LASER i3

The LASER Model:

A Systemic and Sustainable Approach for Achieving High Standards in Science Education

Regional Highlights

Houston Independent School District

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> "The Investing in Innovation Fund, established under section 14007 of the American Recovery and Reinvestment Act of 2009 (ARRA), provides funding to support (1) local educational agencies (LEAs) and (2) nonprofit organizations in partnership with (a) one or more LEAs or (b) a consortium of schools. The purpose of this program is to provide competitive grants to applicants with a record of improving student achievement and attainment in order to expand the implementation of, and investment in, innovative practices that are demonstrated to have an impact on improving student achievement or student growth, closing achievement gaps, decreasing dropout rates, increasing high school graduation rates, or increasing college enrollment and completion rates.
>
> These grants will (1) allow eligible entities to expand and develop innovative practices that can serve as models of best practices, (2) allow eligible entities to work in partnership with the private sector and the philanthropic community, and (3) identify and document best practices that can be shared and taken to scale based on demonstrated success."
>
> – *U.S. Department of Education,*
> http://www2.ed.gov/programs/innovation

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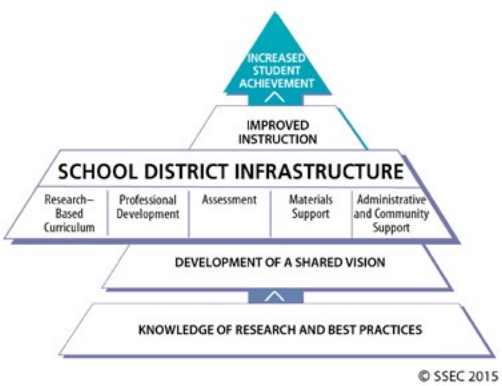
VIDEO 1:
"The kids learn from each other!"
http://bit.ly/kids-learn

Fig. 1 **SSEC's Theory of Action**



The SSEC's Theory of Action describes how research and a shared vision of inquiry science supports the five elements of the LASER model. When all of the elements are addressed together, they support increased student achievement.

The results of the LASER i3 validation study are in! What's more, they bring great news about the impact of inquiry science education on student achievement in elementary and middle schools within Houston Independent School District (HISD) as well as participating schools in New Mexico and North Carolina.

What do we mean by "inquiry"?

Inquiry-based learning and teaching is rooted in decades of research on how students learn. Inquiry is a student-centered method of teaching in which the instructor facilitates conversation and hands-on investigation rather than reciting facts. Students and teachers in inquiry classrooms work together to design investigations, analyze data, and construct explanations, often while incorporating reading and math skills, as seen in Video 1.

What is LASER i3?

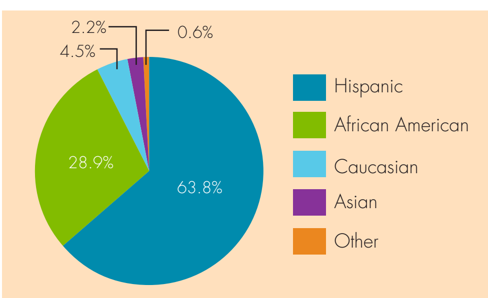
In 2010 the U.S. Department of Education awarded the Smithsonian Science Education Center (SSEC) a five-year Investing in Innovation (i3) validation grant to evaluate the LASER model's efficacy in systemically transforming science education. The LASER (Leadership and Assistance for Science Education Reform) model, developed by the SSEC, is a systemic approach to transforming science education consisting of five elements: a research-based, inquiry-driven science curriculum; differentiated professional development; administrative and community support; materials support; and assessment. These elements, when planned around a shared vision for science, form the infrastructure to sustain student-centered learning and teaching, as seen in Figure 1. "LASER i3" refers to the longitudinal study of the LASER model conducted by the Center for Research in Educational Policy (CREP) at the University of Memphis.

How did the researchers validate LASER?

Evaluators from CREP studied approximately 60,000 students attending public elementary and middle schools (urban, rural, and suburban), 43.8% of whom were enrolled in the HISD. The others attended eight school districts in northern New Mexico and seven school districts in North Carolina. CREP employed a matched-pair randomized controlled trial (RCT) using a comparison group design[1] to investigate whether students in schools implementing the LASER model during a three-year period outperformed students who were not exposed to LASER during the same time period.[2]

An HISD teacher at professional development training for the STC™ unit *Life Cycle of Butterflies.*

Fig. 2 **LASER i3 Student Demographics – HISD Sample**



Sample size (n) is 26,360. Adapted from CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, 2013-14 Annual Report" (Memphis: CREP / University of Memphis, September 2014), 18.

The evaluators began the study with a subsample of more than 9,000 students in elementary and middle school cohorts.[3] CREP assessed the cumulative impact of the SSEC's products and services over three successive school years for selected elementary (grades 3–5) and middle school (grades 6–8) students. Those receiving the intervention were referred to as the "LASER" group and those who did not were the comparison group. CREP reported on student gains from the baseline assessment (Fall 2011) to final post-tests (Spring 2014). In addition to this aggregate data, the evaluators collected detailed information from a subset of focal schools and conducted case studies to better contextualize their data output.

Why does LASER i3 matter in Houston?

Among the three study regions, the HISD experienced the most dramatic impact on achievement with the most diverse group of students. As the seventh largest school district in the United States with over 215,000 students in 283 schools, the HISD educates racially and ethnically diverse students, the majority of whom are economically disadvantaged with 75.5% qualifying for free and reduced price lunches (FRL). A significant number of HISD students are also English language learners (ELL) with 29.9% having limited English proficiency.[4] This diversity is evident in the demographic makeup of the LASER i3 student sample from the HISD, which was 63.8% Hispanic, 28.9% African American, 4.5% Caucasian, and 2.2% Asian comprising 50 schools, as seen in Figure 2.[5]

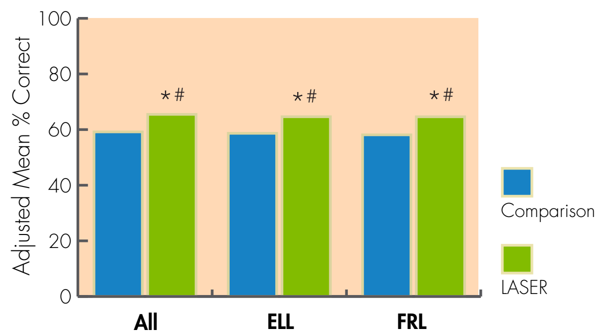
What were the outcomes of LASER i3?

The LASER i3 study resulted in many statistically significant[6] and educationally meaningful[7] improvements in achievement in science as well as in reading and mathematics. "Statistical significance" refers to the likelihood that an outcome can be attributed to a specific cause (i.e., improved student achievement due to the LASER model). "Educationally meaningful" signifies the magnitude of difference between two measures (i.e., the LASER and comparison groups) has practical significance. These results were achieved through analysis of elementary and middle school state standardized assessments in reading, math, and science. To compare students across all three regions, schools participating in the study also administered the Partnership for the Assessment of Standards-Based Science (PASS).[8] Disaggregated data show that the positive benefits recorded in science, as well as reading and math, due to implementation of the LASER model transcended all social, economic, and ethnic boundaries.

What do student assessments tell us about LASER i3 outcomes?

The strongest gains in the PASS assessments by LASER students relative to the comparison group were seen in the hands-on performance tasks, which are particularly noteworthy. These gains indicate students are able to apply what they have learned in science to hands-on tasks, just as professional scientists apply their expertise to conduct scientific investigations and solve complex problems.

Fig. 3 **HISD Elementary – PASS Performance Task**

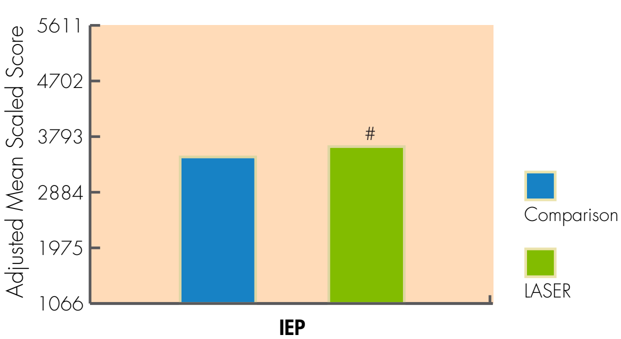


"*" indicates statistically significant results. "#" indicates educationally meaningful results. HISD indicates Houston Independent School District. Comparison group sample size (n) is 273 students and LASER sample size (n) is 427 students. ELL students are English Language Learners. ELL comparison (n= 165) and LASER (n=219). FRL students participate in free or reduced price lunch. FRL comparison (n=260) and LASER (n=351). Adapted from CREP, "The LASER Model, Summative Report, Section 4" (Memphis: CREP / University of Memphis, July 15, 2015).

In the HISD, all elementary school students, including ELL and FRL in LASER schools, showed statistically significant and educationally meaningful achievement outcomes on the **PASS performance task** relative to the comparison group (Figure 3).[9]

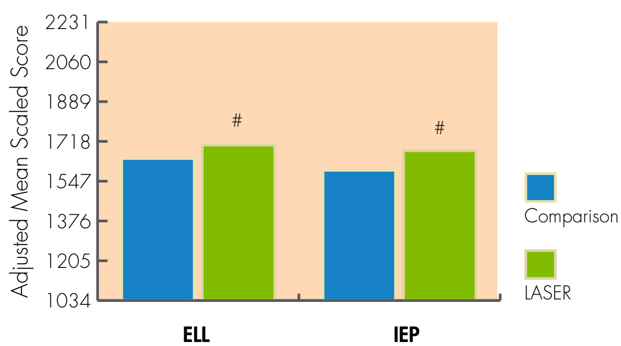
In addition to tremendous achievements on the PASS, the LASER model led to statistically significant and/or educationally meaningful improvements for both elementary and middle school students in state reading, mathematics, and science assessments. The State of Texas Assessments of Academic Readiness (STAAR) tests content students studied that year, and in the case of the Science STAAR, the two grades prior, relative to the Texas Essential Knowledge and Skills (TEKS).[10] Elementary IEP students made educationally meaningful gains on the Science STAAR (Figure 4), while ELL and IEP middle school students achieved educationally meaningful gains on the STAAR administered for mathematics (Figure 5).[11]

Fig. 4 **HISD Elementary – STAAR Science Test**



"#" indicates educationally meaningful results. IEP students possess individualized education programs. Comparison group (n=18) and LASER (n=21). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

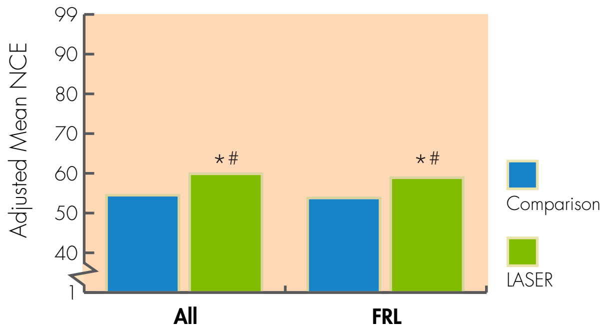
Fig. 5 **HISD Middle School – STAAR Mathematics Test**



"#" indicates educationally meaningful results. ELL comparison group (n=30) and LASER (n=17). IEP comparison group (n=4) and LASER (n=3). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

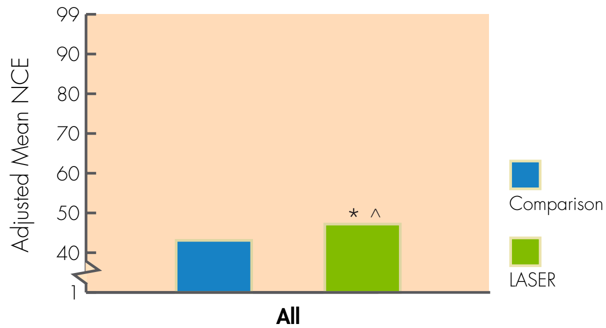
HISD's LASER middle school students also showed statistically significant and/or educationally meaningful results on the Stanford Achievement Tests. Stanford "multiple-choice assessment[s] help to identify student strengths [… and] measure student progress toward content […] aligned to state and national standards."[12] The achievement on this series of state math and reading tests by HISD LASER middle school students illustrates the cross-disciplinary strengths of inquiry science as shown in Figures 5-7.[13]

Fig. 6 **HISD Middle School - Stanford Mathematics Test**



"*" indicates statistically significant results. "#" indicates educationally meaningful results. NCE is the Normal Curve Equivalent Score. Comparison group (n=113) and LASER (n=131). FRL comparison croup (n=111) and LASER (n=115). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 7 **HISD Middle School – Stanford Reading Test**



"*" indicates statistically significant results. "^" indicates nearly educationally meaningful results as defined by Hedge's *g*=0.24. NCE is the Normal Curve Equivalent score. Comparison group (n=143) and LASER (n=148). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

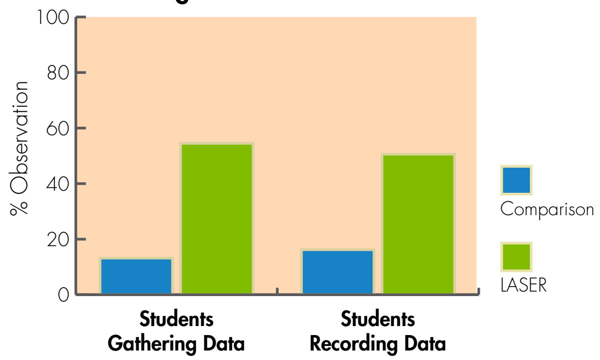
These positive outcomes in reading and math as well as science underscore the many benefits of implementing an inquiry science program in accordance with the LASER model. Not only are gains evident across disciplines but across designations including English language learners, economically disadvantaged students, and those students with special needs. These are exciting results for the future of the LASER model as a vehicle to prepare all students for educational achievement in STEM (Science, Technology, Engineering, and Math), potential career paths, and generally as scientifically literate global citizens

How did student behavior change as a result of LASER?

Teaching science through inquiry challenges students to ask questions, define problems, carry out investigations, gather and analyze data, and construct explanations. CREP's classroom observations offered insights into LASER i3's impact on students' soft skills, supplementing the data from the PASS performance task.

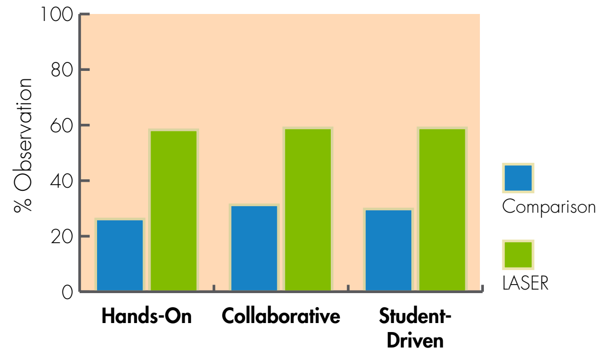
As Figure 8 illustrates, LASER students in the HISD gathered and recorded evidence much more frequently than the comparison group.[14] Evaluators also noted more frequent instances of hands-on, collaborative, and student-driven learning, as seen in Figure 9.[15] These opportunities to work as a team to explore questions and solve problems enable students to practice real-life skills needed in the workforce and as they grow into adulthood. Furthermore, the observational data collected reaffirm student engagement and enthusiasm for learning science in this manner.[16]

Fig. 8 **Students Gathering Data, Students Recording Data – HISD**



Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 9 **Classroom Learning Experiences - HISD**



Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

VIDEO 2:
"I love the training!"
http://bit.ly/love-training

A HISD LASER teacher examines her mixture at PD in the STC™ unit *Experimenting with Mixtures, Compounds, and Elements.*

How did teacher practice change in the HISD as a result of LASER?

Of the 823 HISD teachers who began the project, those participating in the LASER group at grades 1–8 received a Science and Technology Concepts (STC™) unit, produced by the SSEC, each year for three years to implement in their classrooms. The research-based, inquiry-centered STC™ curriculum was accompanied by another integral part of the LASER model: high-quality, differentiated professional development (PD). LASER teachers received two levels of PD in each of their three science units (Video 2). An introductory level training enabled teachers to practice pedagogical strategies with lesson-by-lesson guidance to successfully implement their unit. Intermediate level training took place roughly one year after each introductory training and offered a deeper dive into the science content with investigations geared towards adult learners.

HISD LASER teachers work on their K'Nex car design at professional development training in the STC™ unit *Motion and Design.*

LASER teachers found these ongoing PD opportunities useful in improving their own knowledge and skills as well as preparing them to implement the curriculum. In 2014, evaluators asked teachers, "How useful to your science instruction was the professional development you received last year?" Of LASER teachers in the HISD receiving the SSEC's PD, 68.1% found it "very useful" while only 43.6 % of teachers in the comparison group said the same of their PD.[17]

How did regional partnerships support this effort?

One of the foremost aspects of the SSEC's work, which differentiates it from other systemic reform efforts, is the LASER model's inclusion of community and administrative support. The SSEC worked closely with regional partners from the project's outset to better understand the concerns of each locality and contextualize its programming accordingly. In Houston, several key personnel in the HISD's Science Department served as these partners.

Fig. 10 **Five elements of the LASER model**

With their invaluable input, the SSEC was able to identify key stakeholders to engage in supporting efforts to transform science education. After the LASER i3 project's launch, school and district-level administrators, teacher leaders, government officials, parents, community organizations, and local businesses were invited to building awareness events designed to share information about LASER i3 and demonstrate the importance of inquiry science, thereby garnering support for the initiative.

Once LASER implementation was underway, leadership teams representing a cross-section of each participating school gathered for Strategic Planning Institutes. These weeklong experiences, based on research and best practice, guided teams through developing a five-year strategic plan centered on their shared vision for science and addressing the five elements of the LASER model (see Figure 10).

After attending a Strategic Planning Institute, many leadership teams returned to their schools and discovered specific aspects of implementing their strategic plans to be particularly challenging. The SSEC offered "Implementation Institutes" to reconvene leadership teams with additional support for those specific topics and extra time dedicated to updating and revising their plans.

This responsive, tiered leadership development structure kept LASER i3 participants focused on owning and sustaining the project beyond the grant period while offering opportunities for leaders at all levels to grow. The regional and community partnerships established through this project were fundamental to building local capacity in this way.

What challenges are faced by school systems across the nation and how did the SSEC address them in the HISD?

During its 30-year history, the SSEC has encountered many challenges faced by school systems across the nation. The LASER model's engagement of community partners and inherent capacity building through the leadership development described earlier enables the SSEC to more nimbly respond to these obstacles.

High teacher and administrator turnover is one reality shared by many schools across the nation. In the 2012-13 school year alone, 36% of LASER teachers and 24% of principals in the HISD were new to the LASER i3 project. The high turnover rates posed challenges to the SSEC in providing adequate professional development and to CREP in maintaining its evaluation schedule. This challenge was addressed through regular communication about the project in an effort to maintain and grow buy-in.

The SSEC addressed the need for continuous PD by expanding its offerings to include condensed kit trainings led by experienced LASER teachers. In Houston, 34 teachers led these abbreviated trainings to fill in the gaps in implementing an STC™ unit for newly hired teachers or teachers unexpectedly assigned to a different grade.

The SSEC also developed a collection of on-demand digital offerings to support ongoing PD. *Quick Tips* videos, for example, offer practical suggestions from experienced teachers in teaching specific STC™ units. An animated series called *Good Thinking!* distills valuable educational research to promote effective classroom practice. Finally, the SSEC supported the establishment of five Professional Learning Communities (PLCs) within and across LASER i3 schools in the HISD as a homegrown capacity-building effort.

Good Thinking! The Science of Teaching Science: online, on-demand professional development.

Compounding the pressures of high turnover is the added stressor of high-stakes testing focused on reading and math, felt in classrooms across the United States. The time subsequently taken away from science instruction is particularly acute for inquiry science as it requires ample time to conduct investigations and analyze results. Furthermore, the district-wide goal of improving student achievement in literacy in the HISD was perceived as a competing priority with implementation of LASER i3.

VIDEO 3:
Smithsonian literacy materials
http://bit.ly/literacy-materials

VIDEO 4:
Impacting student learning
http://bit.ly/impacting-students

The SSEC's building awareness efforts helped ameliorate concerns by emphasizing the natural integration of math and literacy skills into the STC™ units. Plenary sessions and principals meetings at summer professional development workshops highlighted the literacy resources accompanying the units, as described in Video 3. A regional coordinator employed by the SSEC but based in Houston made regular school visits to meet with the principals and teachers and address their concerns. The SSEC also hosted a Regional Leaders Meeting annually in which it convened LASER leaders from all three i3 regions to build relationships, share success stories like that in Video 4, and collectively address mutual challenges.

The stress of these high turnover rates, inadequate time allotted for science, and the emphasis on reading was exacerbated by a number of competing initiatives. These projects, designed to support students in the primarily Title 1 school district, led principals and teachers to feel overburdened by the addition of the LASER i3 study. As a result, fidelity of implementation varied from campus to campus. To provide implementation support for these multiple initiatives, HISD administrators developed modified scope and sequence documents with appended pacing calendars, aiding teachers in integrating their STC™ units into the district science curriculum plan.[18]

What is the future of LASER i3?

The LASER i3 study demonstrates that inquiry science improves student achievement not only in science but also in reading and math for students of all abilities at elementary and middle school. In no place is this truer than the HISD. Armed with this validation, the SSEC will continue its efforts to transform science education and support the LASER i3 regions as they sustain and scale the great work that has already been done.

HISD LASER teachers work on their K'Nex car design at professional development training in the STC™ unit *Motion and Design*.

In the Houston Independent School District, the news of SSEC's growing catalog of digital resources was most welcome. The HISD has expressed its intention to host these on-demand digital professional development offerings on its own online teaching and learning platform to be made available to all of its teachers. While funding for inquiry science is limited and competing initiatives abound in this urban district, there is no question LASER will live on in committed schools and classrooms (Video 5). One partner at the district level is optimistic about a proposal to expand the existing materials center to accommodate and support more of the STC™ materials acquired in the project. In the meantime, the strong core of teacher leaders dedicated to inquiry science will continue to be engaged by the SSEC as trainers, speakers, and advocates in Houston and beyond.

VIDEO 5:
The impact of LASER i3
http://bit.ly/LASERi3-impact

We know inquiry science programs supported by the LASER model play a critical role in bolstering student learning in science, reading, and math among all students and especially among English language learners, the economically disadvantaged, and students receiving special education. Students are learning science and loving it, thanks to the legacy of LASER i3 and the LASER model's five elements: a research-based, inquiry-centered curriculum; differentiated professional development; administrative and community support; materials support; and state and local assessments to measure the impact on student learning.

NOTES

[1] A comparison group design is a study design in which outcomes for a group using an intervention are compared to those for a group not using an intervention, with standards set by the U.S. Department of Education What Works Clearinghouse (WWC). See http://ies.ed.gov/ncee/wwc/glossary.aspx.

[2] Participating schools were matched based on demographic and achievement variables and then randomly assigned to intervention and comparison groups. The final sample included 60,000 students, 1,900 teachers, and 140 district administrators and principals from 125 schools in 16 urban, suburban, and rural school districts. Conducting an analysis of school level data would have reduced the ability to detect statistically significant findings due to a lower number of schools. It would also render outcome data unreliable by not factoring in the similarity of the learning environment among students in the same school. Therefore the Hierarchical Linear Modeling (HLM) statistical analysis was employed, which is specifically designed for use with clustered data (e.g., students nested within school). See Marty Alberg, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 1: Executive Summary" (Memphis: The Center for Research in Educational Policy [CREP] / University of Memphis, July 15, 2015), 3.

[3] The statistical analyses included a subsample of students in Grade 3 (elementary cohort) and Grade 6 (middle school cohort) who could be followed over the three years of data collection and have outcome data available. This left 9,000 elementary and middle school cohort students who were eligible to be included in the analyses of achievement outcomes. Due to student and school attrition, there were over 6,000 students remaining in the two cohorts by the third and final year of the study. Statistical analyses were then performed on those students with both baseline and final year data available (e.g. Fall 2011 and Spring 2014 data for the analysis of PASS multiple choice outcomes).

[4] "HISD at a Glance," HISD, accessed August 23, 2015, http://www.houstonisd.org/domain/7908. See "2014-2015 Facts and Figures."

[5] SSEC calculations based on: CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, 2013-2014 SSEC LASER i3 Annual Report" (Memphis: CREP / University of Memphis, September 2014), 18.

[6] "Statistically significant" is a result that cannot occur randomly but rather is likely to be attributable to a specific cause. Statistical significance in LASER i3 is indicated as $p \leq 0.05$. The WWC labels a finding statistically significant if the likelihood that the difference is due to chance is less than five percent ($p = 0.05$). See http://ies.ed.gov/ncee/wwc/glossary.aspx#letterS.

[7] "Educationally meaningful," sometimes called "substantively important," communicates that a result is meaningful as measured by an effect size, which is a descriptive statistic that indicates the magnitude of difference or comparisons between two measures that are meaningful in the research design to which they are applied. The effect size is an indicator of the change in the average student outcome that can be expected if that student is given the intervention. This is the WWC standard. Effect size change is measured in standard deviations. See http://ies.ed.gov/ncee/wwc/glossary.aspx#letterE. In the case of the LASER i3 study, the WWC standard for effect size, as calculated by Hedge's g, is $g \geq 0.25$.

[8] PASS (Partnership for the Assessment of Standards-Based Science) in LASER i3 consisted of multiple-choice questions, open-ended questions, and hands-on performance tasks that "meet the science assessment requirements of the Elementary and Secondary Education Act." For further explanation of the PASS assessments, see "PASS Science Assessment: Partnership for the Assessment of Standards-Based Science," WestEd, last modified 2015, http://www.wested.org/service/pass-science-assessment-partnership-for-the-assessment-of-standards-based-science/.

[9] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 4" (Memphis: CREP / University of Memphis, July 15, 2015), 32, Table 19.

[10] For further explanation of STAAR, see "The State of Texas Assessments of Academic Readiness (STAAR): A New Assessment Model," Texas Education Agency, last modified September 2010, http://tea.texas.gov/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2147487729&libID=2147487728

[11] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 6" (Memphis: CREP / University of

Memphis, July 15, 2015), Tables 12 and 16.

[12] For further explanation of Stanford Achievement tests, see "Stanford Achievement Test Series," Pearson Education, last modified 2015, http://www.pearsonassessments.com/learningassessments/products/100000415/stanford-achievement-test-series-tenth-edition.html#tab-details

[13] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015), for math see Table 34, for reading see Table 32.

[14] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015), Appendix A, 55-56.

[15] Ibid., 50-54.

[16] Observational data measured the percent of classrooms in which the behavior was observed "frequently" or "extensively."

[17] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015), Appendix B, 60.

[18] A scope and sequence document can be found at http://www.laseri3.com/houston/scope-sequence-documents/.