LASER i3

The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education

Executive Summary

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This report was developed under a validation grant (U396B100097) awarded to the Smithsonian Science Education Center (SSEC), formerly the National Science Resources Center, by the U.S. Department of Education through the Investing in Innovation (i3) program. The opinions, findings, conclusions, and recommendations contained in this report do not necessarily reflect the view of the U.S. Department of Education or other funders.

> "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

Matching private sector funding for the SSEC LASER i3 study was contributed by: Los Alamos National Laboratory Foundation, Shell Oil Company, JP Morgan – National Philanthropic Trust, Golden Leaf Foundation, North Carolina GlaxoSmithKline, Carolina Biological Supply Company, Rural School & Community Trust, Noyce Foundation, DuPont, AT&T, Intel Foundation, and Teresa Bergeson.

September 2015

Smithsonian Science Education Center. (2015). The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education. Executive Summary. Washington, DC: Smithsonian Institution.

Highlights of LASER i3

The LASER i3 validation study yielded many exciting outcomes related to the impact of research-based, hands-on science taught through inquiry. The third-party evaluation was conducted by the Center for Research in Educational Policy (CREP) at the University of Memphis, and followed students in grades 1-8 at schools implementing the Smithsonian Science Education Center's (SSEC's) Leadership and Assistance for Science Education Reform (LASER) model using SSEC's inquiry-based science program Science and Technology Concepts™ (STC). Highlights of the evaluation include:

- LASER students showed statistically significant gains on the Partnership for the Assessment of Standards-Based Science (PASS) performance assessment relative to the comparison group. These gains indicate students are able to apply what they have learned to novel hands-on tasks.
- The effects were particularly high for subgroups of students who are most in need. When the data are disaggregated, statistically significant gains in science are also seen by LASER students identified as English language learners (ELL), students with individualized education programs (IEPs), and students participating in free or reduced price lunch (FRL) relative to the comparison group.
- LASER elementary and middle school students also demonstrated positive gains in subject areas other than science as measured by standardized state tests. In the Houston Independent School District for example, LASER middle school students outperformed their peers with statistical significance in both math and reading.
- After receiving three Science and Technology Concepts™ units and accompanying professional development (PD) by the SSEC, 64.7% of LASER teachers reported feeling "well prepared" or "very well prepared" to teach inquiry-based science relative to only 44% of teachers at comparison schools receiving PD as usual.

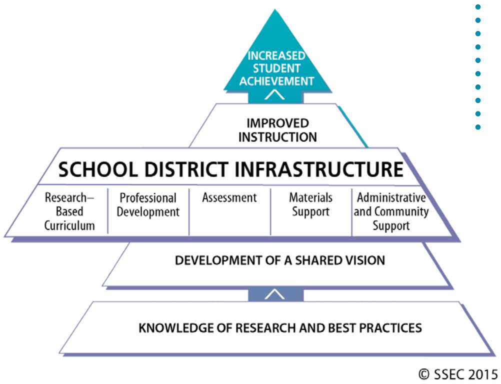
LASER i3 Research Study

Smithsonian Science Education Center

Executive Summary

Students explore the concepts of electricity and circuits through inquiry.

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.

VIDEO 1:
"Inquiry-based learning is incredible!"
http://bit.ly/inquiry-is-incredible

We hear a lot about science today. Science is important. In fact, science and the related fields of technology, engineering, and mathematics—STEM—are crucial to life in the 21st century. Yet America's youth are not pursuing STEM careers in the numbers needed to support today's economy. The Smithsonian Science Education Center (SSEC) is working to change that.

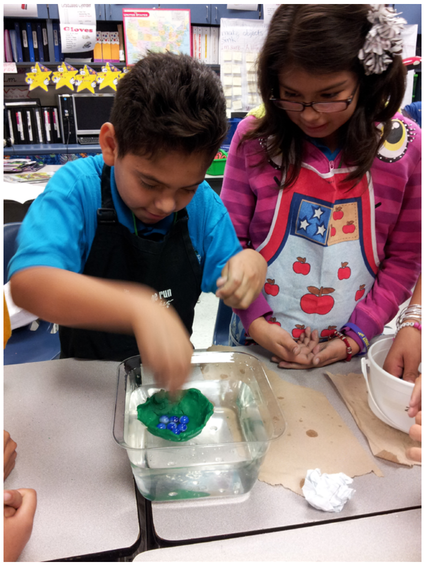
The LASER (Leadership and Assistance for Science Education Reform) model, developed by the SSEC, is a systemic approach to transforming science education consisting of five elements: a research-based, inquiry-driven science curriculum; differentiated professional development; administrative and community 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. (Figure 1).

So what is LASER i3?

In 2010 the U.S. Department of Education awarded the SSEC a five-year Investing in Innovation (i3) validation grant to evaluate the LASER model's efficacy in systemically transforming science education. "LASER i3" refers to the resulting longitudinal study of the LASER model, which unequivocally demonstrates that inquiry-based science improves student achievement not only in science but also in reading and math. LASER plays a critical role in bolstering student learning, especially among underserved populations including children who are economically disadvantaged, require special education, or are English language learners.

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 teacher acts as a facilitator who guides conversation and poses questions alongside their students rather than as an all-knowing purveyor of knowledge. Students and teachers in inquiry classrooms are often carrying out investigations, analyzing data, and constructing explanations, as seen in Video 1.



Students engage in a design challenge assessing their understanding of density and buoyancy from the SSEC's Science and Technology Concepts (STC™) unit *Floating and Sinking*.

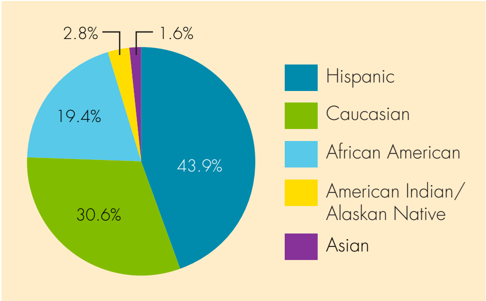
How did the researchers validate LASER?

Evaluators from the Center for Research in Educational Policy (CREP) at the University of Memphis studied approximately 60,000 students attending public schools (urban, rural, and suburban) in (1) the Houston Independent School District (HISD), (2) eight school districts in northern New Mexico, and (3) seven school districts in North Carolina. CREP employed a matched-pair randomized controlled trial (RCT) using a comparison group design.[1] CREP investigated 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]

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?

Fig. 2 **LASER i3 Student Demographics**



Sample size (n) is 6,291. Adapted from CREP, "SSEC LASER i3 Validation Study: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 3" (Memphis: CREP / University of Memphis, July 15, 2015), 6-7.

The face of education is changing. The growing diversity of student populations throughout the United States is evident in the demographic makeup of the LASER i3 student sample, which was 43.9% Hispanic, 30.6% Caucasian, 19.4% African American, 2.8% American Indian/ Alaskan Native, and 1.6% Asian as seen in Figure 2. Of all students studied, 73% qualified as "economically disadvantaged," defined by free and reduced price lunch (FRL) participation.[4] Furthermore, of those students who completed annual assessments, about 18% were English language learners (ELLs) while about 8% had special needs, defined by those children possessing individualized education programs (IEPs).[5] Disaggregated data showed that the positive benefits recorded in science, as well as math and reading, as a result of the implementation of the LASER model transcended these boundaries and classifications.

In this era of global competition, economies depend upon education to fuel innovation. Many people—from parents to politicians—initiate reforms and plan programs designed to improve educational outcomes. But we know little about what truly works… until now.

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] which consisted of multiple-choice questions, open-ended questions, and hands-on performance tasks.

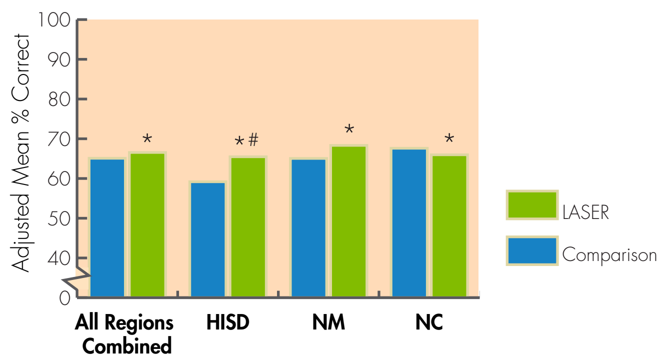
What does the PASS tell us about LASER i3 student outcomes?

VIDEO 2:
"Science is fun, active, and hands-on."
http://bit.ly/science-is

The strongest gains in the PASS assessments by LASER students relative to the comparison group were seen in the hands-on performance tasks, followed by the open-ended, and finally, multiple-choice questions.[9] Gains in the PASS performance task scores 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 (see video 2).

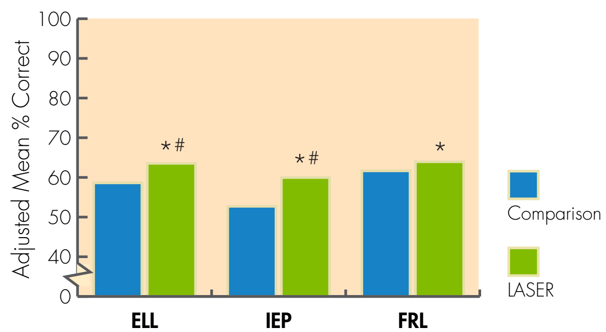
Elementary school students in LASER schools across the three study regions combined showed statistically significant and/or educationally meaningful achievement outcomes on the **PASS performance task** (Figure 3) relative to the comparison group.[10] In North Carolina comparison group students started with an advantage in their baseline scores thatin some cases, LASER students were unable to overcome by project's end, though they did appear to trend towards closing the gap. When analyzing subgroups across regions however, elementary English language learners, special needs students, and economically disadvantaged students all demonstrated statistically significant and/or educationally meaningful outcomes on the PASS performance task (Figure 4).[11]

Fig. 3 **Elementary – All Students PASS Performance Task**



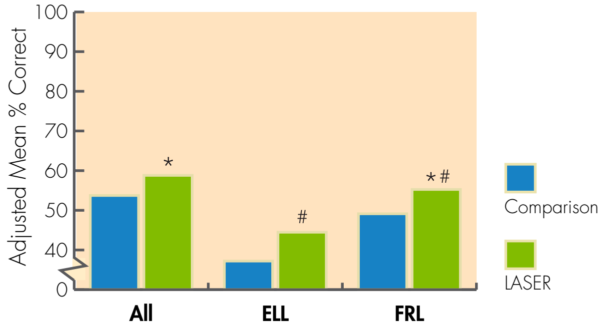
"*" indicates statistically significant results. "#" indicates educationally meaningful results. Comparison group sample size (n) is 1,172 students and LASER sample size (n) is 1,429 students for all regions combined. HISD indicates Houston Independent School District. HISD comparison (n=273) and LASER (n=427). NM indicates New Mexico. NM comparison (n=197) and LASER (n=376). NC indicates North Carolina. NC comparison (n=702) and LASER (n=626). Adapted from 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).

Fig. 4 **Elementary – All Regions Combined PASS Performance Task**



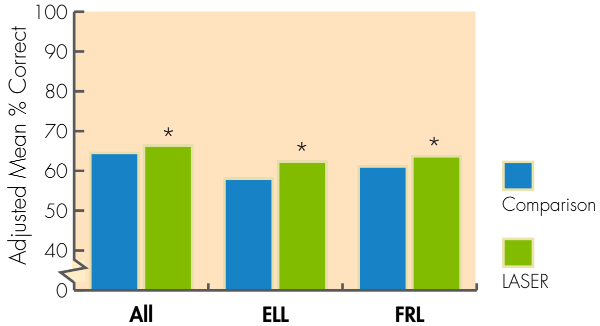
"*" indicates statistically significant results. "#" indicates educationally meaningful results. ELL students are English Language Learners. ELL comparison (n= 238) and LASER (n=371). IEP students possess individualized education programs. IEP comparison (n=94) and LASER (n=132). FRL students participate in free or reduced price lunch. FRL comparison (n=654) and LASER (n=895). Adapted from CREP, "The LASER Model, Summative Report, Section 4" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 5 **Middle School – All Regions Combined PASS Performance Task**



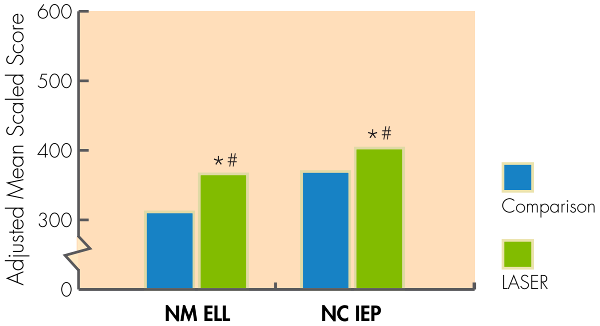
"*" indicates statistically significant results. "#" indicates educationally meaningful results. Comparison group (n=636) and LASER (n=772) for all regions combined. ELL comparison (n=50) and LASER (n=42). IEP comparison (n=61) and LASER (n=84). Adapted from CREP, "The LASER Model, Summative Report, Section 4" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 6 **Elementary – All Regions Combined PASS Open-Ended**



"*" indicates statistically significant results. Comparison group (n=1,176) and LASER (n=1,409) for all regions combined. ELL comparison (n=247) and LASER (n=370). FRL comparison (n=659) and LASER (n=890). Adapted from CREP, "The LASER Model, Summative Report, Section 4" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 7 **Elementary – PASS Multiple Choice**



"*" indicates statistically significant results. "#" indicates educationally meaningful results. NM ELL comparison group (n=37) and LASER (n=71). NC IEP comparison group (n=84) and LASER (n=115). Adapted from CREP, "The LASER Model, Summative Report, Section 3" (Memphis: CREP / University of Memphis, July 15, 2015).

Middle school students showed statistically significant and/or educationally meaningful results that were similar to those of elementary students though not as comprehensive. This is consistent with other intervention studies that show effect sizes drop as students progress through school.[12] All middle school students across all three study regions, including English language learners and economically disadvantaged students (Figure 5), presented statistically significant and/or educationally meaningful gains in achievement as measured by the PASS performance task.[13]

The **PASS open-ended assessments** required students to "communicate scientific information, inquire, reason scientifically, and use science to express positions in societal issues."[14] With statistically significant results, all elementary students in LASER schools outperformed comparison schools (or overcame an educationally meaningful advantage held by the comparison schools) in all study regions combined. Furthermore, all elementary school English language learners and economically disadvantaged students demonstrated statistically significant outcomes (see Figure 6).[15]

The **PASS multiple-choice questions** assess student "understanding of important scientific facts, concepts, principles, laws, and theories…"[16] Though overall student performance was not impacted on the multiple-choice assessment, it is important to note the gains made in the open-ended and performance tasks occurred while still maintaining the achievement on multiple-choice. Among subgroups some gains were seen however, specifically among elementary school English language learners in New Mexico[17] and elementary school students with IEPs in North Carolina (see Figure 7).[18]

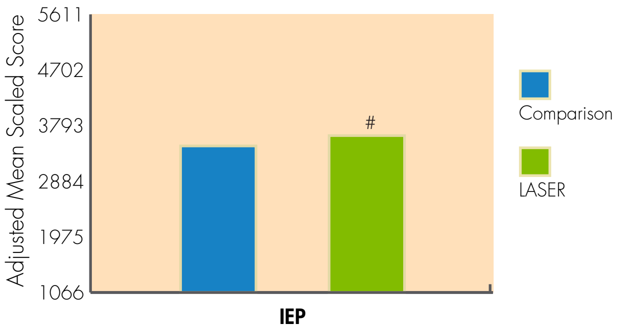
What do standardized state tests tell us about LASER i3 student outcomes?

LASER elementary and middle school students demonstrated statistically significant and/or educationally meaningful improvements in achievement as measured by standardized state assessments in the HISD, New Mexico, and North Carolina relative to comparison schools.

For **Houston Independent School District** students, the LASER model led to statistically significant and/or educationally meaningful improvements in achievement 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).[19] Elementary students with IEPs made educationally meaningful gains on the Science STAAR (Figure 8) while special needs and ELL middle school students achieved educationally meaningful gains on the STAAR administered for mathematics.[20]

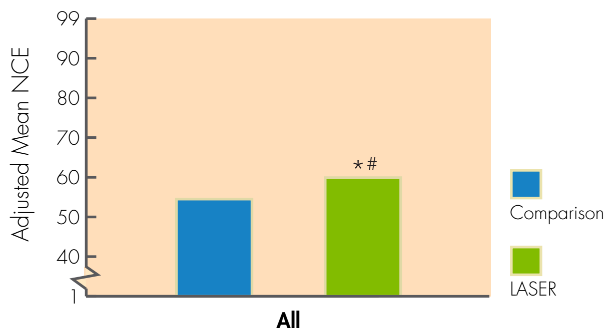
HISD's LASER middle school students also showed statistically significant and/or educationally meaningful results on the Stanford Achievement Tests. Stanford "multiple-choice assessment[s] help to identify student strengths [… and] measure student progress toward content […] aligned to state and national standards."[21] The achievement on both Stanford math and reading tests by HISD LASER middle school students illustrates the cross-disciplinary strengths of inquiry science as shown in Figures 9 and 10.[22]

Fig. 8 **HISD Elementary – STAAR Science Test**



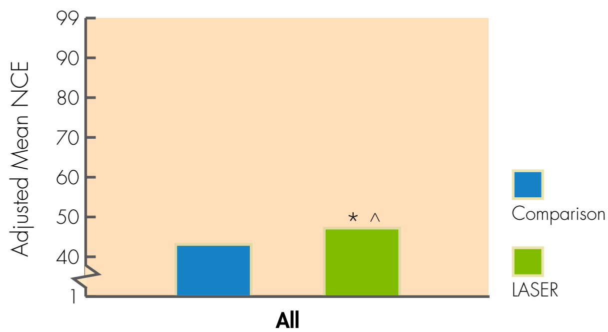
"#" indicates educationally meaningful results. Comparison group (n=18) and LASER (n=21). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 9 **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). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

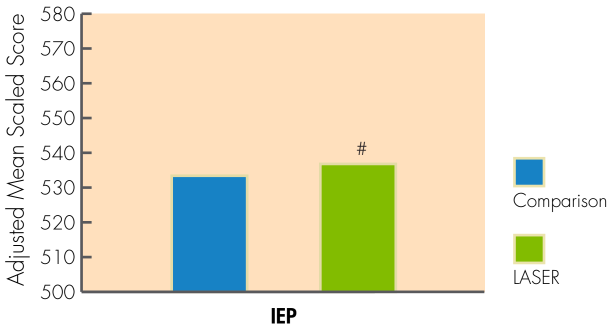
Fig. 10 **HISD Middle School – Stanford Reading Test**



"*" 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).

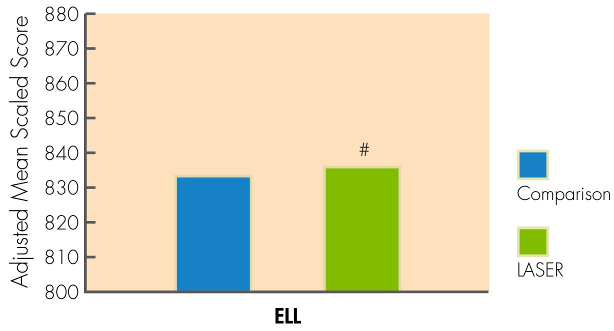
In **New Mexico**, LASER schools saw similar upticks in their standards-based assessment (SBA) in reading relative to comparison schools. Specifically, elementary IEP students (Figure 11) and middle school ELL students (Figure 12) both demonstrated educationally meaningful gains in their reading scores.[23]

Fig. 11 **NM Elementary – Standards-Based Assessment in Reading**



"#" indicates educationally meaningful results. Comparison group (n=44) and LASER (n=64). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

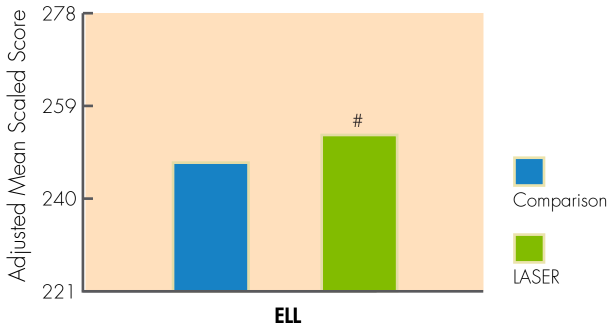
Fig. 12 **NM Middle School – Standards-Based Assessment in Reading**



"#" indicates educationally meaningful results. Comparison group (n=32) and LASER (n=23). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

In **North Carolina**, LASER school performance was assessed against the end-of-grade (EOG) test. Despite the pre-existence of inquiry science in many comparison schools, LASER students still demonstrated statistically significant and/or educationally meaningful gains in achievement. As Figure 13 illustrates, middle school ELL students' scores demonstrated educationally meaningful gains on the North Carolina EOG assessment in science.[24] Furthermore, all LASER middle school students measured statistically significant improvement on the EOG test in mathematics.[25]

Fig. 13 **NC Middle School – End-of-Grade Test, Science**



"#" indicates educationally meaningful results. Comparison group (n=63) and LASER (n=53). Adapted from CREP, "The LASER Model, Summative Report, Section 6" (Memphis: CREP / University of Memphis, July 15, 2015).

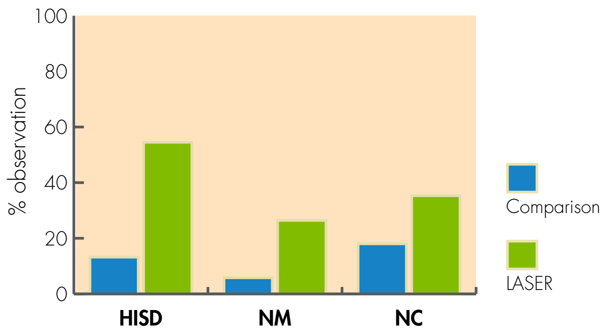
These positive outcomes, seen across the three study regions, in reading and math as well as science underscore the many benefits of implementing an inquiry science program in accordance with the LASER model. Not only are gains evident across disciplines but across designations including English language learners, the economically disadvantaged, and those students with special needs. All told, these are exciting results for the future of the LASER model as a vehicle to prepare all students for educational achievement in STEM, 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.

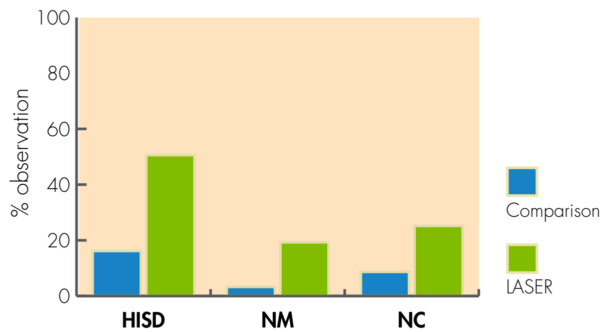
As Figures 14 and 15 illustrate, LASER students gathered and recorded evidence more frequently than the comparison group.[26] Evaluators also noted more frequent instances of collaborative, student-driven, and hands-on learning, as seen in Figures 16-18.[27] These opportunities to work as a team to explore 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.[28]

Fig. 14 **Students Observed Gathering Evidence**



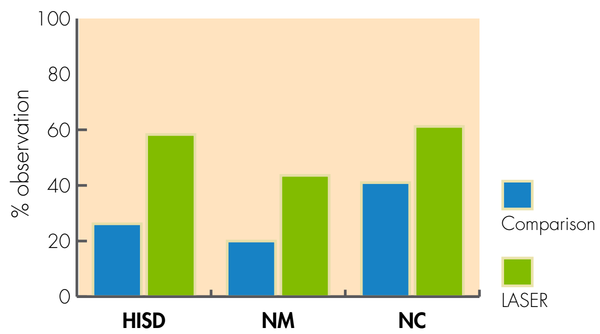
Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 15 **Students Observed Recording Evidence**



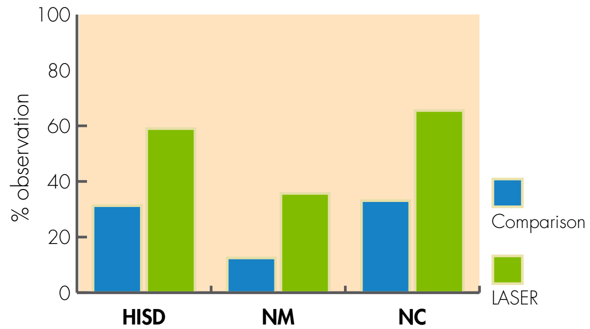
Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 16 **Experiential Hands-On Learning**



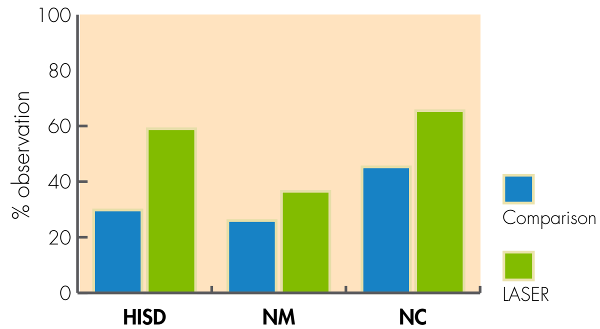
Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 17 **Collaborative Learning**



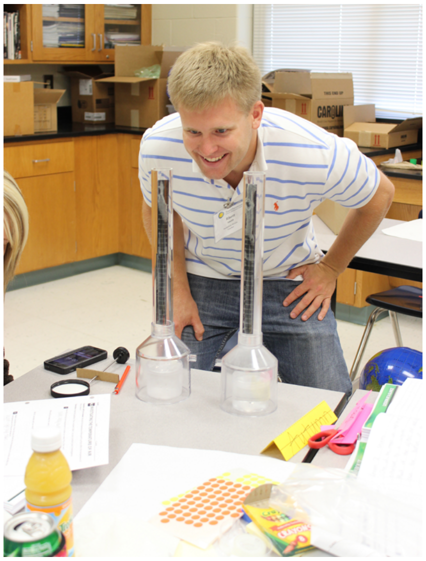
Observational data presented was collected during the 2013-14 school year. Adapted from CREP, "The LASER Model, Summative Report, Section 2" (Memphis: CREP / University of Memphis, July 15, 2015).

Fig. 18 **Student-Driven Learning**



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).

How did teacher practice change as a result of LASER?



A North Carolina LASER teacher examines convection tubes at professional development training in the STC™ unit *Understanding Weather and Climate*.

VIDEO 3:
The training is fantastic!
http://bit.ly/training-is-fantastic

VIDEO 4:
Students can't wait for science!
http://bit.ly/kids-benefit

Participating LASER teachers 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 (Appendix A). 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 training twice in each of their three science units (Video 3). The first introductory training enabled teachers to practice pedagogical strategies with lesson-by-lesson guidance to successfully implement their unit. The second intermediate level training took place roughly one year after the introductory training and offered a deeper dive into the science content with investigations geared towards adult learners.

LASER teachers found these ongoing PD opportunities useful in improving their own knowledge and skills as well as preparing them to implement the curriculum (Video 4). In 2014, evaluators asked teachers, "How useful to your science instruction was the professional development you received last year?" Of LASER teachers receiving the SSEC's PD, 67.6% found it "very useful" while only 23.1 % of teachers in the comparison group said the same of their school district's PD.[29] In that same survey, 64.7% of LASER teachers said they felt "well prepared" or "very well prepared" to teach science using inquiry-based methodologies relative to teachers from comparison schools who received PD as usual. Only 44% of teachers in the comparison group reported that same level of self-confidence.[30]

LASER teachers attending a PD workshop in the STC™ unit *Land and Water* examine the effects of erosion using a stream table.

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 representing the Houston Independent School District served as partners. In New Mexico, staff at the Los Alamos National Laboratory Foundation offered their insights and expertise as the regional partner. In

North Carolina students plan an experiment to explore electric circuits.

North Carolina, the North Carolina Science Mathematics, and Technology Education Center (SMT Center) served as the regional partner.

With the invaluable input of these three partners, the SSEC was able to identify key stakeholders in each region 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.

Fig. 19 **Five elements of the LASER model**

Once LASER implementation was underway, leadership teams representing a cross-section of each participating school or district 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 19).

After attending a Strategic Planning Institute, many leadership teams returned to their communities 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 at LASER i3 sites?

During its thirty-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.

One of the greatest pressures felt in classrooms across the United States is that of high-stakes testing focused on reading and math, which has taken time away from science instruction. The pressure of inadequate time is particularly acute for inquiry science as it requires ample time to conduct investigations and analyze results. The SSEC's building awareness efforts helped regional partners ameliorate concerns about the time needed to implement STC™ units with fidelity. Plenary sessions and principals

Middle school students in the HISD investigate matter using the STC™ *Properties of Matter* unit.

meetings at summer professional development workshops targeted varied audiences to share research and make the case for inquiry science as a vehicle for improving student performance across disciplines. Regional coordinators employed by the SSEC but based in each region 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 their successes in the project, and collectively address mutual challenges.

High teacher and administrator turnover is another reality shared by many schools across the nation. The high turnover in LASER school districts 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. These abbreviated trainings helped 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 local Professional Learning Communities (PLCs) within and across LASER i3 schools as a homegrown capacity-building effort.

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

Many LASER schools encountered the additional challenge of aligning the STC™ units they received to state standards. In Houston, 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.[31] In North Carolina, the NC SMT Center convened standards alignment workshops to address this issue. Curriculum specialists and LASER teachers worked together to develop supplementary materials, including extension activities, to fill the gaps between the STC™ units and state requirements. This work was then posted online as a resource for all.[32]

VIDEO 5:
Hands-on science and non-English speakers
http://bit.ly/science-and-english

Finally, language barriers added complexity to the implementation of the LASER model in all study regions. While the hands-on nature of inquiry science is hugely beneficial to language acquisition,[33] teachers and principals expressed a need for Spanish language materials "to help students transition to English"[34] (see video 5). The SSEC responded by producing and distributing instructional resources in Spanish to support ELL teachers and students including literacy readers, assessments, student guides, and even the science "safety contract" required for students to participate in some STC™ units. The SSEC also provided Spanish translations of communications for parents.

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. 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.

A student in New Mexico examines a larva using a hand lens from the STC™ unit *Life Cycle of Butterflies*.

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 the urban district, there is no question LASER will live on in committed schools and classrooms. 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.

In **New Mexico**, the Los Alamos National Laboratory (LANL) Foundation carries on the work of transforming science education. Discussions are ongoing to determine how LANL Foundation and the SSEC can best serve the needs of northern New Mexico students. The Foundation's overall plan is to integrate LASER schools with the Inquiry Science Education Consortium (ISEC) into one inquiry science initiative serving the region. The LANL Foundation has earmarked $2 million per year to ensure sustainability, and the state of New Mexico has pledged $100,000. The LANL Foundation aims to build a coalition of support for the initiative drawing from multiple funding sources to grow to more districts. In addition, it plans to work with a wider group of leaders to broaden the commitment to inquiry science in New Mexico.

In **North Carolina**, the longstanding relationship between the SSEC and the SMT Center forms a firm foundation for continued implementation of the LASER model. With the results of the LASER i3 project in hand, the SMT Center with support from the SSEC will continue growing its infrastructure for sustainable science education in North Carolina. The SSEC was awarded a three-year i3 evaluation extension grant from the U.S. Department of Education in which CREP will follow select North Carolina LASER elementary and middle school students as they move on to middle and high school, measuring post-i3 student outcomes and systemic change in school. This evaluation extension will allow the SSEC to study factors around post-i3 sustainability of student achievement and whole scale change.

On the basis of the sustainability planning done by participating LASER districts at leadership development institutes in North Carolina, the SMT Center is well prepared

VIDEO 6:
The kids learn from each other!
http://bit.ly/kids-learn

for a post-i3 world. They will continue their role in supporting inquiry science with $2.5 million earmarked to grow buy-in of new districts and finance plans for two regional materials refurbishment centers. These centers were first conceptualized by LASER leaders forming community partnerships as a result of their attendance at the SSEC's Strategic Planning Institute.

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 (Video 6), 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] 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.

[5] SSEC calculations based on: CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 3" (Memphis: CREP / University of Memphis, July 15, 2015), 6-7.

[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), 6, Table 2.

[10] 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), 18, Table 10.

[11] Ibid., Table 10.

[12] Howard S. Bloom, Carolyn J. Hill, Alison Rebeck Black, Mark W. Lipsey, "Performance Trajectories and Performance Gaps as Achievement Effect-Size Benchmarks for Educational Interventions," MDRC, October 2008, http://www.mdrc.org/sites/default/files/full_473.pdf.

[13] 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), 21, Table 12.

[14] WestEd, "PASS: Frequently Asked Questions and Sample Assessment Questions" (San Francisco: WestEd, 2007), 8. http://www.wested.org/online_pubs/pass2007_faq_4_07.pdf.

[15] 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), 12, Table 6.

[16] WestEd, "PASS: Frequently Asked Questions and Sample Assessment Questions" (San Francisco: WestEd, 2007), 8. http://www.wested.org/online_pubs/pass2007_faq_4_07.pdf.

[17] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, Summative Report, Section 3" (Memphis: CREP / University of Memphis, July 15, 2015), 27, Table 18.

[18] Ibid., 38, Table 26.

[19] 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

[20] 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.

[21] 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

[22] 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.

[23] Ibid., Tables 40 and 42.

[24] Ibid., Table 60.

[25] Ibid., Table 58.

[26] 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.

[27] Ibid., 50-54.

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

[29] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, 2013-2014 SSEC LASER i3 Executive Summary (Memphis: CREP / University of Memphis, September 2014), 9.

[30] Ibid., 8.

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

[32] To see supplementary units and extension activities, see North Carolina Science, Mathematics, and Technology Education Center, "i3 Curriculum," last modified 2015, http://www.ncsmt.org/teacher-resources/i3-curriculum/.

[33] As discussed in "English Learners in Science Education." In Handbook of Research on Science Education, edited by Sandra K. Abell and Norman G. Lederman, 204-222. New York, New York: Taylor & Francis, 2014.

[34] CREP, "The LASER Model: A Systemic and Sustainable Approach for Achieving High Standards in Science Education, 2014 Professional Development Analyses, Section 7" (Memphis: CREP / University of Memphis, July 15, 2015), 28-29.

Appendix A: STC™ titles implemented in the LASER i3 validation study

	Life Sciences	Earth Sciences	Physical Sciences
Grades 1-5	Organisms	Soils	Solids and Liquids
	The Life Cycle of Butterflies	Weather	Changes
	Plant Growth and Development	Land and Water	Sound
	Animal Studies	Rocks and Minerals	Electric Circuits
	Microworlds	Ecosystems	Motion and Design
			Floating and Sinking
Grades 6-8	Investigating Biodiversity and Interdependence	Exploring Planetary Systems	Exploring the Properties of Matter
	Studying the Development and Reproduction of Organisms	Understanding Weather and Climate	Experimenting with Forces and Motion
		Exploring Plate Tectonics	Experimenting with Mixtures, Compounds, and Elements
			Investigating Circuit Design