and aligned resources, supports, and structures for educators:

> "Districts should ensure that their STEM curricula are rigorous and are articulated as a sequence of topics and performances. Ideally, STEM curricula should be aligned across disciplines from grades K-12… [D]istricts should devote adequate instructional time and resources to science in grades K-5. A quality science program in the elementary grades is an important foundation that can stimulate students' interest in taking more science courses in middle school and high school and, possibly, in pursuing STEM disciplines and careers… [D]istricts need to enhance the capacity of K-12 teachers. Teachers should have…an understanding of how students' learning develops in that field, the kinds of misconceptions students may develop, and strategies for addressing students' evolving needs..."[1]

A. 1. MAGNITUDE OR SEVERITY OF THE PROBLEM

The United States has transitioned from a low-skill, manufacturing-focused economy to a high-skill, service- and knowledge-based economy. STEM has been a primary lever of change:

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[1] National Research Council. (2011)

over the past decade, growth of STEM jobs has been three times that of non-STEM jobs, with STEM workers earning 26% more than non-STEM workers (Langdon et al., 2011). As of May 2018, 13 of the top 20 fastest growing industries (per the U.S. Bureau of Labor Statistics) are STEM-related, including information services, healthcare services, computer systems design, software publishing, and scientific research. Furthermore, according to a 2015 study ranking the median income of college majors, the top 23 majors with the highest income are all in STEM-related fields (Carnevale et al., 2015).

Unfortunately, *access* to those careers is not universal. Nationally, only a third of students matriculating to two- and four-year colleges select STEM majors, with those percentages even lower for women, African-American, and Latino students (15%, 18%, and 22%, respectively) (Sahin, 2013). As a result, the U.S. has seen a "persistent and dramatic shortage of STEM workers" (New American Economy, 2017). Further, a lack of diversity represents a significant loss of talent and ideas to a sector dependent on a breadth and depth of perspectives.

Harmony's home state is no different. Texas was ranked second in Forbes' "Best States for Business" list in 2017[2]. Among the factors cited in the rating: 109 of the 1,000 largest public and private companies in the U.S. are based in Texas, including STEM giants such as AT&T, ExxonMobil, and Dell; startup activity is also second in the nation among larger states, per the Kauffman Foundation[3]. But Forbes found that "one of the only things holding Texas back is the education rate among its labor supply. Only 83% of adults have a high school degree, which is second lowest among the states." And, according to the National Science Foundation, Texas has been in the bottom quartile of Bachelor's degrees conferred in science and engineering.[4]

[2] https://www.forbes.com/places/tx/
[3] https://www.kauffman.org/kauffman-index/reporting/~/media/b27f0b8eb4a8414295f23870538e5372.ashx
[4] https://www.nsf.gov/statistics/state-indicators/indicator/se-bachelors-degrees-per-1000-18-24-year-olds

Although Harmony has a track record of success in addressing this problem (see Exceptional Approach section) by graduating STEM-prepared students from its secondary schools, the quality of HPS' elementary program has lagged. During the 2016-2017 school year, the grade levels (3rd-12th) with the lowest percentage of students passing the State of Texas Assessment of Academic Readiness (STAAR) or End-of-Course (EOC) exams in math were 3rd and 4th grade (see Appendix G). Moreover, whereas a recent evaluation found that Harmony "consistently produced better achievement at grades 6-11 on mathematics and reading for all students," the same could not be proven for elementary students (Sahin, Willson, and Caprano 2018).

Harmony believes it is missing an opportunity to build an even stronger STEM foundation for its learners, not to mention for the thousands of students across the country using Harmony's codified instructional model, curriculum, and materials.

A. 2. NATIONAL SIGNIFICANCE

A sizable body of evidence indicates that introducing systemic approaches to STEM education that engage teachers and diverse student populations across the K-12 continuum lead to exciting outcomes for students, educators, and the economy. In response to disappointing student achievement scores in math and reading, and in relation to the importance of these skills, the Alabama State Department of Education developed a K-12 initiative to improve teaching and student achievement in math and science called the Alabama Math, Science, and Technology Initiative (AMSTI). Consistent with the strategies proposed by Harmony, the AMSTI initiative deployed three primary strategies for change anchored by a focus on standards-aligned, hands-on, inquiry-based instruction in math and science that extended to the elementary years:

1. Access to <u>supporting curriculum, materials, and technology</u> to deliver hands-on, inquiry-based instruction including curricular resources (e.g., lesson plans, assessments);

2. Professional development: A Summer Institute with ongoing school year follow-up; and
3. In-school support for teachers: mentoring and coaching by lead teachers and site specialists.

The effort began in 2002; by 2009, roughly 40% of Alabama schools were active participants in AMSTI. Newman et al. (2012) launched a longitudinal, cluster randomized controlled trial involving 82 schools, over 18,500 students, and approximately 780 teachers in grades 4-8 in five regions of the state to determine the effectiveness of AMSTI. This study was reviewed by What Works Clearinghouse (WWC) in 2014 and deemed to meet the highest level of rigor: Meets WWC Standards Without Reservations. Students represented a diverse population. 64% qualified for Free or Reduced Price Lunch; the sample was nearly equally split between males and females (49 to 51%, respectively) and included 2% English Language Learners. Though race was not reported, public school students in Alabama come from diverse racial and ethnic backgrounds: 56% Caucasian, 33% African-American, 6% Hispanic, and 5% American Indian, Asian, or Biracial. The proportion of minority students ranges from 9 to 99% by county.

The effect of AMSTI on student achievement in mathematics after only one year, as measured by end-of-the-year scores on the SAT 10 mathematics problem solving assessment of students in grades 4–8, was 2.06 scale score units, a difference of 0.05 standard deviation (SD) in favor of AMSTI schools. When converted to days of instruction, the average estimated effect of AMSTI was equivalent to 28 days of additional student progress over conventional instruction.

AMSTI also had a positive and statistically significant effect on classroom practices in mathematics and science after one year. Based on multiple surveys in which teachers reported the number of minutes of active learning strategies used during the previous 10-day period, AMSTI mathematics teachers averaged 49.83 more minutes (i.e., 0.47 SD), and AMSTI science teachers averaged 40.07 more minutes (i.e., 0.32 SD) than control teachers.

The exploratory investigation of the two-year effect of AMSTI on student achievement on the SAT 10 mathematics problem solving test found a positive and statistically significant result of 0.10 SD (i.e., an estimated 50 days of additional student progress). The exploratory investigation of the two-year effect of AMSTI on student achievement in science also found a statistically significant result of 0.13 SD in favor of AMSTI schools, and the effect of AMSTI on student achievement in reading after one year, as measured by end-of-the-year scores on the SAT 10 reading assessment of students in grades 4–8, was a statistically significant result of 0.06 SD (i.e., an estimated 40 days of additional student progress).

The Newman et al. (2012) evaluation of AMSTI provides credibility to each of the specific strategies integrated into Harmony's LEAF to STEM approach.

A. 3. AN EXCEPTIONAL APPROACH TO EIR PRIORITIES

Through this proposal, Harmony plans to adapt its PBL-based STEM curriculum and resources (STEM SOS) and associated teacher supports (summer professional development (PD), mentoring) to elementary school. The efficacy of this can best be demonstrated by Harmony's success at the middle and high school levels using a similar approach.

In the four years following Harmony's 2012 RTT-D grant to deepen personalized learning and PBL for 6-12th grade students, HPS achieved a network-wide graduation rate of nearly 100%, with an average college matriculation rate of 86%, and a college persistence rate of 73% (all significantly higher than national averages). In addition, a recent evaluation found that Harmony "consistently produced better achievement at grades 6-11 on mathematics and reading for all students" relative to comparably sized districts (Sahin, Willson, and Caprano 2018).

Harmony's success is not only demonstrated through achievement in grades 6-12; indeed, Harmony's program has also successfully increased students' interest in pursuing STEM careers.

A study of Harmony alumni (N=2,246) found them more than twice as likely to choose a STEM major in college than typical high school students within Texas and the United States as a whole (Sahin, Ekmekci, and Waxman, 2017a). This finding held for Harmony's female, Black, and Hispanic students when compared with their typical peers, a promising sign that Harmony is helping to close the STEM opportunity gap. Similarly, Harmony's class of 2019 ninth grade students (N=1,520) were more than twice as likely to express interest in majoring in a STEM-related field as compared to other high school students in Texas and the U.S.; this finding again held for Harmony's female (3 times as likely), Black, and Hispanic students (both 2 times as likely) when compared with their typical peers (Sahin, Ekmekci, and Waxman, 2017b).

Specific elements of Harmony's model were predictive of these choices, such as the completion of STEM projects, the digital presentation of their projects, and encouragement from STEM teachers. Harmony's PBL approach captures the natural inquiry of students and provides a forum for methodical and continuous investigation, coupled with ongoing opportunities to discuss and present work (Sahin & Top, 2015). PBL is linked to strong outcomes with Harmony's secondary students and alumni, and possesses pedagogical characteristics that lead to positive, developmentally appropriate learning practices in elementary students irrespective of the subject matter, such as understanding multiple perspectives (ChanLin, 2008), conflict resolution (ChanLin, 2008), initiative, project management, and teamwork (Horan, et al., 1996).

Importantly, HPS also has the infrastructure needed to successfully execute this project: proven staff, commitment to continuous improvement, partnerships with research institutions (including those who will serve as evaluators for this work), and partnerships with a wide variety of leading private sector STEM organizations (see Appendix C for letters of endorsement from Harmony partners).

Finally, Harmony's Innovation Department—which helps to disseminate Harmony's practices to other schools and districts—will help to increase the impact of this proposal on students across the country. Currently, over 10,000 students from 10 districts in 8 states use Harmony's curricular materials to positive effect (see Strategy to Scale section).

Given its demonstrated success applying a similar approach to middle and high schools to improve student achievement and increase student interest in STEM careers, HPS is confident that this project will help increase the number of HPS graduates entering the U.S. economy each spring with even sounder preparation for and stronger interest in STEM fields. The indirect impact—through codification and dissemination of LEAF to STEM strategies—is far greater.

B. STRATEGY TO SCALE

Through the LEAF to STEM project, HPS will produce a broad, diverse, and capable group of students who more frequently pursue STEM postsecondary studies and careers, develop a high-quality set of STEM-focused curricular materials that can be used by elementary schools across the country, and also demonstrate for the education sector an innovative, system-wide, multi-stakeholder STEM professional development and mentoring program that supports the development of teacher pedagogy, content knowledge, and confidence in PBL instruction.

B. 1. DEMAND FOR THE PROJECT

The K-12 STEM "pipeline" that Harmony proposes to develop through this project will directly support tens of thousands of students in Texas and across the country to achieve postsecondary success in STEM. There are several reasons to believe that there is strong demand for expanding STEM programming and teacher supports at the elementary school level.

First, as described above, the demand for "STEM-ready" high school and college graduates has been on the rise, and there is increasing awareness of the need for diversity in the sector.[5] As the demand for STEM graduates—particularly those from disadvantaged backgrounds—rises, so too will demand for programs that effectively prepare students beginning in elementary school.

Second, though early exposure to STEM is critical, there is a dearth of teacher resources available to support delivery of STEM at the elementary school level. Research indicates that students who are exposed to STEM activities from an early age develop positive attitudes towards STEM (Esbach, 2005, Patrick, et al., 2008), achieve stronger outcomes in STEM subjects (Bruce, et al., 1997, Neathery, 1997), and are more likely to pursue STEM careers later on (Lindahl, 2007, Tai, et al., 2006). But as DeJarnette writes (2012): "numerous programs abound for high school and middle school students in regard to STEM initiatives; however, fewer opportunities exist for elementary students and their teachers."

Finally, Harmony has strong family demand for its schools and external demand to use its high-quality materials and professional development supports. More than 24,000 students are on a waitlist to attend a Harmony school, and more than 10,000 students in 10 different districts and eight different states utilize Harmony's STEM SOS curriculum designed for grades 6-12.

Together, demand for students prepared for STEM careers, the dearth of curricular resources and materials to engage and prepare students during elementary school, and strong regional and national demand for Harmony's quality programming will ensure a strong base for this project.

B. 2. BARRIERS TO REACHING SCALE

Elementary teachers have been described as the "gatekeepers to fostering the gifts and talents of future STEM innovators" (Cotabish, et al., 2013). Improving STEM instruction at the

[5] Committee on STEM Education National Science and Technology Council (2013).

elementary school level presents an opportunity to build on the natural curiosity of children, capture their interest in STEM themes and concepts, and build foundational capacities (DeJarnette, 2012). The early years are critical for STEM teaching and learning and are important to make STEM fields more diverse and sustainable (PCAST, 2010). While this proposal's goal is to increase the quality of STEM instruction students receive in the primary grades, large gaps in teacher *competence* and *confidence* in STEM—particularly acute at the elementary school level—are significant barriers to succeeding at this goal at scale.

Research has established a large gap in teacher *competence* in STEM between elementary and secondary teachers. STEM has a relatively fertile instructional foundation in high schools, where 73% of math teachers have an undergraduate or graduate degree in math or math education, and 82% of high school science teachers have an undergraduate or graduate degree in science, engineering, or science education (National Science Foundation, 2014). In elementary schools, only ~5% of the teachers of math or science have a degree in those subjects. 77% of elementary school teachers report feeling "very well prepared" to teach mathematics, but only 39% report feeling equally prepared in science; for engineering it is a mere 4% (Banilower et al., 2013). Elementary teacher preparation programs only require two math and science courses, insufficient preparation for teaching within an integrated STEM program (Nadelson et al., 2013).

This gap is true nationally, and also within Harmony. In a survey of all Harmony elementary teachers, educators indicated a need for more curricular materials, classroom resources, and professional development tailored for the elementary grades to be able to effectively deliver STEM instruction. Currently, Harmony's training for elementary teachers focuses on pedagogy, reading, and math and does not deeply address project-based learning, nor does it focus on core

STEM skill-building. And, while teachers receive coaching from school- and district-level instructional coaches, supports are not explicitly tied to STEM or PBL.

Not only do elementary teachers have competence gaps in STEM, but they also exhibit *confidence* gaps in their ability to lead effective STEM instruction. Nationally, students majoring in elementary education have the highest levels of math anxiety of any college major (Hembree, 1990). Moreover, elementary teachers report low self-efficacy regarding their understanding of engineering and, not surprisingly, low self-efficacy related to ability to teach engineering content. (Hammack & Ivey, 2017). Harmony's internal experience supports these national trends. In a 2018 survey of Harmony's elementary school teachers, only 40% of teachers reported feeling comfortable leading PBL-focused STEM activities in their classrooms.

When teachers have gaps in competence or confidence in STEM instruction, it affects students. When teachers experience discomfort with content, they are likely to spend less time teaching it (Appleton, 2003; Harlen & Holroyd, 1997). When they do teach this content, their discomfort may send discouraging signals to students. Beilock, et al. (2010) found that when female elementary school teachers (grades 1 & 2) were math-anxious, their beliefs that girls could be good at math were weakened, and the math achievement of their female students was negatively impacted. Because early elementary school teachers in the United States are 90%+ female, this presents a major barrier to diversifying the STEM pipeline when its greater diversity is paramount to economic success. (Langdon et al., 2011a; Langdon et al., 2011b.)

Gaps in elementary teacher confidence and competence are the major barriers to scale high-quality STEM instruction in elementary school, and are directly addressed by the three key components of Harmony's LEAF to STEM proposal:

Strategy 1: Adapt “STEM SOS” curriculum and supplemental resources for K-5. Harmony will invest curriculum team resources on aligning its elementary curriculum with middle and high school programming, bringing STEM-centered, interdisciplinary PBL to younger students. This effort will include the creation of curriculum guides, lesson plans, and instructional materials for teachers to implement “off the shelf” or with modifications, which is especially relevant for Harmony’s ~700 new teachers each year who come in less prepared to teach inquiry-based STEM content. Moreover, this proposal will equip elementary schools with the supplemental resources and technology they need to structure these PBL learning opportunities for students.

Strategy 2: Launch a professional development institute for elementary teachers focused on PBL and STEM. In addition to creating strong curricular resources and providing additional materials, Harmony will develop robust professional development modules for elementary teachers to help them develop the skills and mindsets needed to be effective facilitators of STEM instruction. This professional development will occur during the summer and be ongoing throughout the year. Along with internal trainings, it will expose elementary teachers to university and industry partners (e.g., the University of Texas, the National Center for Earth and Space Science Education; see Appendix C for a full list) who are engaged in STEM work so that teachers can develop a real-world understanding of the topics they are teaching. Harmony will integrate these learning modules into its system of teacher micro-credentials developed under its TIF grant.

Strategy 3: Implement STEM focused peer-to-peer mentoring program. Harmony will create a cadre of stipend-paid mentors from middle and high schools, leveraging the teachers who have driven the success of the STEM SOS curriculum under RTT-D. These mentors have two main roles: providing instructional support by leading ongoing professional development (the PBL Summer Institute and year-round workshops on STEM integration, interdisciplinary planning, and PBL instructional methods) and building teacher confidence by serving as grade-level and/or 1:1 mentors for elementary teachers. Each fall, school leaders benefiting from this program will identify one to two PBL development priorities for each grade level, and then the human capital team will skill-match mentors from the pool with schools in the same HPS district based on those priorities. The mentor cohort will also provide elementary teachers with a pool of collaborators for developing interdisciplinary projects. Harmony will integrate this mentoring program into its TIF-funded teacher development programs by creating specific “role cards” and competency maps for STEM mentor teachers and new STEM teachers.

The strategies described above are directly aimed at increasing teacher competence and confidence in STEM education and are evidence-based. As discussed, AMSTI demonstrated the effectiveness of professional development, provision of materials and technology (including curricular resources), and in-school supports (including mentors) for teachers in improving student achievement. Though gaps in teacher competence and confidence in STEM have been past barriers to scale, Harmony’s proposal accounts for and directly addresses these issues.

B. 3. REPLICATING THE PROJECT SUCCESSFULLY

Harmony has an 18-year history of strong growth; refining and scaling successful initiatives is part of its organizational DNA. Because this project builds on previous investments in curriculum, human capital, and data management systems, many of the systems and structures that need to be in place to grow the project to full integration are already there. Harmony’s ability to scale the project across the network is supported by:

- A codified approach to developing, piloting, and rolling out curriculum, projects, extra-curricular programs, and changes across the system (developed through RTT-D);
- An effective human capital management system with attention to growing teacher and leader

instructional effectiveness through differentiated professional development (currently being refined through TIF);

- Organizational commitment to continuous improvement with a data-driven culture and feedback loops embedded in existing processes and protocols, enabled by a variety of customizable dashboards (developed through RTT-D);
- Long-standing partnerships with research institutions, including Texas A&M and Rice University (who will serve as evaluation partners for this project) to measure effectiveness and quality of programming;
- Seasoned staff with a decade-long track record of designing, managing, and successfully stewarding high-impact programs across the HPS network, including through grant-funded initiatives such as Charter Schools Program, RTT-D, and TIF; and
- Dedicated resources to research, evaluation, and best practice sharing (including a full-time research scientist, Dr. Alpaslan Sahin, who actively publishes in peer-reviewed journals, presents at national conferences, and authors books about the HPS STEM evidence base).

Harmony will scale this project across its campuses and, more broadly, to students across the nation. Harmony has an established Innovation Department designed to support external partnerships that disseminate successful HPS practices to schools throughout the country. The department has a formal approach to leveraging successful system-wide best practices beyond the network called "Share and Shine." The STEM SOS curriculum developed through the RTT-D grant is currently being used by more than 10,000 students across 10 districts in 8 states, with plans to roll it out to many more in the future. In addition, Harmony's STEM curriculum leaders and instructional coaches have provided on-demand professional development sessions on PBL and STEM SOS programs to several independent school districts in Texas such as San Elizario ISD, School of Science and Technology, and Fabens ISD.

Evidence suggests that Harmony's materials are not only being used by other districts and students, but that they are also leading to significant improvements in student achievement. For example, School of Science and Technology (SST)[6] is a growing, seven-campus network of schools in Texas that has utilized Harmony's curriculum, assessments, and professional development resources. Since adopting Harmony's materials, SST schools have consistently outperformed the state and district on statewide assessments and on nationally normed tests. For example, in the 2016-17 school year, 62% of students on SST campuses using Harmony materials achieved their NWEA progress goals, outpacing the national average by 12 points.

During years 3-5 of this project, Harmony plans to raise funds (see Budget Narrative) to educate school systems about the imperative of STEM learning in the elementary years with focus on Harmony's strategies. HPS will codify and share with educators at the local, regional, and national levels, inviting them to observe the project in action. In addition, Harmony will provide webinars about the rationale, strategies, and outcomes of LEAF to STEM; and will host in-person activities, such as open houses with student-designed demonstrations, in each school in the intervention group. Harmony will also disseminate formative evidence from the evaluation, coupled with internal studies led by Harmony's research scientist, via peer-reviewed journals, professional conferences, and summary briefs oriented to policy and practitioner audiences.

Harmony's track record of success in other grant proposals and evidence of external demand for Harmony resources substantiate Harmony's ability to replicate this grant both within the Harmony context and in other schools and systems.

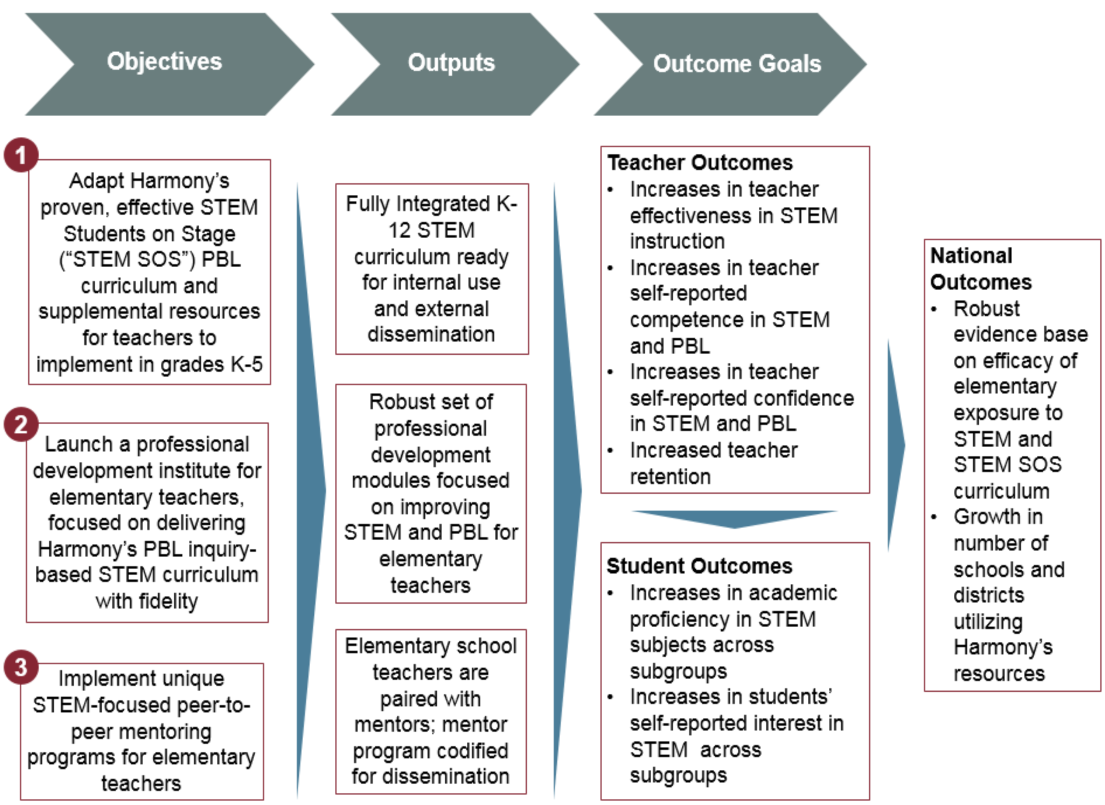
[6] SST has similar student demographics as Harmony. The network serves 2,700 students in San Antonio, Corpus Christi, and Houston. 66% of students receive free or reduced-price lunch, 55% are underrepresented minorities.

C. PROJECT DESIGN AND MANAGEMENT PLAN

LEAF to STEM is designed to build on successful initiatives to date. HPS' management plan is grounded in a commitment to excellence and on deep experience executing against big goals: winning and managing a $30M RTT-D grant supporting 37 schools across 16 Texas cities over the last four years; successfully managing a complex $14.5M Texas STEM initiative in 14 geographically diverse schools over more than a decade; and opening two or more new charter schools annually since 2006. Harmony will borrow from these lessons in executing this plan.

C. 1. PROJECT GOALS, OBJECTIVES, AND OUTCOMES

When scaled, LEAF to STEM will have a significant impact on Harmony's 14,500 elementary school students and 857 teachers, as well as on students and teachers across the country. Harmony has identified a set of internal teacher and student outcomes goals *and* national outcome goals to measure impact; these are illustrated in the logic model below:



Working with the evaluation team, Harmony has identified a series of measures to assess progress against these outcomes (see Appendix G for a complete summary of data collection procedures, data sources, and analysis techniques).

Outcome Goals	Measures	Frequency
Teachers	• Elementary teacher observation, focused on quality of STEM instruction (see Appendix G for the three specific instruments used) • Elementary teacher evaluation ratings • Elementary teacher retention • Elementary teacher survey, self-reported perceptions (e.g., "I feel comfortable leading PBL-focused STEM activities in my classroom") • Administrator survey, self-reported perceptions (e.g., "My teachers are well-equipped to lead STEM instruction")	• Once / semester • Annual • Annual • Annual • Annual
Students	• Student growth and attainment on STAAR assessments (math and science, overall and by sub-group) • Student growth and attainment on NWEA MAP assessment (math, overall and by sub-group) • Elementary (grades 3-5) student survey, self-reported perceptions (e.g., "I want to pursue a career in STEM") • Elementary student participation rates in STEM extensions (total number and percentage of students)	• Annual • Annual • Annual • Annual
National	• On-time delivery of evaluation reports • # of students / schools / districts using Harmony materials • Increases in student achievement by schools / districts using Harmony materials (e.g., increased performance on NWEA MAP)	• On-going • On-going • On-going

C. 2. MANAGEMENT PLAN AND TIMELINE

HPS has mapped roles, responsibilities, and decision-making authorities across the network's central office, district (regional) offices, and individual campuses that will contribute to project success. The central office will hold primary responsibility for EIR implementation by setting organization-wide strategy, standardizing policies and procedures, providing resources and supports, and holding districts and campuses accountable. District offices will serve as a bridge between the central office and the various campuses by building capacity in campus leaders, providing operations and finance support, and managing external relations. Campus leaders will be in charge of implementing this program including mentor selection and teacher development.

Harmony's central office has a history of successfully launching and scaling large-scale curriculum and human capital projects and managing federal grants. This project will be run by a cross-departmental team of existing, seasoned HPS staff, overseen by an experienced federal grant project director. Please see Appendix B for full team credentials.

Dr. Burak Yilmaz will serve as the project director for LEAF to STEM, overseeing the entire scope of the EIR initiative, reporting directly to the Superintendent of Schools. He will manage budget tracking, analysis, and implementation with the support of staff from the curriculum, human capital, innovation, and finance departments. He currently serves as the director for Harmony's TIF grant, and recently oversaw the RTT-D project. A former Harmony STEM teacher, principal, and project lead on Harmony's recent professional development assessment, Dr. Yilmaz also brings experience in training, budgeting, stakeholder engagement, implementation, and grant reporting. He completed his undergraduate studies in mathematics, holds a master's degree in education, and recently completed his doctorate of education.

Gemma Olson will serve as the project manager, reporting to Dr. Yilmaz. Ms. Olson is a curriculum director for grades K-2 at HPS; she previously taught English Language Arts across all grades in the Harmony system and has held a variety of leadership roles. Dr. Nicola Esch, the director of elementary curriculum, will oversee the development of the new K-5 STEM SOS curriculum and the development of elementary school professional development units. Carnita Thomas will support the development and implementation of the staff mentoring component of the project; she is the director of the existing HPS mentorship program for first-year teachers.

The independent external evaluation team will be led by Dr. Hersh Waxman and Dr. Jacqueline Stillisano, supported by a team of highly qualified evaluation researchers from the Education Research Center (ERC) at Texas A&M University and Rice University. The ERC team collectively represents over 50 years of experience in conducting evaluation research and brings the requisite knowledge, skills, and experience in program evaluation using qualitative and quantitative methodology. The team has the demonstrated capacity and experience for planning and managing statewide evaluations and conducting in-depth case studies.

In order to ensure effective implementation of this project and achieve its outcome goals, Harmony has created a detailed implementation plan for this project over the next several years. (see Appendix G for a visual sequencing of this implementation plan):

DETAILED PROJECT MILESTONES		
MAJOR ACTIVITIES AND MILESTONES	**OWNER**	**TIMING**
GRANT MANAGEMENT		
Finalize project budget with key stakeholders	Project Director	Upon approval
Finalize implementation timeline; build project plan		September 2018
Finalize key staff members; on-board staff to project (including project steering committee)		October 2018
Create org-wide communication plan for strategy; build organizational clarity on the scope of this project		November 2018
Set up continuous improvement structures; ensure effective dashboards for monitoring are in place		December 2018-January 2019
Submit ongoing grant requirements to the U.S. DOE		Per U.S. DOE
Monitor progress, make adjustments as necessary		Quarterly, ongoing
OBJECTIVE 1: STEM SOS PBL curriculum and resources for grades K-5		
Identify ES teacher leaders with curriculum development interest to partner with MS and HS STEM SOS architects	Director of Elementary Curriculum	October 2018
Select external partners who will be used to develop K-5 STEM SOS curriculum		November 2018
Engage external partner to extend PBL platform for K-5		November 2018
Backwards map curriculum from grade 6 to K		By March 2019
Procure classroom resources & technology needed to implement curriculum		May 2019
Complete build of K-5 STEM SOS curriculum		August 2019
Develop supporting materials to roll-out curriculum		August 2019
Roll-out curriculum and supplemental resources		August 2019
Implement curriculum and resources, measure impact, collect feedback, and make adjustments as necessary		Ongoing
OBJECTIVE 2: Launch a PBL professional development institute for elementary teachers		
Finalize PD approach (drawing from 6-12 lessons)	Director of Elementary	by December 2018
Develop PBL Summer Institute content for K-5 teachers		by March 2019

Integrate elementary STEM micro-credentials into newly created and existing PD modules	Curriculum	by April 2019
Develop year-round PBL instructional PD units		by July 2019
Launch PBL Summer Institute for treatment schools		July 2019
Launch year-round PD for treatment schools		August 2019
Implement PD, measure impact, collect feedback, and make adjustments as necessary		Ongoing
OBJECTIVE 3: Implement unique STEM-focused peer-to-peer mentoring program for ES teachers		
Finalize "role cards" and competency maps for STEM mentor teacher and new elementary STEM teacher	Project Director	by December 2018
Select external partner to develop mentor teacher training materials and build out credentials	Director of Mentorship	by December 2018
Identify, recruit, and select MS and HS teachers for mentor credential cohort		by February 2019
Train teacher mentors for treatment group		by May 2019
Identify mentoring goals for individual elementary teachers; match with mentors		by June 2019
Launch teacher mentoring program for mentor teachers		July 2019
Implement mentoring program, measure impact, collect feedback, and make adjustments as necessary		Ongoing
CODIFICATION AND DISSEMINATION		
Codify K-5 curriculum and supplemental resource needs for dissemination	Director of Academic Innovation	by August 2020
Codify PD modules for dissemination		by August 2020
Codify mentor program practices for dissemination		by August 2020
Create webinars to introduce other school systems to the LEAF to STEM program		by December 2020 and then ongoing
Organize external site-visits for other school system leaders to observe Harmony's STEM SOS curriculum		by December 2020 and then ongoing
Drawing on evaluation findings, author articles and conference presentations to increase awareness of LEAF to STEM's impact	Director of Evaluation	by December 2020 and ongoing

C. 3. COLLECTING FEEDBACK AND DRIVING IMPROVEMENT

Harmony is devoted to continuous improvement. The organization's experience implementing large grants (e.g., RTT-D, TIF) has helped HPS refine its systems for collecting timely and actionable data on project progress and has helped Harmony develop effective processes for responding to this data to continually improve. Harmony will leverage these systems and processes in this grant proposal:

Systems for collecting timely and actionable data on project progress and outcomes: As part of its RTT-D grant, Harmony developed dashboards to measure the implementation and outcomes of its STEM SOS curriculum in grades 6-12. These dashboards synthesize data on project progress (e.g., # of project milestones met, # of projects supported by mentor teachers, # of training modules completed), as well as the outcomes for students and teachers (e.g., increases in student proficiency, increases in teacher retention). These dashboards are functional at multiple levels and can be customized for system-level, district-level, or school-level views. Harmony's statistician, Dr. RuiLi Luo, will adapt these dashboards to elementary schools so they can be used to measure progress. In addition, HPS' evaluators will continuously collect data and present this information to the steering committee biannually.

Processes to respond to data in service of continuous improvement: To monitor progress and ensure continuous improvement, Harmony will execute concurrent processes at a system, district, and school level. At a system level, Harmony will convene a steering committee that will oversee overall project implementation. Dr. Yilmaz, as project director, will chair this committee, which will include stakeholders from across the organization who are responsible for the project's execution (e.g., STEM curriculum leaders, Director of Mentorship, statistician, district level STEM coaches and Directors of Academics). This committee will meet quarterly to review data on the project's progress and outcomes, troubleshoot issues, and make course corrections as necessary. Harmony's evaluation team will present its "data briefing" during one of these quarterly meetings in the fall of each year. Following these quarterly system-level steering committee meetings, Harmony will then execute quarterly district-level meetings where Dr. Yilmaz will conduct walkthroughs of participating schools and then meet with district leaders to discuss dashboard progress as well as walkthrough findings. Subsequently, district leaders will meet with individual campus principals to review data and make adjustments. At least once a year, central office steering committee members will visit each treatment school to see project execution and ensure implementation fidelity, as well as meet with key campus leaders and participating teachers to gather feedback. Once annually, the project director will execute a feedback survey from all stakeholders throughout the organization to solicit input.

C. 4. INCORPORATING LEAF TO STEM: 2022 AND BEYOND

As described, this proposal aligns closely with ongoing Harmony efforts and supports two out of five goals within Harmony's Strategic Plan 2020: maximize academic achievement of every child and recruit, develop, and retain a talented workforce. Harmony will incorporate the EIR work in any major go-forward strategies across the system—especially since the new K-5 STEM curriculum, mentoring program, professional development infrastructure, and outcomes of this project are inherently designed to be sustained and grow beyond the five-year grant term.

Financial sustainability is also top of mind in designing this project. As detailed in the Match Budget Narrative, Harmony's financial sustainability plan for LEAF to STEM includes aligning state funds and private philanthropy. As it has done with other grants, Harmony will utilize State funds to continue the initiatives after EIR funds expire, sharing resources from other existing programs to help the remainder of elementary schools implement the LEAF to STEM initiatives.

Dissemination and knowledge sharing is core to Harmony's approach to growth and the strategies in this project were identified with their potential systemic impact on the network in mind. They will be codified into "turn-key" tools for all current and future schools in the HPS network (and partner schools beyond the HPS community). As detailed in the Match Budget Narrative, Harmony will raise funds to share what is learned from LEAF to STEM with elementary educators and school leaders from traditional public and charter schools.

In addition, Harmony's internal data scientists will partner with evaluators to write papers, case studies, and peer-reviewed articles on Harmony's progress with LEAF to STEM. Harmony's data scientists will share their findings on the project's progress, the components most critical for success, and lessons for enhancement at conferences and other gatherings. By disseminating its learnings to the broader education sector, Harmony hopes to encourage elementary schools across the nation to integrate STEM PBL in their classrooms.

D. EVALUATION PLAN

D.1. EVALUATION METHODS AND EVIDENCE STANDARDS

HPS has a total of 14,572 grades K-5 students on 32 elementary campuses across Texas. The table below shows HPS system-wide descriptive statistics for number of students by grade level.

Grade Level	Campuses	Mean	S.D.	Min	Max	Total
Kindergarten	32	65.13	26.10	21	111	2,084
Grade 1	32	74.19	26.78	24	113	2,374
Grade 2	32	74.09	25.52	28	114	2,371
Grade 3	32	79.28	26.99	31	123	2,537
Grade 4	32	81.81	26.98	26	123	2,618
Grade 5	32	83.48	27.41	27	152	2,588

In order to meet What Works Clearinghouse's (WWC, 2017) highest rating of Meets WWC Group Design Standards without Reservation, this project will employ a cluster randomized-control trial (RCT) utilizing a stratified random sample. The RCT will be implemented in project years 2 – 5, following a Year 1 planning and data collection period. Due to large variation in total student enrollment and percentage of economically disadvantaged (ED) students across HPS campuses, stratified random sampling will be used to ensure treatment and control groups are representative of HPS schools as a whole. The first strata (total student enrollment) will have two levels determined by whether a campus's total student enrollment falls above or below Harmony's average student enrollment. Within each of those levels, schools will be further stratified into two further groups, based on whether their percentage of ED students is above or below average percentage. A random number generator will be used to assign approximately half of the campuses within each of the groups to either the intervention group or control group (WWC, 2017). The table below shows HPS descriptive statistics for stratification variables.

Variable	Mean	S.D.	Min	Max
Total student enrollment	455.4	150.9	194	662
Percent ED students	69.0	15.4	35	92

Power analysis using G*Power 3 (version 3.1.9.2; Faul, Erdfelder, Lang, & Buchner, 2007) was conducted for this project's research design. For comparisons specific to each grade level, the student samples sizes for control and intervention groups at each grade level will be 1,200 each. For student-level outcomes, this sample sizes of 1,200 (control) and 1,200 (intervention) students would yield a very powerful comparison ($\beta = .96$) by grade level to detect very small effect sizes of Cohen's $d = .15$ (Cohen, 1988) with an alpha level of $\alpha = .05$ (two-tailed). Overall comparison of 7,200 intervention and 7,200 control students would produce a power of $\beta = .99$ detecting even smaller effect sizes ($d = .08$; with a two-tailed $\alpha = .05$).

At the teacher level, power analysis again indicates a very high power ($\beta = .98$) for this project's research design to detect effect sizes as small as $d = .25$ with a two-tailed $\alpha = .05$.

D.2. EVALUATION OF STRATEGIES FOR REPLICATION

In addition to the cluster randomized-control trial (RCT), an improvement science research paradigm will generate critical knowledge about the project’s improvement process. Following the theoretical and empirical work of the Carnegie Foundation for the Advancement of Teaching, the Science Leadership Scholars project will conduct research on four of the critical improvement science principles: (1) making the work problem-specific and user-centered, (2) focusing on variation in performance, (3) explicating a working theory of improvement that can be tested against evidence, and (4) measuring key outcomes (Bryk, 2015, Bryk et al., 2015).

Focusing on a specific problem is one of the key principles of improvement research and this project clearly identifies the critical problems of improving (a) elementary school students' engagement and performance in STEM and (b) elementary teachers' confidence and instruction in STEM. Focusing on performance variations is another key principle of improvement research, and this project focuses on increasing STEM engagement and achievement for students from low-income and historically underrepresented groups. The third principle of improvement research is developing a systems perspective to the problem, and this project utilizes this approach by adapting a successful secondary STEM curriculum and adapting it for elementary school. The fourth improvement science principle is measuring key outcomes, and this project will use or develop a number of practical tools to identify specific outcomes of the project.

In addition to the focus on system and campus improvement, the evaluation will assess three aspects of fidelity of implementation of treatment: (1) the relation between treatment outcomes and variation in the extent and quality of the implementation of the intervention as determined by teacher observations, and interviews; (2) processes that mediate the observed relation between intervention and outcomes; and (3) whether subgroups of students and schools differ in their responses to the treatment. Focusing on variation in the extent and quality of implementation is one of the key principles of this project's evaluation. As such, evaluators will collect teacher-level data on the extent to which: (a) treatment strategies were implemented as planned, and (b) the degree to which teachers perceived the treatment resulted in changes to practice.

Additionally, the evaluation will focus on mediators to increasing STEM engagement and achievement for elementary students from low-income and underrepresented groups. An in-depth examination of implementation records and student data will provide evidence as to whether subgroups of students and schools differ in their responses to the treatment, as well as factors that may facilitate or hinder implementation fidelity. Factors to be examined include the point at which a cluster entered the treatment condition, as well as programmatic changes and school-level factors that may lead to differential outcomes for clusters and student subgroups.

Formative evaluation data will be shared with HPS program staff in the form of biannual reports to allow for any necessary adjustments to implementation of treatment between project years 2 – 5. The formative data will allow for the adaptation of a successful STEM curriculum model that can be codified and made replicable in various school contexts. Studying the implementation process as well as fidelity of implementation to treatment will provide robust evidence over time to Harmony Public Schools of what works, for whom, and under what set of conditions, thus providing a systematic set of principles and research methods that will advance learning on how to improve elementary school students' and teachers' success in STEM.

To address our research questions, quantitative and qualitative data will be collected each year to examine both implementation of the program and the effects of implementation on teacher and student outcomes. Quantitative data will be collected via multiple classroom observation instruments as well as surveys. Qualitative data will be collected via semi-structured interviews conducted during and at the culmination of each school year.

Instruments and Data Collection

Observations. Three teacher observation instruments will be used in the study: (1) the Teacher Roles Observation Schedule (TROS; Waxman, Wang, Lindvall, & Anderson, 1988), (2) Classroom Observation Measure (COM, Ross & Smith, 1996), and (3) the Reformed Teaching Observation Protocol (RTOP; Piburn et al., 2000). The description of these instruments is included in Appendix G. Using multiple instruments allows researchers to investigate different aspects of teaching and learning and supplies a multidimensional conceptualization of classroom dynamics (Hilberg, Waxman, & Tharp, 2004; Waxman, Padron, Franco-Fuenmayor, & Huang, 2009). Trained, experienced observers will conduct observations of each teacher participant once per semester during each year of the intervention. The classroom observations will focus on the teachers' STEM instructional practices and characteristics of the classroom environments.

Surveys. The online survey for teachers will be adapted from multiple instruments for this project. The survey will address STEM teaching experiences, self-efficacy beliefs, perceptions of the school climate, and satisfaction. The survey items will be adopted and adapted from the 2015 Trends in International Mathematics and Science Study Teacher Questionnaires in mathematics and science (National Center for Education Statistics, 2015), the TAMU Collaborative Cohort Survey, and the TAMU Current Undergraduate Survey (Weber, Hodges, & Waxman, 2013). Treatment and control teachers will complete a survey at the end of each school year.

Teacher Interviews. At the end of the school year, we will conduct 15-minute interviews with a sample of treatment teachers. The semi-structured protocol will be developed based on the survey responses and will provide teachers with the opportunity to share illustrative anecdotes highlighting how professional development and mentoring have influenced their teaching and impacted their STEM self-efficacy, as well their intent to remain in the teaching profession.

School-Level Factors. To supplement the observation and survey data, the most recent and up-to-date campus-level data will be obtained from the Texas Education Agency's Texas Academic Performance Reports (TAPR). School climate measures for each school will be aggregated from the teacher survey.

Data Analysis. The quantitative data collected via the classroom observations, surveys, and school-level factors will be analyzed using a combination of hierarchical and multiple regression and descriptive statistics. The qualitative data collected from the teacher interviews will be transcribed, coded, and triangulated with the quantitative data. The use of multiple modes of data collection will allow for a more complete understanding of the impact of the program on treatment teachers' effectiveness, self-efficacy, and satisfaction with teaching.

Formative Evaluation. The project's formative evaluation will serve to assess progress towards objectives; make viable, evidence-based recommendations for adjustments; ascertain the effectiveness of project activities; measure the impact of the project, and confirm the integrity of its outcomes. The formative evaluation will assess the planning and implementation processes used to design, develop, and implement the STEM SOS model for grades K-5. Resulting data will be used to make revisions to the model, report results concerning the implementation fidelity and effectiveness of the STEM SOS model, and help guide the project's practices and procedures throughout the project to increase the likelihood of success. Process and implementation evaluation activities will continue simultaneously. Evaluators will regularly meet with the PI and the rest of the leadership and utilize a biannually updated tracking mechanism to assess progress.

D.3. METHODS WILL PROVIDE VALID, RELIABLE DATA ON RELEVANT OUTCOMES

For students, academic outcomes (both growth and attainment) on Texas state assessments (mathematics and science STAAR) and NWEA MAP (mathematics) will be examined annually each year. Second, increased equity of participation in STEM learning extensions will be examined annually by analyzing HPS records for student participation by grade, sex, and ethnicity. We will also conduct observations of STEM extensions at all treatment schools. Third, we will examine students' interest, confidence, and aspirations related to STEM

For teachers, we will examine (a) teacher ratings on annual evaluation, (b) teacher retention and advancement within HPS, and (c) teacher confidence as measured by annual surveys and interviews. We will determine baseline equivalence between the treatment and control groups by calculating a standardized mean difference (i.e., effect size) on achievement outcomes.

We will use the What Works Clearinghouse baseline equivalence standards (WWC, 2017) to make statistical adjustments (e.g., multiple regression & HLM) if the absolute value of the obtained effect size for baseline equivalence is greater or equal to 0.05 and less than or equal to 0.25. Our study will follow the What Works Clearinghouse (WWC, 2017) attrition standards that limits the amount of bias that could result from attrition in a RCT that receives the highest rating. Since we do not expect the intervention to affect attrition, we will follow the WWC model and use the optimistic attrition threshold developed by the WWC (2017) to calculate overall and differential attrition in this study. Finally, to meet WWC (2017) evidence standards, we will not impute missing outcome data in any analyses. The analysis sample is defined as all cases with non-missing outcome data. The table in Appendix G summarizes our research questions, data sources, data collection procedures, and data analysis techniques.

D.4. COMPONENTS, MEDIATORS, OUTCOMES, IMPLEMENTATION THRESHOLDS

Cost Effectiveness Analysis. We will use cost-effectiveness analysis to systematically compare the costs and outcomes of the project's major components to the control group in order to make decisions about the most efficient project levers (Levin, 1988; Yeh, 2011). We will collect (a) cost data from HPS regarding various project components, and (b) implementation data, and then determine the relative cost-effectiveness of each individual component as well as their combined effects on the measurable student and teacher evaluation outcome data.