

# Partnerships to Transform STEM Learning

A Case Study of Tulsa, Oklahoma's Ecosystem



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## EXECUTIVE SUMMARY

STEM innovation is important to the growth of the U.S. economy, and a skilled and talented workforce drives innovation. In recent years, as more and more professionals see the need to build STEM literacy in students, there have been multiple influential public and private sector collaborations designed to build STEM engagement, knowledge, and awareness and to attract more young people to STEM. An innovative effort that aims to transform STEM education models through community partnerships is *The STEM Learning Ecosystem (SLE) Community of Practice (CoP)*. Launched by the STEM Funders Network in 2015 and organized by the Teaching Institute for Excellence in STEM (TIES), this national effort promotes local collaborations between community sectors to improve STEM teaching and provide quality STEM-rich learning experiences for all young people, their families, and the larger community (Traphagen & Traill, 2014). The development and enrichment of strategic partnerships through STEM learning ecosystems has been identified as one of the key pathways to success by the U.S. federal government in its latest five-year strategic plan for STEM education (National Science & Technology Council, 2018), underscoring the importance of studying ecosystems over time.

As the SLE CoP is an established initiative entering its fifth year—with 68 communities across the world working to change STEM education models—it is time to explore in-depth how ecosystems put theory into action to transform STEM teaching and learning. By focusing closely on one established ecosystem, this study allowed for a comprehensive review of assets and resources, origin story and developmental trajectory, partnership stages, ecosystem theory in practice, impact on program quality and youth experiences, opportunities and barriers, and indicators of sustainability, especially shared qualities and strategies that can provide a roadmap for others. Partnering with the Tulsa Regional STEM Alliance (TRSA) — the lead entity of the Tulsa, Oklahoma (OK) ecosystem and one of the first in the SLE CoP’s history to conduct the case study — we examined data sources from the organization and its partners. Educational data, interviews and focus groups, exit surveys, indicator tools, document review, observations, and extensive online research were performed as part of the study.<sup>[1]</sup> Questions related to development and impact of the ecosystem framed the study, as did alignment with the national SLE strategies.

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<sup>[1]</sup> For a more comprehensive understanding of SLEs, two additional case studies were simultaneously conducted by another research group – one in Orange County CA (Orange County STEM Initiative, Cohort 1) and one in Jacksonville FL (Northeast Florida Regional STEM2 Hub, Cohort 2).



Additionally, to understand how collaborations formed to create, develop, and sustain the ecosystem and the STEM learning opportunities it provides to children and youth, a four-dimensional partnership typology was also explored within each of the themes identified below (Noam & Tillinger, 2004). Findings from the case study will be used to generate hypotheses that can be tested on a larger scale with other ecosystems. Stories from Tulsa will be shared widely to convey their lessons to others, including their strategies as well as their strengths and challenges.

Several themes were synthesized from the multitude of data. First, the *landscape* of Oklahoma and Tulsa revealed a young, growing, and diversifying population, with one-third identifying as people of color and one-quarter under 18 years of age. STEM-based industries including energy, aerospace, and manufacturing are ample and various STEM jobs are projected to grow between 6% to 13% between 2016 and 2026 in Oklahoma (Oklahoma Employment Security Commission & Economic Research and Analysis Division, 2017). However, science and math performance are lagging, with only 24% of eighth-grade students in Oklahoma at or above Proficient in math and 28% in science (NAEP Report, 2018). Budget cuts, chronically low teacher salaries, teacher shortages, and teacher strikes also pose challenges to the city and the state.

Examining the *origin* and *evolution* of the TRSA revealed that the pathway took five years from incubation to independence (2013-2018) and grew organically out of various area organizations with similar intentions to grow and support STEM by addressing existing educational and workforce gaps. Initially managed by the Oklahoma Innovation Institute (OII), TIES worked with STEM partners to build out the TRSA initiative thanks to local funding, and as of 2018, the organization became an active, independent 501(c)(3) not-for-profit enterprise with well-defined organizational structures, goals, and programming established. The TRSA, the sole STEM intermediary in Tulsa, has a vertical structure with a board of directors, an advisory council, over 140 diverse STEM partners, and seven paid staff, including a dynamic, guiding leader.

The TRSA is successfully putting SLE CoP **theory into action** (*theory of action*) through their diverse and growing events and program offerings, often implemented in collaboration with multiple partners (53% involve two or more sectors). Most partners also reported during interviews or on exit surveys that the TRSA's involvement in the SLE CoP and their implementation of the four national strategies strengthened Tulsa's local ecosystem and its *impact*. Quantitative data show significant growth in STEM participation, with increasing numbers of youth participating in events, programs, and camps (177,858 in 2017; 194,914 in 2018), educators participating in



professional development offerings (1,232 in 2017; 1,310 in 2018), and STEM professionals participating in mentoring opportunities (229 in 2017; 301 in 2018). Direct and indirect youth STEM participation has grown more than 1,800% since 2013. It is estimated that nearly 250,000 children and youth will participate in TRSA-supported events, programs, and camps within Tulsa County and beyond by 2020. Note that these values do not represent unique cases given that young people may participate multiple times per year. There has also been substantial financial growth, with a 7,366% increase in the TRSA's operating budget (\$15,000 in 2013; \$1,120,000 in 2018), and a 188% boost in advisory council membership (50 members in 2015; 144 members in 2018).

Evaluation efforts are ubiquitous throughout the ecosystem, and the TRSA has formed a community of practice around the collection of data to improve quality and outcomes of informal STEM programs (*impact*). Based on the Dimensions of Success (DoS) observation tool, TRSA-supported programs consistently displayed reasonable to compelling evidence of STEM program quality in features of the learning environment, activity engagement, and relationships. Persistently challenging areas were identified, including inquiry, relevance, reflection, and youth voice. The top three areas of professional development desired by educators surveyed using the Common Instrument Suite for Educators (CIS-E) included programming ideas (48%), teaching and leading STEM activities (41%), and helping students with science (19%). Students surveyed using the Common Instrument Suite for Students (CIS-S) reported significant improvements in STEM-related attitudes because of their participation in TRSA-supported programming. Aggregate findings from 2016-2018 showed that, at the end of programming, Tulsa youth reported significantly more growth in all STEM-related attitudes and 21st-century skills measured (except STEM activity participation) relative to peers participating in similar programs across the U.S.

The TRSA has taken comprehensive strides to formalize goals and a mission to promote STEM in Tulsa, establish well-defined organizational and governance structures, build staffing and cross-cutting partnerships (that are collaborative or interconnected in nature), secure funding streams, institute autonomy and independence as an organization, and build capacity and sustainability for future success and growth (*sustainability*). The organization's encouragement of data collection to inform practices, prioritization of high-quality STEM programming, and usage of a continuous improvement model with data made rapidly available through a dynamic dashboarding system strengthens the ecosystem. With the TRSA becoming an independent 501(c)(3) non-profit, having an integral staff member become the Executive Director, and entering



its fifth year of existence as an alliance and fourth year as a national SLE CoP, the TRSA is at a significant transitional point in the evolution of their ecosystem. Furthermore, the culture of optimism and inclusion, the promotion of transparency in its operations, and a strong brand with community recognition and buy-in further builds the organization's continued sustainability and future planning, as does their active engagement with the efforts of the national SLE CoP.

Along with the strengths of the TRSA, areas for improvement were equally identified, which have been translated to the following goals: develop deeper partnerships within and across all sectors (including families, school districts, and businesses), improve communication within and between all sectors, reach diverse settings and students, especially those in low-income and underserved communities, balance the quantity of events and activities with quality of efforts, strategize and delegate to mitigate growing pains felt from rapid scaling, balance the potential influence of funders on planning and decision-making, and devote time to reflect on organizational priorities and long-term strategies. These challenges notwithstanding, Tulsa's ecosystem has displayed many signs of growth and sustainability, and it is important to recognize the great accomplishments of the TRSA despite the many economic, political, and environmental challenges beyond the community's control.

The evidence supports the TRSA as an exemplary model for the SLE CoP that is still growing and evolving. There are many strengths and assets that have galvanized Tulsa's growth, stability, and resiliency, with strong leadership, governance, and partnerships being at the core. Tulsa is a fertile landscape for transforming STEM; the city is in a period of revitalization with major investments being made to put Tulsa on the map as a leader in STEM education. TRSA programming is diverse and growing, designed for all students, educators, and partners alike and spanning early education through workforce. The alliance is focused on data and a quality framework to guide continuous improvement and a community of practice around evidence. While leading from the out-of-school time (OST) sector, the TRSA is actively working to develop collaborative partnerships between school and OST settings to enrich STEM learning for all youth and to address persistent challenges to program quality and academic performance in math and science. By going into depth with this case study, it was possible to see what the ideas and principles of the SLE CoP have contributed to Tulsa's ecosystem. Many of the lessons learned through the TRSA, both strengths and challenges, can be replicated in other ecosystems with time, support, and guidance.



## Introduction

### *A Call for Unified Action in STEM*

Science, technology, engineering, and mathematics—the disciplines collectively known as STEM—are critically important for strengthening economic and societal development through research and innovation. The acronym was coined by the U.S. National Science Foundation (NSF) in 2001 as an easy way to refer to the career fields that integrate knowledge and skills across the four areas (prior to this time, “SMET” was widely used). STEM has become increasingly integrated in educational research and practice, especially as the national agenda shifted in response to several high-impact reports, including *Rising Above the Gathering Storm* (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007), which emphasized the need to increase STEM literacy and proficiency to prepare young people for the STEM workforce and to promote innovative capacity and prosperity of the nation. STEM education is continually evolving in the U.S. with the adoption of new standards, including the Common Core and Next Generation Science Standards, the development of new approaches to curriculum and professional development, implementation of new strategies and logic models, and the availability of new opportunities for young people to learn STEM outside of school. However, while these calls to action have inspired key educational stakeholders to get involved to transform models for STEM education, there was no mechanism to bridge the silos that formed within and between diverse community sectors invested in STEM.

### *STEM Learning Ecosystems (SLE) Community of Practice (CoP)*

To reconcile the many divides—ones that are political, social, cultural, philosophical, pedagogical, financial, and logistical in nature—between the different sectors at the center of a national STEM reformation, a new and inclusive approach to STEM education, known as *The STEM Learning Ecosystems (SLE) Community of Practice (CoP)*, was developed and implemented on a national scale (Traphagen & Traill, 2014). The initiative was launched by the STEM Funders Network at the Clinton Global Initiative in 2015 and organized by the Teaching Institute for Excellence in STEM (TIES). The SLE CoP model promotes local collaborations between school districts, businesses, cultural institutions, research organizations, youth-serving organizations, and funders to provide quality STEM teaching and learning experiences to benefit all young people,

their families, and the larger community (Figure 1). The mission of the SLE CoP is to “spark young people’s engagement, develop their knowledge, strengthen their persistence and nurture their sense of identity and belonging in STEM disciplines.” (STEM Learning Ecosystems, 2018) The development and enrichment of strategic partnerships through STEM learning ecosystems has recently been identified as a key pathway to success by the U.S. federal government in its latest five-year strategic plan for STEM education (National Science & Technology Council, 2018).

**Figure 1. STEM Learning Ecosystems Model**



The SLE CoP framework encompasses four strategies (Table 1, below). All ecosystems are also provided with ten design principles that align to the framework (see Appendix A) (Traill, Traphagen, & Devaney, 2015). Principles include focusing on cultivating dynamic partnerships between diverse stakeholders, experimenting with new and creative means of partnering across sectors, and increasing the quantity and quality of active, inquiry-based STEM learning opportunities for all young people (including youth historically underserved or underrepresented in STEM).

Importantly, the language is flexible as opposed to prescriptive, and it emphasizes the unique context of each community. As examples, the first principle advises: “There is no one right way, no ‘correct model’ for cultivating STEM Learning Ecosystems.” The fifth suggests that: “Ecosystem cultivators embrace the values, beliefs, interests, and strengths of diverse cultures representative of the communities they serve.” (see Appendix A). Individual ecosystems are encouraged to adapt the strategies in ways that best suit the community—taking into consideration the various sectors and unique political, social, economic, educational, and cultural contexts.

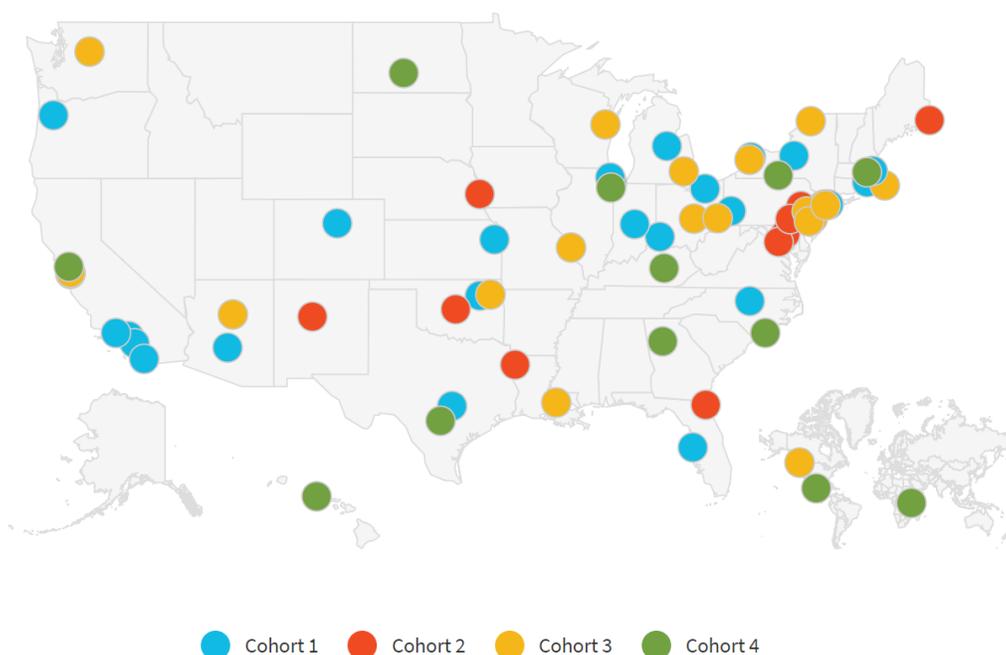
**Table 1. SLE CoP Strategies**

Strategies	SLE CoP Definitions	Examples of actions
<p>1. Cultivating cross-sector partnerships</p> 	<p>“This first strategy is foundational – assessing gaps, identifying partners and determining collective goals creates a strong base from which to engage in creative approaches to the remaining three strategies that are based on each community’s needs, assets and interests. Robust cross-sector partnerships designed to create a collective vision of STEM success for young people are key to cultivating a rich STEM learning ecosystem.”</p>	<p>Identifying a lead organization, engaging a broad range of stakeholders from key sectors, assessing the community’s readiness to collaborate, and defining the landscape and potential gaps.</p>
<p>2. Creating and connecting STEM-rich learning environments</p> 	<p>“STEM learning opportunities are everywhere. In a STEM Learning Ecosystem, those <b>opportunities should be high-quality, universally accessible, youth-centered and connected</b> so learners can deepen their skills and interests and tackle increasingly complex challenges over time.”</p>	<p>Aligning with reputable and vetted national standards, connecting in and out-of-school STEM learning, and employing evidence-based strategies to promote successful STEM learning for all students, especially those traditionally underserved.</p>
<p>3. Equipping educators</p> 	<p>“In a STEM Learning Ecosystem, <b>educators... build their capacity through high-quality relevant professional development, cross-sector experiences and sharing effective practices.</b> Educators understand and respect the role of educators in other settings”</p>	<p>Designing and implementing high-quality trainings, connecting educators with private/public sector STEM employees and developing approaches to continuous improvement (e.g., data sharing to increase quality).</p>
<p>4. Supporting youth pathways</p> 	<p>“In a STEM Learning Ecosystem, <b>pathways enable young people to become engaged, knowledgeable and skilled in the STEM disciplines as they progress from childhood through adolescences and into early adulthood.</b>”</p>	<p>Connecting young people to STEM mentors, teaching about the range of STEM careers and opportunities starting at an early age, and creating new credential models (badging, certifications, e-portfolios).</p>

(STEM Learning Ecosystems, 2018)

The national SLE CoP has scaled rapidly over the course of four years, growing from 27 communities in the U.S. in 2014 (Cohort 1) to 68 communities in the U.S., Canada, and Africa in 2018 (Cohort 4; see Figure 2). Now entering their fifth year, ecosystems collectively are serving millions of young people, with the support of thousands of school districts, informal and out-of-school time partners, pre-K-12 teachers and informal educators, and philanthropic, business, and industry partners. Further, through the initiative, thousands of hours have been invested to cultivate the ecosystems, and hundreds of peer-based learning opportunities have been fostered to promote the building of the national collaboration (STEM Learning Ecosystems, 2018). This impressive and ambitious initiative was established at a time when many communities were ready to connect their local work to a national effort to enhance coordination and collaboration.

**Figure 2. STEM Learning Ecosystems by Cohort (2015-2018)**



***Tulsa Regional STEM Alliance (TRSA)***

Now that the national SLE CoP is well-established, it is possible to begin to understand how different communities across the U.S. have interpreted and implemented SLE CoP strategies to change STEM learning models for education. The present report focuses on one community that has actively participated in the national SLE CoP since it launched in 2014: Tulsa, Oklahoma. At



first glance, and like many other U.S. cities, STEM employment opportunities in Tulsa are growing, but the community is struggling to hire local people with adequate technical skills and experience needed for STEM positions. A few of the public schools have been praised by national media for their innovative approaches to STEM education (Kirp, 2017; Thompson, 2017), but progress has been stymied by recent financial crises and teacher strikes, and performance on local and national math and science assessments has been consistently low (Oklahoma State Department of Education, 2018ab; The Nation’s Report Card: Oklahoma, 2017). The stories of Tulsa have the potential to resonate in communities throughout the U.S. because Tulsa is facing similar challenges in STEM. An in-depth analysis of the STEM landscape, ecosystem origin and development, impact, and sustainability actions can inform the efforts of the many other ecosystems. Research on the ecosystem movement is essential for understanding how communities develop and enrich strategic partnerships to increase STEM literacy among all Americans, to increase access to quality STEM, especially among historically underserved youth, and to increase the number of youth who pursue STEM careers (National Science & Technology Council, 2018; Levy et. al., 2018).

The Tulsa Regional STEM Alliance (TRSA) emerged to advocate, support, and transform STEM education in Tulsa, Oklahoma. The TRSA is an intermediary organization (a self-described “*dynamic mesh network*”) that serves as an “. . .advocate for STEM teaching and learning to ensure that education policy initiatives on a local, state, and federal level appropriately identify needs and deploy vital resources responsibly and effectively to ensure every student has access to the best possible STEM education.” (Tulsa Regional STEM Alliance, 2019). The organization, which leads the community from the afterschool sector, has four goals (“the four C’s”): to *calculate* (i.e., to use common performance metrics to measure the efficacy of TRSA programs and events), *communicate* (i.e., to increase awareness and access to STEM resources and activities through centralized information sharing), *collaborate* (i.e., to use shared resources to broaden impact), and *cultivate* (i.e., to grow the ecosystem with STEM education events and activities and to secure resources necessary to sustain the ecosystem’s activities). The TRSA provides training and professional development opportunities for STEM educators, collaborates with other organizations (inside and outside the afterschool sector) to implement STEM-related programs and events, and designs and delivers STEM programming to children and adolescents.



## ***Research Goals and Framework***

The present case study aims to explore how ecosystems form, develop, evolve, and sustain over time. Evidence will be used for two purposes: (1) to identify key factors that contribute to the resilience and vulnerability of ecosystems to inform practice, and (2) to generate hypotheses that can be used to inform future studies on a larger scale. This foundational work is necessary for understanding whether SLE CoP strategies are effective in engaging children and youth in STEM learning and motivating more children and youth to persist through a pathway leading to a STEM career. With funding from the Overdeck Family Foundation, three ecosystems were chosen as sites for case studies: Orange County, CA, Jacksonville, FL, and Tulsa, Oklahoma. The three communities were selected for case study to ensure lessons were representative of regional, organizational, and developmental differences. However, the case studies are free-standing because existing community assets, as well as their reconfiguration per the development of the ecosystem, must be studied contextually. Significant data available are different across communities, and the ecosystems have different emphases and experiences.

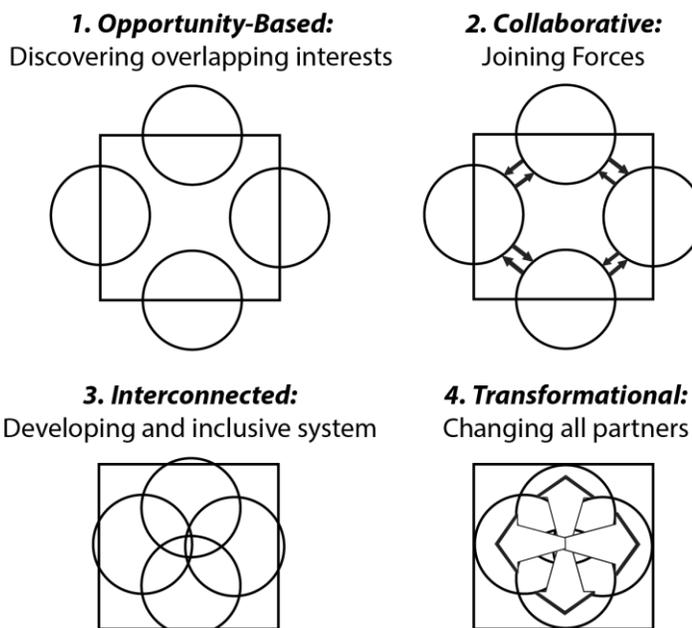
Our inquiry of Tulsa, Oklahoma’s ecosystem was guided by the following questions:

- Why and how does a community come together to form an ecosystem?
- How are ecosystem aspirations transformed into action?
- How does an ecosystem measure the effectiveness of its efforts?
- What are indicators of ecosystem sustainability?

To address these questions, we began by reviewing the four SLE CoP strategies and ten design principles. It was evident that partnerships are the essence of their function as well as their growth and impact potential. Ecosystems are coached to “maximize, grow, and connect,” to commit themselves to “collaborative practice,” to cultivate “dynamic partnerships and diverse partners,” to implement “cross-sector strategies,” and to prioritize “peer exchange, among and between practitioners engaged in implementing cross-sector strategies” (see Appendix A). Thus, to explore how different community sectors join within an ecosystem to transform STEM education models, we used a four-dimensional typology designed to study partnerships between institutions and organizations (Noam & Tillinger, 2004).

This partnership typology (Figure 3) is used to describe and explain intermediary environments, or settings that are created at their intersections. For the purposes of our study, this essentially refers to the co-ownership and management of learning spaces that engage children and youth in STEM activities. The advantage of this framework is that it can be used to inform strategies that promote healthy and productive environments and sustainable relationships, which we hypothesize will improve and expand STEM learning opportunities for children and youth. We used this developmental systems approach to track the ecosystem, as a whole and in parts, from opportunity-based (overlapping interests) to collaborative (joining forces) to interconnected (inclusive system) to transformational (changing all partners).

**Figure 3. Partnership Typology**



In *opportunity-based partnerships*, members maintain their autonomy as an organization and with the services they provide. Collaboration with other organizations is seen as functional and as opportunities for networking and the sharing of knowledge and resources.

In *collaborative partnerships*, participants develop common goals, mutually benefitting from one another’s strengths and experiences, and establish a level of accountability.

In *interconnected partnerships*, equal voices develop among members, there is clear communication, a level of intimacy, joint decision-making, shared programming, and group celebrations of accomplishments.

In *transformational partnerships*, a system of hierarchy is discouraged, instead equality and an intermediary environment is promoted with members accomplishing more together than independently (Noam & Tillinger, 2004).

Because we expect partnering trends within ecosystems to be inherently complex, given the myriad collaborations that form within an ecosystem—between individuals, within and between individual organizations, within and between community sectors, and within the system as a whole



—a flexible, developmentally-sensitive framing is essential. This partnership typology considers how systems can develop over time but also acknowledges that, like people, systems can function at different developmental levels of partnerships at the same time.

The guiding hypotheses for this study are that ecosystems benefit children and youth by developing strong partnerships within and between sectors, improving quantity and quality of STEM-rich learning opportunities, and promoting inclusiveness and diversity in STEM teaching and learning. By conducting an in-depth analysis of a well-established ecosystem, we can understand how key stakeholders in the community are collaborating to support student learning, how key stakeholders and their programming aid the development of STEM skills and knowledge in children and youth, and how other ecosystems can use this model to guide their own development and progress.

## **Methodology**

### ***Approach***

The present case study employs a mixed-methods approach (using quantitative and qualitative methods) to understand how a community uses the SLE CoP network and how it can transform STEM learning models using SLE CoP principles. The case was defined as an active STEM learning community that joined the SLE CoP when it launched (Cohort 1) and that has a credible, highly engaged lead organization committed to collaborative practice. The ecosystem that formed in Tulsa, OK, led by the Tulsa Regional STEM Alliance (TRSA), met all criteria for inclusion. Multiple data sources were used to build evidence for the case, including: the ecosystem design blueprint; the SLE CoP membership application; ecosystem website; one focus group ( $n=10$ ), 15 one-on-one interviews with key ecosystem stakeholders; 10 post-interview exit surveys; 37 standardized observations of STEM activities; 7,713 youth self-report surveys, and 30 educator self-report surveys. The methods and measures are described in more detail below.

### ***Participants***

**Stakeholders.** A focus group and individual interviews were conducted with 21 stakeholders who represent various sectors of Tulsa’s ecosystem, including afterschool (9.1%), business (9.1%), higher education (9.1%), philanthropy (9.1%), K-12 schools (27.3%), and



community (educational alliances like the TRSA, 36.4%). Several participants were also parents in the community whose children participated in programming provided by the TRSA. The majority of interviewees ( $n=15$ ) who completed an anonymous exit survey ( $n=10$ ) identified as White/Caucasian (81.8%), college-educated (100%), and female (63.6%); half held a master's degree (54.5%) in addition to a bachelor's degree.

**Programs.** The ecosystem, led by the TRSA, supports a wide array of STEM-focused programming within Tulsa city limits, across Tulsa County, and beyond. Many of these learning opportunities involve partnerships between sectors. For example, Me and My Math Mentor is a math-focused mentorship program that brings Tulsa STEM professionals (business) to Tulsa Public Schools (K-12) to help third-graders develop essential math skills. To evaluate quality and youth experiences of ecosystem-supported programming between 2016 and 2018, the TRSA invited afterschool and summer programs to participate in a local community of practice that is centered around the use of survey and observation tools for continuous improvement purposes. Most of these programs led STEM activities in school settings (80%)—as opposed to community centers (5%) or other learning settings outside of school buildings (15%)—and most were in urban (55%) or suburban (45%) areas within Tulsa County. Additionally, most programs were designed to engage youth (grades K-12) in learning in two or more STEM areas (76.2%), and about 25% used a formal curriculum to plan activities. Some examples of hands-on STEM activities that students participated in include, but are not limited to, designing and flying drones, building circuits to power lights, programming robots to move underwater, collaborating in teams to solve math problems, making nests outdoors to meet survival needs of local birds, building models of real-life bridges, testing how skyscrapers withstand air pressure, and dissecting plants.

**Educators.** Between 2016 and 2018, 30 educators representing the same 16 programs described above completed a survey about their experiences leading STEM in afterschool and summer programs supported by the TRSA. Educators largely identified as White (85.7%), college-educated (92.6%), and female (78.6%) between the ages of 23 and 61. Most educators have been working in their program for at least one-year (65.0%) and have prior or current experience working in an elementary school, secondary school, or university setting (88.9%).

**Students.** A total of 7,713 surveys (1,797 at the start of programming, and 5,916 at the end of programming) were administered to youth (grades K to 12) participating in STEM-focused programming supported by the TRSA. For validity reasons, only surveys from respondents in



grades 4 and above were used in the present analyses. Based on end-of-program (or retrospective) surveys, there were a similar number of boys and girls participating in programming (50.9% female). Additionally, the sample was diverse and included many groups that are historically underrepresented in STEM. Specifically, students identified as African American/Black (13.0%), Asian/Asian American (2.1%), Latino or Hispanic (21.8%), Middle Eastern/North African (0.1%), Native American (7.7%), Native Hawaiian or other Pacific Islander (0.5%), White/Caucasian (18.9%), or “more than one group” (17.1%). About one-fifth of students preferred not to answer questions about race or ethnicity. In addition, about one-third of students (27.0%) reported speaking a language other than English at home.

### ***Materials***

**Focus groups and individual interviews.** To deepen our understanding of the motivations and development of the ecosystem over time (from the perspective of different community sectors), as well as to understand the ecosystem’s assets, barriers, cross-sector partnership styles, and strength of cross-sector partnerships, we conducted a semi-structured focus group and several semi-structured individual interviews with key ecosystem stakeholders. Interviewers had a list of questions developed based on the guiding questions, SLE CoP strategies, and partnership typology. The sessions were 45 to 75 minutes in duration.

**Interview exit survey.** Interview participants were asked to complete a brief exit survey (10 minutes or fewer) using an anonymous online survey link (created using the Qualtrics platform) following individual interviews to provide an opportunity for key stakeholders to share additional thoughts, to provide demographic information such as gender, race/ethnicity, and education, and to assess perceptions of the overall well-being and sustainability of the ecosystem. Additionally, to quantify how members of Tulsa’s ecosystem perceived the influence of the national SLE CoP on their community, stakeholders were asked to rate whether the following factors were the same or different because of their community’s participation in the national SLE CoP: funding to support the ecosystem, resources to support the ecosystem, public awareness of STEM and the ecosystem, partnerships between sectors, policies and protocols, and sustainability. Items were rated on a five-point Likert scale that ranged from 1 (“Much Weaker”) to 5 (“Much Stronger”) with 3 as the neutral midpoint (“No Change”). Lastly, to quantify the partnerships,



participants were asked to rate their agreement with items that were characteristic of opportunity-based, connected, interconnected, and transformational partnerships. For example, “The partners in my local STEM Learning Ecosystem . . . take pride in collaborative work.” Items were rated on a 4-point Likert-type scale that ranged from 1 (“Strongly Disagree”) to 4 (“Strongly Agree”).

**Table 2. Dimensions of Success (DoS): Domains, Dimensions, and Examples of Quality**

Domain	Dimension	Examples of STEM Program Quality
Features of the Learning Environment	<b>Organization</b>	Materials available, logical sequence, flexibility, smooth transitions
	<b>Materials</b>	Appropriate and appealing
	<b>Space Utilization</b>	Conducive to STEM learning with minimal distractions
Activity Engagement	<b>Participation</b>	Students doing activities, following directions
	<b>Purposeful Activities</b>	Students understand activity goals and time is used to support learning
	<b>Engagement with STEM</b>	Opportunities for hands-on activities so students do the cognitive “minds-on” work
STEM Knowledge & Practices	<b>STEM Content Learning</b>	Accuracy of content presented in activities and evidence of student learning
	<b>Inquiry</b>	Students using inquiry practices of STEM professionals (e.g., scientists, mathematicians, engineers)
	<b>Reflection</b>	Opportunities for students to reflect and engage in sense-making about activities
Youth Development in STEM	<b>Relationships</b>	Degree of positive, respectful interactions among students and facilitators
	<b>Relevance</b>	Students and facilitators explicitly connect activities to real-world, other subjects, STEM careers, etc.
	<b>Youth Voice</b>	Students’ opinions and ideas are heard, and they have opportunities to make decisions



**The PEAR Institute’s Dimensions of Success (DoS).** DoS is an observation tool designed to assess levels of quality of STEM activities (Shah, Wylie, Gitomer, & Noam, 2018). The tool is evidence-based and captures 12 dimensions of STEM program quality along four organizing domains (see Table 2, above). Training and certification are required to perform DoS observations. Observers record field notes for a minimum of 30 minutes (a maximum of 120 minutes), and the strength of evidence for each dimension is quantified by the observer using a standard rubric on a 4-point scale ranging from low (1, Evidence Absent) to high (4, Compelling Evidence). Previous psychometric work has shown DoS to have similar, and sometimes stronger, levels of agreement between raters than the agreement levels reported for observation tools used in formal settings (Bell et al., 2015; Shah et al., 2018). All programs supported by the TRSA have the opportunity to participate in DoS training to support their data collection and continuous improvement efforts.

**The PEAR Institute’s Common Instrument Suite – Student (CIS-S).** The CIS-S is a student self-report measure of five STEM attitudes predictive of future STEM participation (e.g., STEM engagement, STEM identity) and four 21<sup>st</sup>-century skills (e.g., critical thinking, perseverance) that are valued by youth development workers and STEM employers (see Table 3 below; Allen, Noam, & Little, 2017; Little et al., in press; Martinez, Linkow, Velez, & DeLisi, 2014; Noam, Allen, Sonnert, & Sadler, in preparation). Scales range from 5 to 10 items, and the survey concludes with questions about student characteristics, including gender, grade, race/ethnicity, primary language, and program dosage/duration. All programs supported by the TRSA are invited to participate in CIS-S data collection, with funding typically made available for 10 to 20 programs per year. Between 2016 to 2018, some programs completed all nine scales, and other programs with a younger student population completed a shorter version of the survey that included STEM engagement only, or STEM engagement and the four 21<sup>st</sup>-century skills.

Surveys were used to understand the experiences of youth participating in programming because self-reported attitudes and expectations have been shown to predict future engagement with STEM (Tai, Liu, Maltese, & Fan, 2006). Young people who feel positive emotions when engaging with STEM (such as energized or excited; Mazer, 2017; Noam et al., in preparation; Shernoff, 2013) and young people who personally identify with STEM (such as see a place for themselves in STEM) (Aschbacher, Ing, & Tsai, 2014; Cribbs, Hazari, Sonnert, & Sadler, 2015) are more likely to engage in approach behaviors toward STEM learning, including participating in activities and engaging more deeply with content and materials (Mazer, 2017). Moreover, young

people who are interested and knowledgeable about STEM careers are more likely to make decisions that lead to STEM-related educational and career choices (OECD, 2010, 2015). Lastly, young people who have developed strong 21<sup>st</sup>-century skills (such as critical thinking, perseverance, and relationships with peers and adults) are more likely to be equipped with 21<sup>st</sup>-century skills necessary to navigate an increasingly complicated social and technological world (Malti, Zuffianò, & Noam, 2017; Noam, Malti, & Guhn, 2012) and meet the expectations of STEM hiring managers (The Business Roundtable & Change the Equation, 2014).

**Table 3. Common Instrument Suite for Students (CIS-S): Domains, Scales, Definitions, and Examples of Items**

Domain	Scale	Definition	Example Item
STEM-Related Attitudes	<b>STEM Engagement</b>	Interest and excitement in participating in STEM	“I like to participate in STEM projects.”
	<b>STEM Career Interest</b>	Motivation to pursue a career in STEM	“STEM will help me find a job.”
	<b>STEM Career Knowledge</b>	Knowledge of STEM-related careers and the steps to attain them	“I know about different kinds of STEM jobs.”
	<b>STEM Identity</b>	Understanding of oneself as a person who can do STEM and be in STEM	“I think of myself as a STEM person.”
	<b>STEM Activity Participation</b>	Pursuit of STEM activities in everyday life	“I watch STEM-related TV shows.”
21 <sup>st</sup> -Century Skills	<b>Relationships with Adults</b>	Positive connections and attitudes toward interactions with adults	“There are adults who are interested in what I have to say.”
	<b>Relationships with Peers</b>	Positive and supportive social connections with friends and classmates	“I have friends who care about me.”
	<b>Perseverance</b>	Persistence in work and problem-solving despite obstacles	“I keep working even if it takes longer than I thought it would.”
	<b>Critical Thinking</b>	Examination of information, exploration of ideas, and independent thought	“I like to think of different ways to solve a problem.”



**The PEAR Institute’s Common Instrument Suite – Educator (CIS-E).** The CIS-E is an assessment for informal STEM educators that was designed to complement the CIS-S and DoS. It captures the unique qualities of STEM programs and the practitioners who lead STEM activities in informal environments. The CIS-E contains questions about the training and professional development that afterschool STEM educators received to lead informal STEM, the training and professional development that they would like to receive in the future, their interest and ability and confidence levels for leading STEM, and their feelings about how they have impacted their students’ proficiency and confidence in math, science, and social skills. Other items were included to obtain program characteristics, such as curriculum usage, as well as educator characteristics, including gender, race/ethnicity, highest level of education completed, and years of experience leading STEM. Educator attitudes can be correlated with quality ratings or student attitudes.

**Teaching Institute for Excellence in STEM’s (TIES) STEM Learning Ecosystem (SLE) Indicator Tool.** In 2016, TIES developed an ecosystem self-report survey to measure ecosystem progress in five domains that align with the SLE CoP strategies and design principles: (1) cross-sector partnerships (e.g., “Pre-K-12 school system is engaged in the Ecosystem”), (2) architectural and organizational features required for sustainability (e.g., “Ecosystem has a clearly articulated Mission/Aspiration that is understood and supported by all stakeholders.”), (3) alignment of learning inside and outside of school with evaluation to ensure quality and impact (e.g., “Ecosystems focus on inquiry and allowing learners in school and in OST/Expanded Learning to discover answers to questions rather than providing the answers.”), (4) equipping educators with tools and training to maximize benefit (e.g., “The Ecosystem has identified, catalogued, and classified existing STEM professional development opportunities within the region.”), and (5) college and career readiness and development of articulated career pathways (e.g., “Ecosystems have a plan to ensure equal access to career pathway initiatives to historically underrepresented populations.”). Each of the five domains contains between four and eleven items that are rated by ecosystem leadership using a five-point Likert scale; while the response options are customized by item and domain, a rating of “0” broadly indicates that no progress has been made in a given area and a rating of 4 indicates that substantial progress has been made in a given area (i.e., very advanced). To approximate ecosystem progress in these five important indicators of SLE sustainability, as perceived by ecosystem leadership, ratings for each of the items within the five domains were averaged and plotted over time.

## ***Procedures***

First, to understand the historical context of the case, we conducted an extensive review of documents, archival records, and physical artifacts (Marshall & Rossman, 2016). These secondary data sources, which were publicly available or obtained with permission from the rightsholder, aided our understanding of the ecosystem timeline and allowed us to map the landscape of the community (including its population, assets, resources, and ecosystem membership). It also allowed us to explore evidence of ecosystem impact on the learning environment, such as standardized test results, the quality of programming, and learning experiences of youth. Some examples of these secondary sources of evidence include: ecosystem design documents, SLE CoP membership application, organization website, SLE Indicator Tool data, organization budget reports, newspaper/internet articles, U.S. Department of Education databases, OK State Department of Education databases, STEM program quality observation fieldnotes and data (DoS), youth self-report survey data (CIS-S), and educator self-report data (CIS-E).

Second, to develop an understanding of ecosystem partnerships, ecosystem growth and development, and the use of the SLE CoP by local ecosystem members, we performed research interviews and a focus group with key stakeholders from various educational settings (e.g., preK-12 teachers, afterschool facilitators/educators, business leaders, STEM professionals). An initial list of community stakeholders to interview was generated from the focus group conducted at a national SLE CoP event with members of Tulsa's ecosystem. To increase the representativeness of the sample of interviewees, we also recruited ecosystem members using an email advertisement that was shared widely with all ecosystem members by the TRSA leadership. We also asked interviewees for referrals for other members who may be interested in participating. The focus group and each individual interview used a semi-structured format. The discussions were guided by a set of predetermined questions, but respondents were encouraged to talk freely and ask their own questions. A link to an exit survey was emailed to each participant following the conclusion of the interview. For the collection of these primary sources of data, a study information sheet was provided, and verbal consent was obtained by research study staff prior to the start of the interviews and the focus group.

All study procedures were reviewed and approved by Partners Human Research Committee Institutional Review Board at McLean Hospital, an affiliate of Harvard Medical School, in Boston, MA, USA.

## ***Data Analysis***

Qualitative data from interviews and the focus group were transcribed, categorized, and organized thematically (Table 4, below). Thematic analysis is the most common form of analysis in qualitative research. It emphasizes pinpointing, examining, and recording patterns (or "themes") within data. Themes are patterns across data sets that are important to the description of a phenomenon and are associated to a specific research question. We also assembled key events and outcomes into a chronology to examine the ecosystem's development over time.

Quantitative data collected from observations, exit surveys (completed by interviewees), the SLE Indicator Tool, and youth and educator surveys (completed by participants in ecosystem-supported programming) were analyzed using SPSS version 23 to determine descriptive statistics and correlations among variables. Repeated measures analyses of survey ratings and quality ratings were not possible because data were deidentified and represented different cohorts of programs and children (i.e., different programs and different groups of students each year).

## **Results**

Six themes were synthesized from qualitative and quantitative data sources described above, including the ecosystem's landscape, origin, evolution, theory of action, impact, and sustainability. These themes are presented in Table 4 with definitions and examples. Evidence for partnerships (i.e., opportunity-based, collaborative, interconnected, and transformational) was interwoven throughout each of the six themes. Partnerships were found to be integral to all themes and therefore not designated as their own distinct theme.

We began the results by mapping the landscape of the community – to understand the population, existing educational system, and businesses and industries – and then by reviewing the origin story of Tulsa's ecosystem – to identify champions and key events that motivated Tulsa to join the SLE CoP. Next, we explored the evolution of the ecosystem – including a review of how the ecosystem grew and developed over time and established current governing structures – and then documented how the community put SLE CoP theory into action – such as examining the community's perceptions of SLE CoP strategies and providing evidence for how the community translated each of the strategies. Lastly, we explored evidence of impact – such as growth in STEM participation, funding, partnerships, quality of STEM programming, and youth experiences – and we concluded with evidence of sustainability – such as indicators of longevity and productivity.

**Table 4. Key Themes of Case Study Research with Definitions and Questions**

Themes	Definition	Examples of Questions Answered by Theme
<b>Landscape</b>	Distinctive features of the ecosystem’s location and community	What do we know about the ecosystem’s population? Are there STEM-supporting businesses, industries, foundations, community organizations, and educational systems?
<b>Origin</b>	Time and place where the community came together to form an ecosystem	Which people or organizations played an essential role in the establishment of the ecosystem? What were the motivating factors for each sector of the community to partner?
<b>Evolution</b>	Development of the ecosystem over the course of time, before and after joining the national SLE CoP	How did the ecosystem grow and diversify in terms of governance, partnerships, funding streams, resources, and other assets?
<b>Theory of Action</b>	Transformation of the four principles of SLE CoP theory into practice, and how practice is put into action	Is the work performed together as an ecosystem different from the work done before? Were there some principles that cut across all partners that served children and youth?
<b>Impact</b>	Effects of the SLE CoP on people and organizations within the community	Is there evidence for improvements to funding, equity, access, or STEM teaching and learning? Is there evidence of change in the quality of practices in the implementation of STEM learning activities?
<b>Sustainability</b>	Ability of the ecosystem to meet the needs of the community without compromising its ability to function	What indicators of sustainability already exist in the ecosystem? What indicators are needed to approximate ecosystem sustainability?

***Landscape***

**Population.** Oklahoma is the 20th-most extensive and the 28th-most populous state in the United States. Located in the south-central region of the United States, Oklahoma has an estimated population of 3,930,864 (see Table 5). Nearly a quarter of the residents are under 18 years old (24%) (U.S. Census, 2017). Tulsa is the second largest city in the northeastern region of Oklahoma



with a population of 401,800 as of 2017 (an increase of nearly 10,000 citizens since 2010). One in five Tulsans are below the national poverty level (U.S. Census Bureau, 2012-2016). Relative to the state overall, a higher percentage of Tulsans are college-educated and engaged in the labor force, but there also is a higher percentage of Tulsans living in poverty.

**Table 5. Population Statistics for Community Served by TRSA from the U.S. Census**

Location	Tulsa, City	Tulsa, County	Oklahoma, State
Population estimate, # (2017)	401,800	646,266	3,930,864
Persons under 5 years, % (2017)	7.40%	7.20%	6.70%
Persons under 18 years, % (2017)	24.60%	25.40%	24.40%
High school graduate or higher, % of persons age 25 years + (2012-2016)	87.00%	88.80%	87.30%
Bachelor’s degree or higher, % of persons age 25 years + (2012-2016)	30.70%	30.70%	24.50%
In civilian labor force, % of population age 16 years+ (2012-2016)	65.70%	67.70%	60.90%
Persons in poverty, %	20.30%	15.70%	16.30%

According to the U.S. Census (2018), the three largest ethnic groups in Tulsa are White/Caucasian (65%), Hispanic and Latino (15%), African American/Black (15%). Notably, 4.3% of Tulsa citizens are Native American, and both Tulsa and Oklahoma are deeply immersed in Native American culture. Oklahoma has the highest enrollment of Native American students in the nation with 126,078 students in the 2009–10 school year and with 25 native languages spoken—more than any other state in the nation (Southwest Educational Development Laboratory, 2018). Native American tribes within the city of Tulsa include the Creek, Cherokee, and Osage.

**Education.** According to the Oklahoma State Department of Education, 694,816 students were enrolled in pre-kindergarten (pre-K) through 12th grade across Oklahoma in 2017, an increase of 1,106 students compared to 2016 and an increase in 21,626 students compared to 2012 (Oklahoma State Department of Education, n.d.). Almost nine out of ten people (87%) age 25



years or older graduated from high school or higher-level institutions across Oklahoma, while only one out of four people (25%) received a bachelor's degree or higher. Similarly, among Tulsa citizens, almost nine out of ten people (87%) age 25 years old or older have earned a high school diploma, while only one out of three people (31%) have obtained a bachelor's degree or higher (U.S. Census, 2018)

According to the results from the 2017 National Assessment of Educational Progress (NAEP) standardized testing, students in Oklahoma performed below the national average in fourth-grade reading and mathematics and eighth-grade reading and mathematics (Oklahoma State Department of Education, 2018b). In 2018, fewer than one third of eighth-grade students in Oklahoma reached at or above Proficient in mathematics (24%) and reading (28%), and just over a quarter reached at or above Proficient in science (28%). Results from the 2018 Oklahoma School Testing Program (OSTP) (Oklahoma State Department of Education, 2018a) for 8<sup>th</sup> grade mathematics and science show that about one in ten Tulsa students (11%) scored proficient or higher in mathematics (compared to one in five for Oklahoma overall, 20%), while one in four Tulsa students (25%) scored proficient or higher in science (compared to about two of five for Oklahoma overall, 39%).

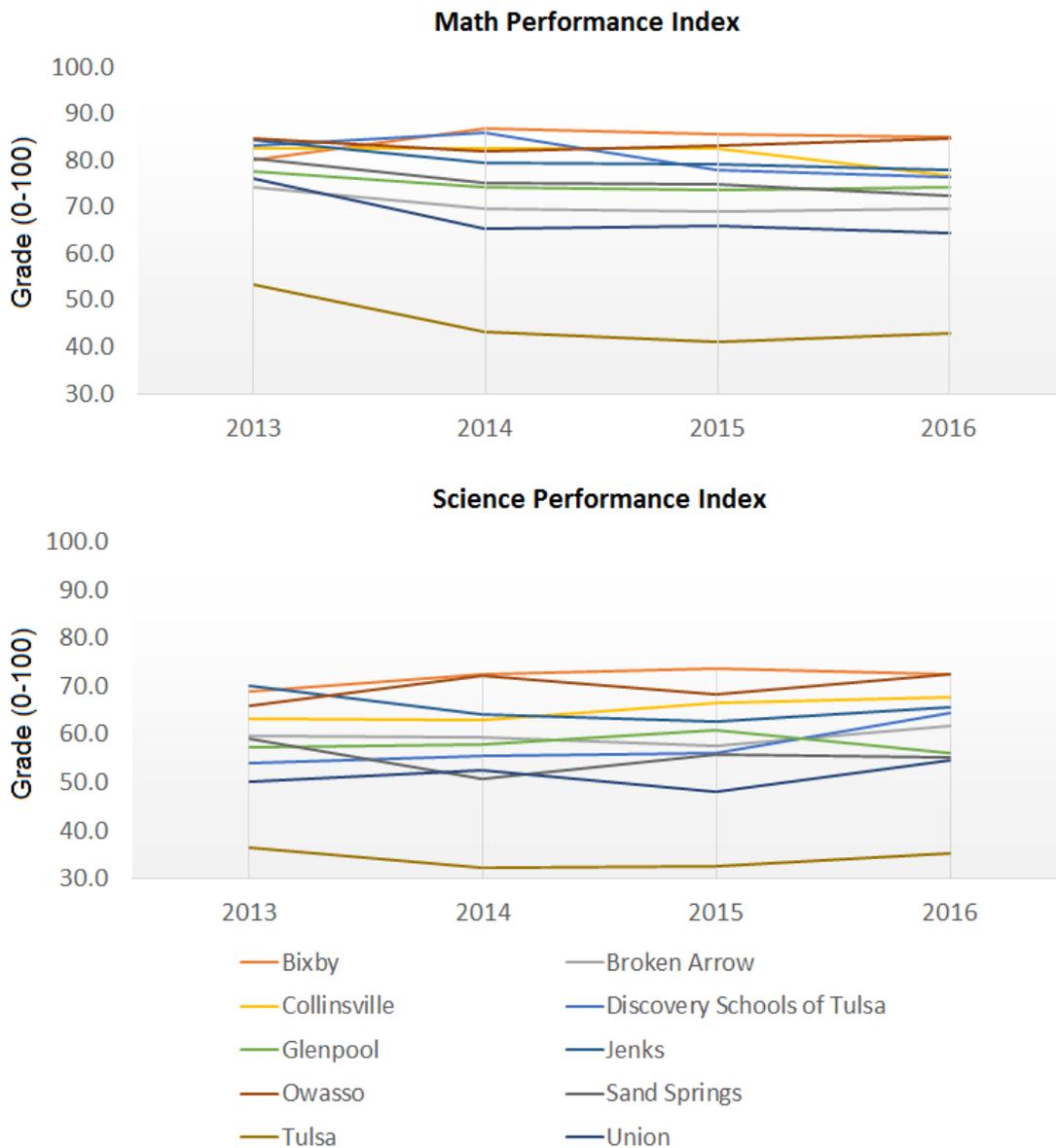
Based on Oklahoma's former Final Report Card Index (2013-2016), academic performance among K-12 schools in Tulsa County (that have received some support from the TRSA, see Appendix B) remained relatively stable over time (see Figure 4, below). There was variation between the school districts in terms of the percentage of students passing the state's math and science performance tests, which ranged from 60% (a "D" letter grade) to 95% (an "A" letter grade; Figure 4, below). Overall, science performance was lower than math performance, with Tulsa districts receiving grades of "C" to "F" in science. Union Public Schools and Tulsa Public Schools have consistently received the lowest Final Report Card grades in math and science relative to other districts in the county (with Tulsa Public Schools scoring approximately 15 to 20 points below Union Public Schools each year, on a scale of 100).

It is important to note that Oklahoma began implementing new standards and assessments in 2017. Because the TRSA did not formally join the national SLE CoP until July 2015, there are not enough data available to determine whether Tulsa's ecosystem has had an impact on math and science performance in Tulsa-area school districts. However, pre-ecosystem efforts did not significantly improve math or science performance of the school districts currently being



supported by the TRSA in Tulsa County. Importantly, the two high-needs school districts cited above – Union Public Schools and Tulsa Public Schools – are currently partnering very closely with TIES and the TRSA to improve STEM outcomes, and it remains to be seen whether these efforts, now being informed by the SLE CoP, will improve math and science performance in these districts. In a few years, longitudinal analyses of math and science performance data (based on the latest assessment methods) will be possible to explore the influence of Tulsa’s ecosystem on students’ math and science learning.

**Figure 4. Performance indices for mathematics and science for schools engaged with the TRSA in Tulsa County (from 2013-2016)**





**Higher Education.** There are a multitude of higher educational institutions located in the city of Tulsa, such as University of Tulsa, Oklahoma State University-Tulsa (OSU-Tulsa) and Tulsa Community College (Table 3). Closely engaged with each other, these institutions have long developed partnerships and share several freshman and sophomore courses for students in these institutions. Other four-year higher education institutions in the area include Oral Roberts University, Northeastern State University-Broken Arrow and Langston University, making for a rich secondary learning environment for the Tulsa community. Meanwhile, because of the abundant resources provided by substantial local industries, many aviation institutions and maintenance bases, such as Spartan College of Aeronautics and Technology and the American Airlines maintenance base, are located in the city of Tulsa.

**Industry.** Oklahoma is home to a wide variety of STEM-related businesses and industries, including oil, natural gas, energy, aerospace, and manufacturing, but aerospace is the largest sector. More than 1,100 aerospace entities have operated successfully in Oklahoma. The economy related to the aerospace industry supports 15% of all employment in Oklahoma and reaches nearly \$44 billion annually (The State of Success, 2018). STEM jobs are projected to grow between 6% to 13% between 2016 and 2026 in Oklahoma (Oklahoma Employment Security Commission & Economic Research and Analysis Division, 2017). The same sources estimate that nearly half of all STEM jobs (45%) will be in computer-related occupations and nearly nine out of ten will require post-secondary education and training (89%). Tulsa City, the principal municipality of the greater Tulsa metropolitan area, serves as an influential base for various local industries in the state, including but not limited to aerospace, manufacturing, oil and natural resources, and telecommunication. Many STEM-related businesses, including NORDAM, Cimarex Energy, ERB, ONE Gas, ONEOK, Cox Media Group, Oklahoma Energy Resource Board, and Williams are actively collaborating with the TRSA, providing financial and resource supports and co-run events to create and sustain local STEM education programs for children and youth in Tulsa County. Business partners are also encouraged to attend the SLE CoP so they can learn about the broader work of STEM education globally. Additionally, influential philanthropists such as George Kaiser Family Foundation and Charles and Lynn Schusterman Family Foundation have also actively worked with local programs and organizations. A summary of Tulsa based businesses and industry can be found in Table 6.

**Table 6. Community Sectors Within Tulsa County, Tulsa, Oklahoma Affiliated with TRSA**

Sector	Name/Description
Industries	Aerospace, Agriculture, Energy, Infrastructure, Information Technology, Manufacturing, Natural Resources, Oil, Telecommunication
Businesses/ Chambers	Architecture, AIA Eastern Oklahoma, Ambler Architects, American Airlines, AAON, Baker Hughes, BAMA Companies, Cancer Treatment Centers of America, Cimarex Energy, Consumer Affairs, Cox Media Group, Excellence Engineering, Explorer Pipeline, Flintco, Forest for the Trees, Google, Matrix Service Company, MidAmerica Industrial Park, Muncie Power Products, NORDAM, OETA, ONE Gas, ONEOK, PSO, QuikTrip, Siemens Industry, Spirit AeroSystems, Standard Testing and Engineering Company, T.D. Williamson, Tulsa Regional Chamber of Commerce, Video Gaming Technologies, Williams, Sylvan Learning of Owasso
Tribal/ Government	Muscogee Creek Nation, Osage County Interlocal Cooperative, Osage Nation, OK State Department of Education
School Districts	Bixby Public Schools, Broken Arrow Public Schools, Collinsville Public Schools, Glenpool Public Schools, Jenks Public Schools*, Owasso Public Schools, Sand Springs Public Schools, Tulsa Public Schools*, Union Public Schools* (*Denotes public schools within city boundaries)
STEM-Expert Institutions/Foundations/ Societies	Engineers’ Society Tulsa, Northeastern State University, Oklahoma Innovation Institute, Oklahoma State University–Tulsa Center for Research on STEM Teaching and Learning, Oral Roberts University, Society of Exploration Geophysicists, Tulsa Community College, Tulsa Engineering Foundation, Tulsa Technology Center, University of Tulsa
STEM-Rich Institutions	Fab Lab Tulsa, Gathering Place, Gilcrease Museum, Oklahoma Aquarium, Tulsa Air & Space Museum, Tulsa Children’s Museum, Tulsa City–County Library, Tulsa Zoo, Tulsa Geoscience Center, Tulsa Glassblowing School, Tulsa Opera, Tulsa Symphony
Community-Based Program Providers or Programs	Engineers Alliance for the Arts (EAA), Camp Fire Green Country, Camp Loughridge Outdoor Classroom, CAP Tulsa, Fab Lab of Tulsa, Girl Scouts, Global Gardens, Junior Achievement of Oklahoma, Junior Botball, Juntos, Me & My Math Mentors, Oklahoma Energy Resource Board (OERB), Oklahoma Society of Professional Engineers (OSPE), STARBASE



	Oklahoma, YMCA of Greater Tulsa, Tulsa City-County Library, Opportunity Project
Local Foundations	Charles & Lynn Schusterman Family Foundation (*Primary), Darby Family Foundation, George Kaiser Family Foundation, Lobeck Taylor Family Foundation (LTFF), Tulsa Area United Way, Tulsa Community Foundation, Tulsa Engineering Foundation, Tulsa Flight Night
Other Local Partners	Central OK Regional STEM Alliance, Mid America STEM Alliance, Route 66 Alliance
Other National Partners	AmeriCorps (VISTA program), Million Women Mentors, The PEAR Institute: Partnerships in Education and Resilience, Project Lead the Way, SeaPerch, STEM Funders Network, Teach for America, Teaching Institute for Excellence in STEM (TIES), US2020, United States Naval Academy

Speaking to the strong presence of STEM in Oklahoma, one member stated, *“Our former governor actually prides herself on her workforce initiatives and STEM education. We have had STEM summits that she has hosted and been a part of, but I believe the incoming governor will have an even greater impact on the STEM fields. In Oklahoma, we have both the oil and gas industry and the aeronautics and space industries who are huge consumers of STEM and STEM education, so I don’t believe STEM will go away in Oklahoma.”* Narrowing in on Tulsa specifically, an individual shared, *“When I am on a plane, on my flight home from Tulsa...I start chatting to someone next to me, and I say something about STEM. They either say “Oh yeah, [TRSA leader’s name]” or they ask me a question about the STEM work, but no one on the plane ever asks what STEM is. Everyone on the flight knows what STEM is . . . it really has permeated this entire city. You see it on the TV - everyone knows what STEM is . . . Tulsa doesn't understand how unique it is.”*

### **Origin**

**Committed Stakeholders.** Interviews with key stakeholders in Tulsa revealed that the beginnings of the Tulsa Regional STEM Alliance (TRSA) involved a mixture of serendipity, creative thinking, passion, dedication, hard work, and resources (i.e., money, materials, and people) all being present at the right places at the right times. There were also many motivated



stakeholders, including businesses and industries that needed skilled workers, teachers and educators eager to improve math and science performance of students, families seeking access to educational opportunities outside of school, afterschool programs and STEM-expert institutions eager to engage young people in STEM, and a local foundation becoming increasingly interested in investing in STEM education in Tulsa.

When asked about the early history of the TRSA and Tulsa’s ecosystem, stakeholders often cited a multi-day “Design Studio” workshop event held between September and October 2013 that was funded in part by two local foundations (the Schusterman Family Foundation and the Tulsa Area United Way), area businesses, and higher education institutions. The event was initiated by the Oklahoma Innovation Institute (OII) and was facilitated by a global educational consulting firm known as the Teaching Institute for Excellence in STEM (TIES). In the design studio process, “. . . a large and inclusive pool of invited stakeholders participate in a series of facilitated collaborative group dialog sessions (*The Design Studios*). The participants in the process are known as “*The Design Team*.” The invitation process is open and intended to create the largest and most diverse possible pool of participants—invitees are encouraged to bring other community members they believe would be beneficial to the process . . . The Design Studios were held over four days in September and October 2013 at the OII offices in downtown Tulsa. In aggregate, 43 Oklahoma stakeholders participated in one or more days of the Design Studios.” (Teaching Institute for Excellence in STEM & Oklahoma Innovation Institute, 2014). A long-time member of the TRSA recalled that people representing groups from all over Tulsa County participated: “. . . all sectors, from community, government, K-12, funders, business [came together], and the topic was what was going on in STEM in our area, what needs to be going on, what can we do that doesn’t duplicate other efforts.” (TRSA Strategy Plan, 2013). Through the Design Studios, the TRSA design blueprints were created, including a logic model structure to guide their initiatives, activities, and outputs and to track their short and long-term outcomes (Tulsa Regional STEM Alliance, 2013). This was about 18 months before the national SLE CoP launched and before Tulsa formally joined the initiative.

An important observation made during the Design Studio was shared by an individual who attended the event. She reported that while all stakeholders were equally encouraged to participate in all components of the Design Studio, she noticed classroom teachers actively contributing during small group work; however, they were quiet during whole group reporting and discussions.



When asked why, teachers shared they were not sure what level of involvement they should have during the whole group session as a representative of the school sector. This was used as a learning moment, since this event requires active participation across all sectors and all sectors are encouraged to have an equal voice.

All sectors of the community were motivated to get involved: “. . . *multiple organizations came together saying it would be great to have some sort of alliance that could address the shortfalls going on . . .*” From a partnership perspective, the alliance began for functional reasons; there was a common funding source (primarily the Charles & Lynn Schusterman Family Foundation) that brought organizations with similar interests together to address issues related to STEM education and to make higher quality programming possible in Tulsa. One stakeholder commented that: “*We very much take the stance that everyone is in this together, and we can all have benefits from it. And I think that is something that is respected a lot throughout our community. We are very fortunate—we have a very giving community with partners who see that.*”

**Guiding Leadership.** Another important part of the TRSA’s origin story is a highly charismatic and energetic leader who emerged early in the design process and who excelled at building bridges across community sectors. Stakeholders believed that her dedication, enthusiasm, sincerity, approachability, tenacity, and ability to build and leverage partnerships catalyzed the community to form a formal STEM alliance: “. . . *we identified one person who ran the Tulsa Alliance for Engineering; we all agreed she was the right fit to move, transform the initiative into the Tulsa Regional STEM Alliance . . . it was kind of a natural evolution for that role. She was already doing a lot of work in informal engineering programming, she had already developed partnerships and relationships with school districts. She speaks to the critical component of the ecosystem—expertise and leadership—and she said that she was able to leverage her relationships. An ecosystem can always go as far as the leaders’ abilities to leverage others and to understand who is best suited to support with their STEM expertise and in what ways. We had that early on, and a big reason why we have been pretty successful.*” This leader has been described as “*the glue and visionary*” and one individual explained, “. . . *beware, without [name of TRSA leader] the TRSA would have fallen apart in six months.*”

In summary, a motivated funder, a dynamic leader, and a motivated group of organizations, who together successfully completed design sessions and produced a blueprint for the STEM learning community with help of expert consultants in the field, set the stage for the launch of a



formal alliance. Opportunity in the form of funding brought together organizations with shared interests, and a champion for the cause who quickly began to build partnerships within and across sectors. The importance of the early design meetings, which forged strong bonds and set the TRSA on a path towards building collaborative partnerships between diverse stakeholders, was best exemplified by one TRSA member: “. . . *even on days we're a super-hot mess, I am very grateful we started together so that we all feel like we are in it together, and we all still feel like we are in it together.*”

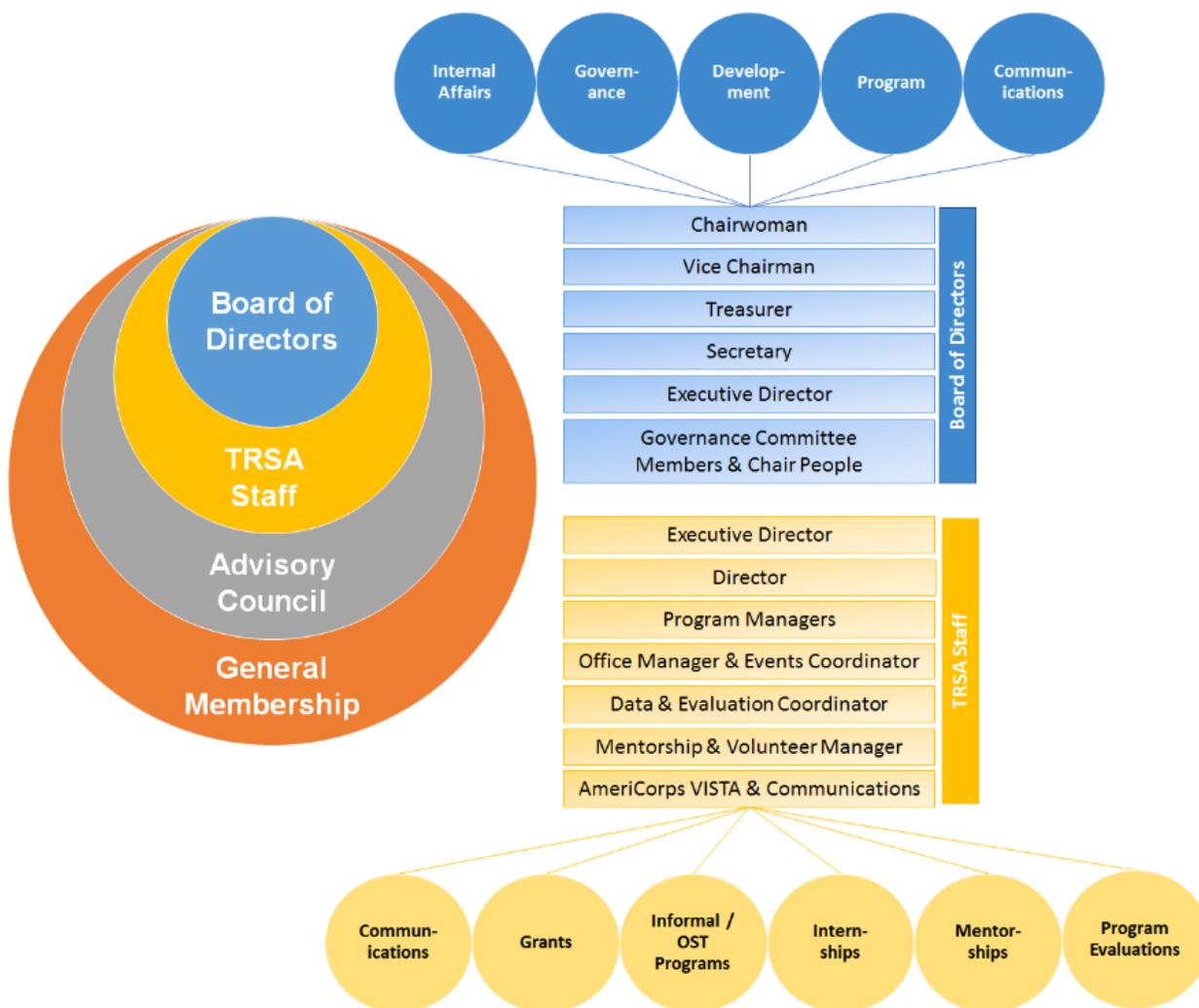
### ***Evolution***

**Incubation to Independence.** The development of the TRSA took five years from incubation to independence (from 2013-2018). Upon launching the TRSA, the organization was managed by the Oklahoma Innovation Institute (OII), a small not-for-profit organization with interests in bringing together like-minded local and statewide STEM visionaries (Teaching Institute for Excellence in STEM & Oklahoma Innovation Institute, 2014). Once established by OII, and with the support and guidance from TIES, the TRSA transitioned under the umbrella of Tulsa Community Foundation (TCF) for a few years. With the goal of having more ownership and transparency with expenditures, the TRSA filed for nonprofit status with the IRS in December 2016. By this point, the TRSA established concise, updated STEM domains and goals to guide their work, including the following focus areas: STEM workforce and economic prosperity, formal K-12 core curriculum, STEM educator development, informal education and STEM literacy, strategic and innovative STEM programming, and STEM leadership and policy support. In June 2018, the TRSA officially activated its independent 501(c)(3) non-profit status and had well-defined organizational and governance structures, goals, and areas of focus that have been refined by TRSA leadership over the last five years.

**TRSA Organization and Governance.** The TRSA began with two staff, a general membership, and a diverse advisory council, the latter of which is considered the backbone of the organization. Given its rapid scaling, increased independence, and need for accountability, the TRSA created seven paid staff positions and implemented a vertical organizational structure with many layers of management (see Figure 5). As of 2017, the TRSA formed a board of directors that serves as a governing body responsible for making high-level decisions about the organization,

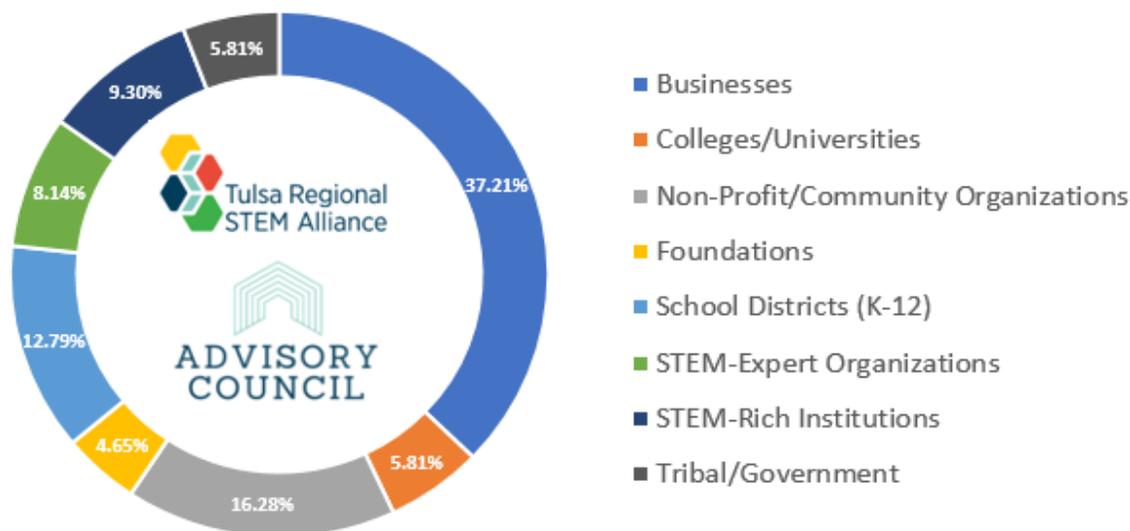
including strategy and finance. The board, which is comprised of an executive body (i.e., chairwoman, vice chair, treasurer, secretary, and executive director) and five subcommittees (i.e., internal affairs, governance, development, program, communications), includes experts from all sectors of the community who genuinely contribute to the organization rather than just use it as a “resume builder” as one interviewee highlighted (see Figure 5). The TRSA also has multiple active Innovation Rooms where partners work together in small groups around key STEM issues. One such room is the joint Professional Development/Tulsa Public Schools STEM Coordinator Innovation Room, which convenes to discuss and plan professional develop opportunities for teachers and STEM programming for students during school and outside of school time. It is a place for sharing STEM resources, ideas, curricula, support, and encouragement.

**Figure 5. Organization and Governance Structure of the TRSA as of 2018**



The TRSA general membership, which comprises the largest constituent of the organization, is open to interested STEM organizations and currently has over 140 partners enrolled from diverse sectors including: government (both state and local), business and industry, philanthropy, formal K-12 education, informal learning organizations (e.g. summer and afterschool programs), higher education institutions, and not-for-profits/associations (see [www.tulsastem.org](http://www.tulsastem.org) for complete and current list). As of 2018, there were 144 TRSA members representing a variety of sectors in Tulsa County and beyond. This number has grown from 50 TRSA members at the launch of the ecosystem in 2015 (Tulsa Regional STEM Alliance, 2019). Figure 6 reflects the cross-sector representation of the TRSA membership. Currently, the business sector represents more than one-third of the membership (37.2%). The second and third most-represented sectors are non-profit/community organizations (16.3%, including informal learning organizations) and K-12 School Districts (12.8%).

**Figure 6. TRSA Membership (2018)**



As reported on their website, the TRSA is “. . . an intermediary organization that is flexible and inclusive enough to welcome all community members yet includes sufficient structure and organizational support to facilitate and coordinate the work that needs to be done.” As one member summarized, “. . . we wear two hats, as a neutral convener and coordinator and as a deliverer of programming.” The current mission of the TRSA is focused on cradle-to-career STEM support for all students by “. . . building broad, deep and innovative STEM pathways for all

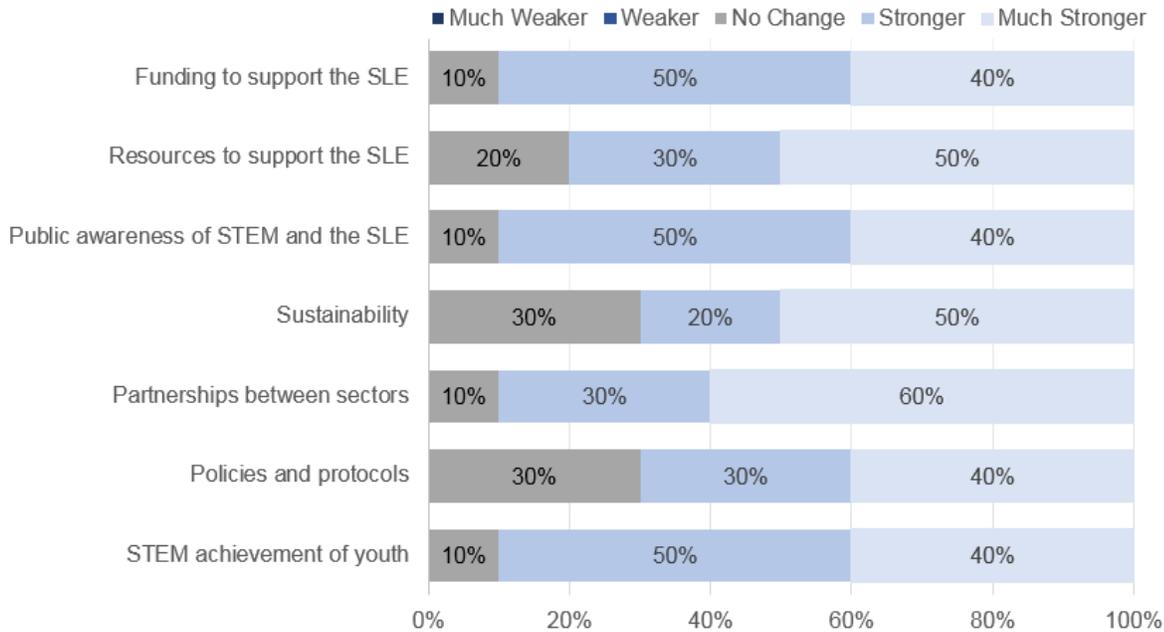


*students to access high-impact careers.” Current organizational goals focus on calculating using common metrics, communicating and promoting awareness and access to STEM resources and events, and collaborating around the use of shared resources and cultivating the growth of STEM ecosystem. When asked about how the alliance identifies priorities, one individual shared, “That’s a very relevant, funny question. We’re actually going through that right now. As we’ve grown, we’ve just been filling the voids that we see and now we’re at a point where our board of directors are divided into . . . all these different committees so we have been looking where a needs assessment of our ecosystem is needed. We are starting to formalize where we need to go from here, so we are spending a lot of time doing that now. Otherwise, it seems like everything we do embarks on three different areas . . . Engage, Empower, and Equip students, teachers, anybody in STEM so everything we do we try to relate back to those three E’s.”*

### ***Theory of Action***

**Adoption of National SLE CoP Model.** Before examining how, and to what extent, Tulsa’s ecosystem put the SLE CoP strategies into action through the TRSA, it is important to know whether ecosystem members valued the national SLE CoP or felt that the SLE CoP had an influence on their local community. Based on exit survey data, there is evidence that stakeholders view the national SLE CoP very positively, with between 70 to 90% of survey respondents ( $n=10$ ) agreeing or strongly agreeing that the SLE CoP strengthened Tulsa’s ecosystem in key areas since it launched in 2015 (see Figure 7). The four areas that participants felt the SLE CoP helped Tulsa’s ecosystem the most included obtaining funding to support Tulsa’s ecosystem, bringing more public awareness of STEM and Tulsa’s ecosystem, building partnerships between sectors, and improving STEM achievement of youth. One third of the stakeholders felt that the SLE CoP had not changed Tulsa’s sustainability nor their policies and protocols. Notably, none of the respondents disagreed nor strongly disagreed with any of the statements, suggesting a high-level of buy-in of SLE CoP strategies in this group of respondents, which included representatives from afterschool and youth development organizations (9.1%), business and industry groups (9.1%), colleges and universities (9.1%), educational alliances, coalitions, and collaboratives (18.2%), philanthropists and funders (9.1%), and preK-12 school systems (27.3%).

**Figure 7. Stakeholder’s Perceptions of the National SLE CoP on the Strength of Tulsa’s local Ecosystem, Based on Exit Survey**

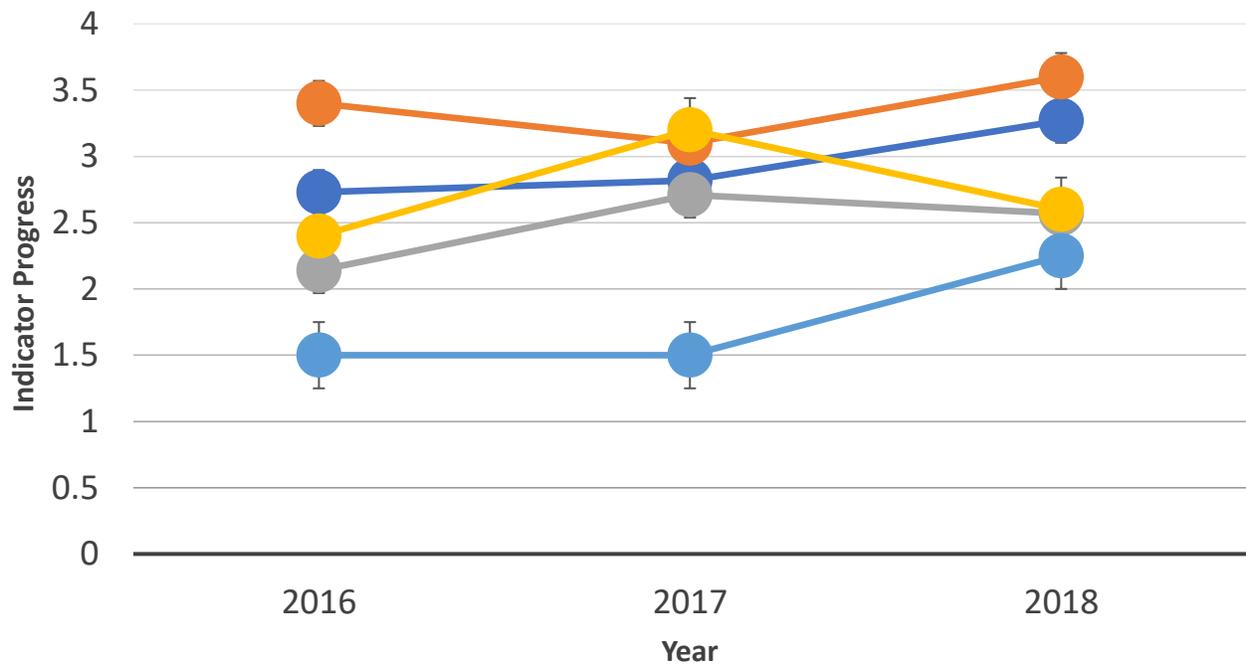


**Implementation of SLE CoP Strategies.** Archival documents, focus groups, interviews, exit surveys, and the SLE Indicator Tool provided evidence for how the TRSA has been putting national SLE CoP theory into action (see Table 1 and Appendix A for review). Longitudinal data based on the ecosystem leadership’s self-assessment of progress (measured using TIES’ SLE Indicator Tool) is presented first followed by evidence for how the ecosystem implemented the four overarching SLE CoP strategies (see Table 1, above). It is important to note that it is difficult to disentangle the self-driven work of the TRSA and efforts influenced by the alliance’s involvement in the SLE CoP at times. We often cannot establish causality, nor can we predict how the TRSA would have functioned or what programming they would have offered if they were not part of national SLE CoP.

*Ecosystem Self-Assessment of Progress in SLE CoP Strategies:* The TRSA’s leadership completed the TIES’ SLE Indicator Tool at the end of each year of its participation in the SLE CoP (2016-2018, Figure 8). Changes over time were examined for each of the assessment items separately (i.e., individual ratings) as well as for the five domains overall (i.e., average scores). Over this three-year period, the TRSA reported the most growth in specific cross-sector partnerships and architectural and organizational features, namely:

- 1.) *Family engagement*: Family and parent organizations like the PTA and PTSO were originally not involved or represented at ecosystem meetings in 2016, but now the ecosystem has parent organization administration and leadership engaged as part of the core ecosystem team with plans to scale more family engagement in 2018.
- 2.) *Funding commitment*: Tulsa’s ecosystem has gone from having some sustaining funding and grants (including philanthropic grants, public sector support, and in-kind resources) in 2016 to having committed long-term funding in 2018.
- 3.) *Communication system*: the ecosystem has gone from a rudimentary stage of piloting and expanding a communication system in 2016 to having a communications system that is dynamic and responsive to community needs and has a bidirectional flow that takes in information as well as puts out communications in 2018.

**Figure 8. SLE Progress Reported by TRSA on SLE Indicator Tool (2016 to 2018)**



- Cross-Sector Partnerships
- Architectural and Organizational Features required for Sustainability
- Learning is Aligned Both In and Out of School and Evaluated to Ensure Quality and Impact
- Equipping Educators with Tools and Training to Maximize Benefit
- College and Career Readiness and Development of Articulated Career Pathways



There are also several areas the TRSA leaders have been consistently strong in from the beginning, with significant progress reported across all years (i.e., ratings of 3 and 4, on a scale of 1 to 4, from 2016 to 2018). Based on item-level analysis, the results of which are not presented in Figure 8, the TRSA has been consistently strong in: (1) deeply engaging all ecosystem partners with the exception of family, government entities, and historically underrepresented youth (the latter of which have shown progress but remain areas for improvement), (2) identifying and supporting professional development opportunities for formal and informal educators as well as aligning formal and informal STEM professional development (although specific areas of professional development were rated lower in 2018, likely due to scaling, which reduced the aggregate score presented in Figure 8), and (3) using common measurements to validate, evaluate, and identify high quality STEM programs.

Some examples of deeply engaged partnerships within the ecosystem include business and industry (as of 2018), *“The Chairwoman of our STEM Ecosystem Board of Directors is an industry representative. We have representatives from the Tulsa Regional Chamber, QuikTrip, ONEOK, Oklahoma Energy Resource Board, NORDAM, and Cox Media Group are also represented on our Board. TRSA regularly engages business/industry through our quarterly Advisory Council meeting, innovation rooms, STEM Cafes, and mentorship programs.”* Out-of-school/afterschool programs/expanded learning (OST) and youth development programs (as of 2018) are also heavily involved, the *“TRSA has the privilege of having 3 staff members and one Board member serving with the Opportunity Project, an intermediary working to align OST programming in Tulsa. We also work with the YMCA, Camp Loughridge, Tulsa Dream Center, Boys and Girls Club, and have the opportunity to fund multiple OST program initiatives through generous donations from Charles and Lynn Schusterman Family Foundation and Flight Night.”*

As an example of progress in equipping educators with tools and trainings, the TRSA noted in 2018: *“For the past 10 years, SENSEsational Science has worked to empower our elementary educators to be confident and competent in teaching standards aligned with science with the support of STEM community partners. We have now extended that preparation to middle school/high school science teachers through the work on inquiry-based science education in STEM<sup>3</sup> inspired by the work of Brett Moulding. In summer of 2018, TRSA is launching Math PD [professional development] based on the work of Jo Boaler on Mathematical Mindsets.”* Lastly, as an example of the expansion of their evidence-based methods, TRSA leadership noted in 2017



that the *“TRSA is very fortunate to be one of five cities using the Harvard-PEAR DoS tool to evaluate programming across the region. This instrument coupled with pre- and post- surveys is instrumental in helping TRSA be a data driven ecosystem . . .”* Their use of data evolved further by 2018, with leadership noting that the *“TRSA has been fortunate to have dozens of partners trained in Harvard-PEAR’s Dimensions of Success evaluation as well as planning tools. These measures are being implemented with the aid of Click2Science to improve program quality across the region in concert with our partners Impact Tulsa and The Opportunity Project.”*

Also using the SLE Indicator Tool, the TRSA leadership identified several areas that have been persistently challenging from 2016 to 2018, with the most notable being college and career readiness (e.g., evaluation, review, and expansion of career pathways, having a communication plan to articulate the value and need for pathway initiatives to stakeholders, and having a plan to ensure equal access to career pathway initiatives to historically underrepresented populations) (see Figure 8). Item-level analysis, in contrast with the average ratings for each of the five categories, identified modest reversals in progress for three specific areas. The most significant reversal was related to the TRSA leadership’s feeling that the ecosystem needs to work on a plan to scale its work in a meaningful and sustainable way, which fits with stakeholder reports of organizational growing pains and a need for dedicated time to think strategically about the direction of the organization, especially as demand for services has increased.

The remaining section reviews evidence for how the ecosystem has put SLE CoP strategies into action based on archival documents, focus groups, and interviews.

*Evidence for SLE CoP Strategy 1 – Establish and Sustain Cross-sector Partnerships:* The TRSA has been characterized by partners as a convener, a networker, a dot-connector, a bridge-builder, a promoter and facilitator of STEM programming, an advocate for working together (and against working in silos and duplicating efforts), and a host to all STEM programs to showcase their work. Describing what has made the partnership work of the TRSA possible, one ecosystem member shared: *“We are trying to get to a point where any kid anywhere in town can have access to high quality STEM experiences. What do we need to focus on to inform future STEM activities . . .? I think we have the staff, a huge support base, a growing donor base, an engaged and enthusiastic donor base, and the leadership and expertise of [the Executive Director] herself, and the team she has built around her are so passionate and committed I think it can get there.”* The ability and willingness of the TRSA to partner with all sectors on programming and events—as



well as the positive, can-do culture of the organization—were often cited in interviews. There is considerable appreciation for the growth in partnerships, but the demand from the ecosystem is high and there is a desire by some partners within the ecosystem to create more meaningful partnerships (not only in the sense of scaling wider to serve more youth, but also going deeper to transform partnerships). As one example, one partner shared: *“I am super excited with the work that is done by the TRSA. I just wish it could be more. I think that is what I have said throughout. I hesitate to think where we would be as a city without the TRSA. They have been a major player in making connections across informal and formal education. They have done a lot of great work to connect across.”*

As of 2018, the TRSA is collaborating with more than 140 local STEM partners and is continuously working to establish new partnerships. Of the 40 events that the TRSA organized in 2018, which have grown in number over the years, one out of two (52.5%) involved the participation of partners representing four or more sectors, and two out of three (67.5%) involved partners from three or more sectors. An example of a TRSA-sponsored event focused on the STEM workforce is a summer engineering camp that engages all sectors of the ecosystem: community/youth-serving organizations (Tulsa HUB, Tulsa Geosciences Center), businesses (Wallace Engineering, Muncie Power, Williams), higher education (Tulsa Community College, University of Tulsa, Oral Roberts University, OU-Tulsa, and OSU Tulsa), funders (Williams, Charles and Lynn Schusterman Family Foundation), K-12 schools (Tulsa Tech), and government (City of Tulsa). An example of a TRSA-sponsored event focused on informal STEM learning is the Seaperch underwater robotics challenge, which engages higher education (United States Naval Academy, University of Tulsa), funders (Flight Night), and K-12 schools (Jenks Public Schools). Finally, one example of a professional development event for teachers sponsored by the TRSA is SENSEational Science, which involves community/youth-serving organizations (Regents for Higher Education, Tulsa Zoo, Oxley Nature Center, Oklahoma Aquarium, Hardesty Center for Fab Lab Tulsa, Tulsa Glassblowing School, Gilcrease Museum, Tulsa Symphony), higher education (University of Tulsa, Tulsa Community College), funders (Regents for Higher Education, Charles & Lynn Schusterman Family Foundation, Flight Night), and K-12 school districts (Union Public Schools, Tulsa Public Schools, Sapulpa Public Schools).

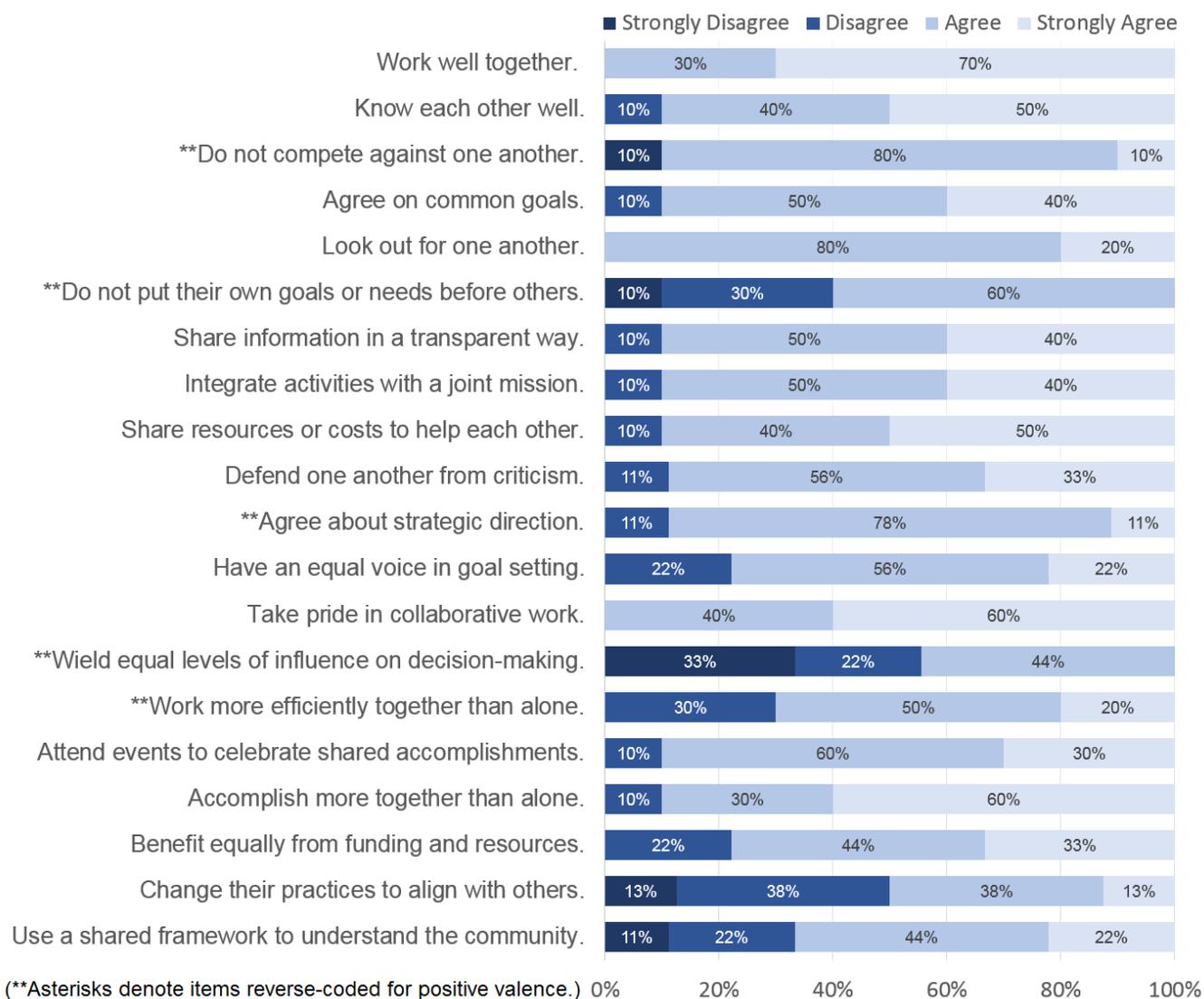
It is clear from the activities and events above that much of the TRSA’s work relies on partnerships. Analysis of partnership typology, based on interviews ( $n=15$ ) and exit surveys



(n=10), the out-of-school time (OST) sector (inclusive of afterschool and summer programs, science centers and museums) has developed strong collaborative partnerships, with increasing signs of interconnectedness. Considering the ecosystem as a whole, most exit survey respondents reported that they know each other well, do not compete against one another, agree on common goals, share information in a transparent way, integrate activities with a joint mission, share resources or costs to help each other, defend one another from criticism, agree about strategic direction, attend events to celebrate shared accomplishments, and believe they accomplish more together than alone (Figure 9).

**Figure 9. Stakeholders’ Ratings of Ecosystem Partnerships, Based on Exit Survey**

*(The partners in my STEM Learning Ecosystem...)*





As one TRSA member shared, *“When TRSA was beginning, [leadership at] TIES told the group of STEM stakeholders to ‘mind the interfaces!’ That sage advice still stands true. Paying careful attention to the ways various STEM community members are engaging, and further could fall short, TRSA has set maintaining mutually beneficial and respectful relationships with all partners as a golden rule for the Alliance.”* However, there were also indications from the data that partnerships within the OST sector, which is most closely aligned with the TRSA, were more developed than other sectors. There was some disagreement reported by members of K-12 school districts and businesses for exit survey items pertaining to efficiency, goal-setting, and decision-making, suggesting that these partnerships are in earlier stages of development (or oscillating between opportunistic and collaborative, depending on the school district or business).

Regarding business, the TRSA leadership noted that *“When TRSA began, before we were part of the SLE, our business partners were in the room when TRSA was being crafted, but we didn’t really know them. After becoming an ecosystem, TRSA became more equipped at engaging our business partners by improving communication, identifying shared goals, and executing on promises made. Over the past four or more years, our business partners have grown to be our most relentless advocates in the community. Our business partners are also not only involved in STEM work itself but, in many cases, leading the charge – from funding, to planning STEM programming to empowering the TRSA to scale and replicate the work in our region - relationships with our business partners are the lifeblood of TRSA.”* This contrasts with what was reported by some in interviews and exit surveys, but this may be the result of turnover within businesses or differences in relationships between people representing different levels within a business.

Crisis and opportunity appear to have shifted stages of partnerships. For example, the TRSA’s partnerships with the K-12 sector were affected by recent distress in the schools related to inadequate resources and teacher strikes: *“...there has been some turnover at TPS [Tulsa Public Schools], which I think probably inevitably causes some instability. Also, Oklahoma overall has had a very difficult year with a teachers’ strike and contentious debate on funding at the state level. That said, I think the relationship is strong. In the beginning there was some skepticism from TPS that the TRSA was just a group of disgruntled business leaders who were going to show them how to “fix public education.” That quickly faded as they engaged with TRSA, and I believe the relationship has improved and strengthened over time.”* Additionally, partnerships take a lot of work to maintain, especially with turnover within organizations, as one interviewee noted: *“The*



*biggest problem is generally having to explain to new people “what is TRSA?” This two-steps-forward and one-step-back is pretty typical in STEM ecosystem communities, and it can slow progress, interrupt things in the works, and worst-case scenario it can result in complete stopping of collaboration. I believe the impact [of the teachers’ strikes] in Tulsa has been moderately felt. Not benign but also not catastrophic.<sup>[2]</sup>”* The leadership of the TRSA acknowledged this common challenge in Oklahoma, asserting that: “...there is a high rate of educator and administration turnover in many districts so transitions and ensuring new educators are aware is an ongoing challenge but with the aid of word-of-mouth, our Pre-K-20 Program Manager and social media we are able to make huge strides in combating this challenge.”

Taken together, the data indicate that the TRSA has moved far beyond opportunity-based partnerships and is beginning to show early signs of interconnected partnerships with the informal/out-of-school time sector and collaborative partnerships with K-12 and business sectors (though crisis and opportunity can and have shifted partnerships forward and backward, requiring monitoring and maintenance). As expected, there were few signs of transformational partnership types, which is rarely observed in practice and is characterized by equal benefit of funding and resources, changing practices to align with others, and adopting a shared framework to understand the community.

*Evidence for SLE CoP Strategy 2 – Create and connect STEM-rich learning environments in diverse settings:* There are two interpretations of diversity in STEM learning found in the Tulsa’s ecosystem: (1) diversity in terms of learning environments, and (2) diversity in terms of the population served. There is evidence that the TRSA has been working to increase diversity in both areas.

First, the creation and connection of STEM rich-learning environments in Tulsa hinge on the strength and depth of partnerships fostered by the TRSA (i.e., building on Strategy 1). Ecosystem partners participating in interviews identified various settings in which the TRSA is successfully hosting programming and promoting STEM learning opportunities in different locations around the city and the county. One example is Camp Loughridge, an inclusive local camp that hosts summer programming, including autism inclusion programming, as well as school

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<sup>[2]</sup> The Oklahoma teacher strike started on April 2, 2018 and lasted a total of nine days. The strike ended after an agreement to increase salaries and state funding for education was reached.



year outdoor classrooms that promote STEM and literature. Teachers and students travel to the outdoor classroom during regular school hours. Through their programming, Loughridge staff work with K-12 teachers to integrate state standards and local curriculum in outdoor STEM-focused activities to help teachers connect textbook learning with everyday life and to ignite curiosity and excitement in children and youth. There are also major events like Flight Night Back to School STEM Expo, made possible by the Cox Media Group and Tulsa State Fair, which is: *“part county fair, part science fair, part job fair, and all fun.”* This event is open to all students, families, educators, and partners, and features over 50 area businesses and organizations in a hands-on STEM activities and experiences.

As one final, and more spontaneous, example of how the TRSA has leveraged partnerships to create STEM learning opportunities in new and unexpected places was during the Oklahoma teacher strike in 2018, when schools were closed, and families were struggling with childcare. The TRSA rallied to work with local churches and community organizations to provide engaging STEM activities and games to ensure that children remain engaged in learning while schools were not in session. Through this example, the TRSA demonstrated the importance of strong partnerships that can be leveraged instantly when crises erupt in the community to ensure that STEM learning continues.

Second, the TRSA has been scaling their efforts to reach all children and youth across Tulsa community, especially low-income youth, youth of color, and youth with special needs. There has been increasing demand on the TRSA, and interest by its own staff, to provide for large, high-need urban public schools within Tulsa city limits as well as the needs of rural areas on the perimeters of the city and county. These efforts, while already challenging, have been strained by well-publicized teacher shortages, strikes, and cuts in education funding. There has been recognition by ecosystem partners, as well as TRSA staff, that more could be done to serve diverse groups of children and youth. TRSA staff have been creative with implementing more access despite limitations in funding and resources, including providing bussing when possible and leveraging technology. For example, one TRSA staff member shared: *“There's just always so much demand. We simply don't have enough supply as in resources, manpower, and time, and transportation to get to all these different places and provide the resources we need to. So, we work through that by offering different avenues. We have a lot of virtual space . . . [that] provides ways to engage various diverse populations that we wouldn't engage otherwise.”*



There are also signs that the TRSA is reaching diverse groups of students through afterschool and summer programming, with student survey data showing that more than half of the participants self-identify as African-American/Black, Latino or Hispanic, Native American, or multi-racial. There have also been significant efforts to provide free summer programming for children, which aims to benefit families who otherwise could not afford to send their children to camps to engage with STEM. Lastly, the TRSA partners with organizations like CAP Tulsa, which provides STEM programming to low-income children in pre-K – further supporting the alliance’s promotion of STEM from cradle to career. Recent interviews with stakeholders indicated that there is now a renewed focus on addressing inequities in terms of opportunity and access: *“I was able to see that really the schools that were participating in STEM were the wealthier schools and the schools in the south side, and so you know I was able to say ok TRSA, if you have this event happening, let’s target these schools – these students haven’t had this opportunity before. There has been a real increase in the equity of programming from 2015 to today . . . [the TRSA has] really tried to target the equity of programming more now than they have before... but there’s a long way to go.”*

The diverse settings created through TRSA partnerships have also provided alternative learning settings for children with special needs. One out-of-school time provider shared a story about a boy who was viewed as a difficult student because he was hyperactive and unfocused in traditional classroom settings, but this same child thrived in informal settings where he could move around open spaces and use his hands to engage with STEM activities. This anecdote shows how diverse settings fostered through TRSA partnerships create new opportunities for learning for young people who do not thrive academically in traditional settings but that have interest and motivation to learn.

*Evidence for SLE CoP Strategy 3 – Equip educators to lead active learning in diverse settings:* The TRSA is working to equip educators to lead active STEM learning in diverse settings and build their confidence as STEM educators and as individuals. Working with TIES and public schools in Tulsa, the TRSA helped to identify and implement STEM priorities, including: (1) piloting grade-level STEM experiences and lessons that promoted partnerships with area STEM organizations (e.g., designing hand-pollinators in 2<sup>nd</sup> grade and working with the Tulsa Botanical Gardens, designing solar ovens in 4<sup>th</sup> grade and partnering with Tulsa Geoscience Center and OneOK, and the development of aquaponic systems in 5<sup>th</sup> with the support of Camp Loughridge),



(2) leading STEM practitioner professional development opportunities (i.e., two cohorts, one per year, where teachers worked on developing inquiry and problem-based pedagogy), and (3) providing STEM programming in out-of-school time settings (e.g., STEM clubs, events, and competitions).

Records from these interventions showed that 1,432 students, 41 teachers, 59 classrooms, and 27 schools from various districts in Tulsa were engaged in these efforts. Based on the school districts in Tulsa County having different levels of capacity and readiness, some partnerships were more in-depth than others. One in-depth partnership was with the Union Public Schools; TIES spent a substantial amount of time assisting the district in their design process and integration of STEM. This partnership resulted in STEM being deeply embedded throughout the district, resulting in more STEM program offerings, the integration of Project Lead the Way coursework, and a new STEM coordinator for program oversight and integration. Data collection was also conducted during these events to determine impact and guide continuous improvement. Union Public Schools have been praised by national media for their innovative approaches to STEM education based on these efforts (Kirp, 2017; Thompson, 2017). The development and expansion of additional STEM grade-level experiences are currently being explored, with the aim to work across various districts in the city of Tulsa. Until recently, this work was mainly concentrated in Tulsa Public Schools and Union Public Schools, although efforts and learnings did filter into other area districts as well, and lessons are being shared across communities and states through the SLE CoP so others are able to benefit (e.g., Baltimore, Maryland).

Various other professional development opportunities are offered through the TRSA, such as SENSEsational Science (i.e., an almost two week training open to K-12 educators, STEM focused or generalists, where they travel throughout Tulsa learning ways of addressing academic standards while engaging students in STEM learning) and STEM<sup>3</sup> (i.e., where professionals in formal, informal, and higher education come together to discuss and develop curricula that aligns with Oklahoma Academic Standards for science and analyze data through the lens of the new standards in an attempt to promote pedagogical exchange and shifts). Several interviewees shared how they or other teachers they know have attended these trainings and will continue to do so because of the quality of the trainings and how they strengthened their STEM pedagogy. Additional learning resources are also provided to educators through the TRSA including online learning opportunities, externships with area STEM businesses, curriculum resources organized



by grade, scholarships and funding opportunities to support STEM teaching, and STEM Shoppes where resources are made available for free or to borrow to support instruction. In 2018 alone, nearly \$153,000 in STEM materials were provided to teachers through the STEM Shoppes according to TRSA records.

To gain a better understanding of the STEM environment within schools and in informal learning settings, the TRSA staff also meet with classroom educators to learn more about needs, efforts and initiatives that are happening, and challenges being faced so they are better able to plan their programming. According to TRSA records, in the past seven months at the request of the districts and schools, they have met with various members of the K-12 sector from nine different districts and 17 different schools. To strengthen connections with the school sector, the TRSA also hired a seasoned teacher to serve as the alliance's K-20 Program Manager in the last year. Regarding fostering collaboration with school settings, one TRSA staff member shared, *“So I often say one of my best moments at TRSA was in one of the first couple months with the organization, sitting down at a table and having all of the local school districts at the same table, not only talking, but talking about what was going well in their district and what wasn't working in their district specifically around PD [professional development] . . . talking about maybe there are ways to collaborate . . . I just have never seen in another city the openness and willingness to connect to other people beyond their district, that was fabulous. So, I feel like the competition aspect... we help them see that coming to the same table was beneficial for them.”*

*Evidence for SLE CoP Strategy 4 – Support youth to access pathways and exploration to further learning and STEM careers:* To foster STEM interest and workforce development, partnering with area businesses and industry, the TRSA has established many programs and events that are designed to support youth to access pathways leading to further learning and careers in the field. One such event is the Engineering Signing co-hosted by the TRSA and Tulsa Engineering Foundation. The Signing provides high school students the opportunity to network with engineers in the community, hear these experts speak on panels, and discover future career opportunities. During the event, seniors who are committing to studying engineering in college come together to sign letters of intent with representatives from their chosen college. Other career building centered programming includes:

- The Engineer Games Scissortail (sponsored by the Tulsa Regional Chamber and inspired by the popular *Hunger Games* movie), an event where high school students compete to



design, build, and solve engineering challenges in a fun, competitive environment working alongside STEM professionals who help guide and mentor students through the challenges.

- Mentorships designed to have professionals work regularly with students to form meaningful relationships, and provide positive influences, encouragement, and guidance to pursue STEM careers (e.g., Me & My Math Mentor, Engineer’s Alliance for the Arts, OERB Mentors who work with elementary students on energy curriculum, and Project Lead the Way mentors who work with high school students engineering curriculum)
- STEM Cafes, which take place once a month before school, where STEM experts visit various schools to discuss their areas of expertise
- Sonia Kovalevsky Day, an “*all girls, all math, all day*” event where the TRSA partners with Cimarex, where company employees (as senior as the president and vice president) are engaged in making STEM meaningful for over 300 middle and high school girls and their teachers “*to empower the next general of female mathematicians, scientists, engineering, and innovators*”
- Student visits to local businesses to learn more about STEM, and professionals coming to schools to educate students about local industry and STEM (e.g., architects worked with students in school to teach them more about the field and possible careers in architecture)

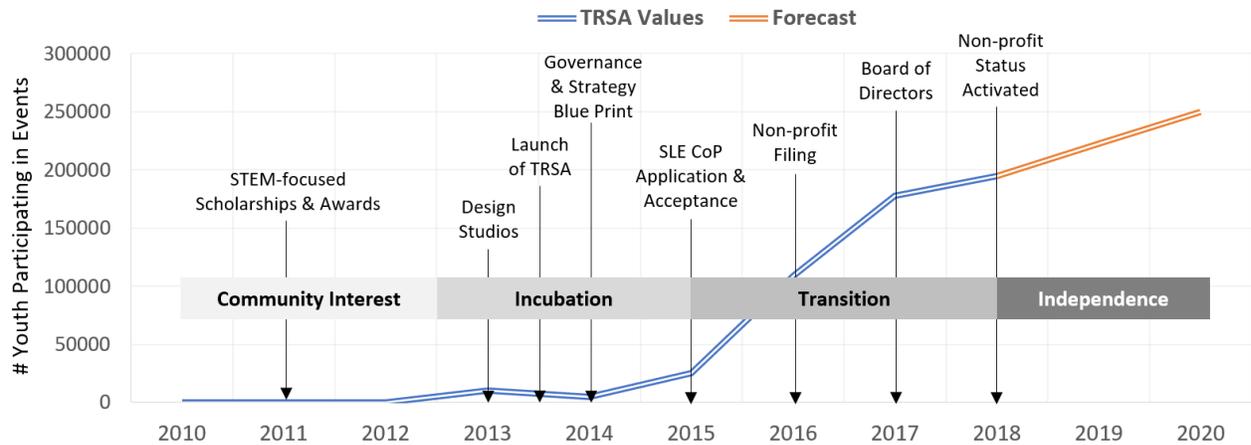
Regarding the math mentoring program, where many of the mentors come from local STEM businesses and industries and are able to informally speak about their careers, one individual shared that it was a “ . . . *good quality program, and the consistency of working with a small group of third grade students for the entire school year at such a pivotal age is extremely exciting . . . and that's just relying on good volunteers . . . people willing to be consistent and show up at a school every week. I don't know the exact number of growth, but it is several hundred students . . . that's pretty exciting when you think about it. Those are impactful relationships . . . when those students are 30 years old, they might not remember the person by name, but they will remember they had a mentor who helped them with factoring and played dominoes with them every week and helped them count forward and backwards. Those students are walking away with more confidence and that is tremendous to me . . .*”



## Impact

**STEM Programming and Participation.** Quantitative data show significant growth in STEM engagement in Tulsa led by the TRSA—with increasing numbers of children and youth participating in events, programs, and camps (177,858 in 2017; 194,914 in 2018), educators participating in professional development offerings (1,232 in 2017; 1,310 in 2018), and STEM professionals participating in mentoring opportunities (229 in 2017; 301 in 2018). Based on these values, it is estimated that nearly 250,000 children and youth will participate in TRSA-supported events, programs, and camps within Tulsa County and beyond by 2020. Note that these values do not represent unique cases, as the TRSA may engage youth (directly or indirectly) multiple times per year (Figure 10). This forecast is based on levels of “student impact” documented and reported by the TRSA between 2013 and 2018, which includes direct student engagement at programs, events, camps, and mentoring opportunities as well as indirect student engagement through professional development, Tulsa Resource Area for STEM educators (TRASE), and grants.

**Figure 10. TRSA and Youth STEM Engagement Forecast**



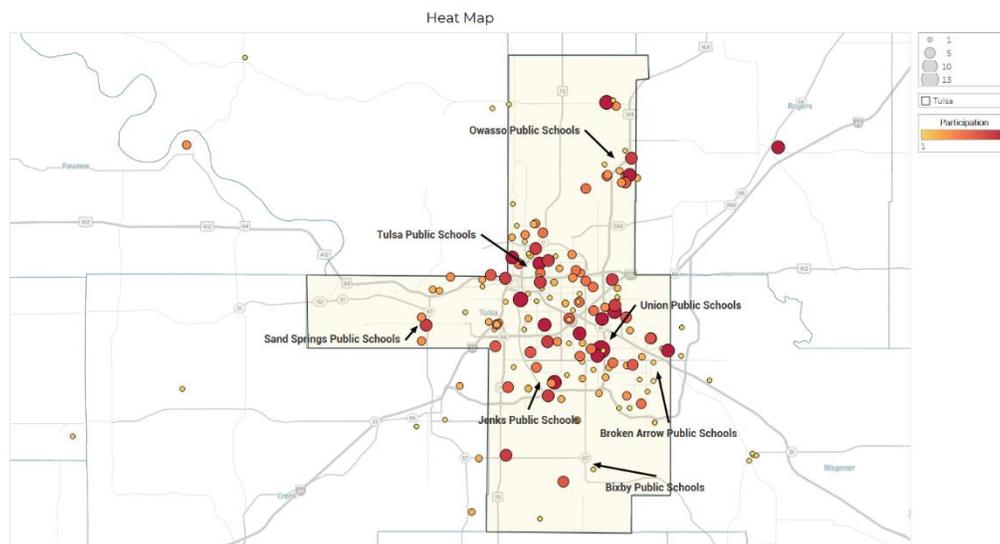
Speaking to growing STEM opportunities and levels of participation, one member of the industry sector stated, “I see students and teachers getting to visit Fortune companies, visiting medical schools, doing a variety of career development opportunities, but without the convening role of the TRSA this would not have happened...There are just plenty of connections that the STEM Alliance has been able to initially make, and maintain, and grow, and the community partnerships they are able to forge. Your average Algebra teacher is not going to be able to make



*the same asks as the STEM Alliance can. I can give you examples every month of those partnerships aiding all the way through the chain. And I would see that as a tremendous story of success of just linking people in the region to the great work that others are doing.”*

**Breadth of Professional Development.** The heatmap below (Figure 11) displays the reach and attendance levels for TRSA professional development events in the 2017-2018 academic year. The location of the bubbles indicates the school or program affiliation of the attendee, and the size and color of the bubble indicate the level of attendance (i.e., light yellow indicates 1 attendee and dark red indicates 7 or more attendees). Attendance at TRSA professional development events ranged from 1-13 teachers or students, however most included seven or fewer. During this period, the breadth of professional development opportunities provided by the TRSA has expanded over the years (Figure 11), with many events happening at the school districts within Tulsa city limits as well as some happening far outside Tulsa city proper. The TRSA website, which is updated weekly, describes a variety of resources, programs, and trainings that the organization offers throughout the school year and during the summer. There is also a listing of available teaching materials through their STEM Shoppe, which include free resources to lead STEM activities and large items to borrow. As another example, there are several programs designed to improve STEM teaching for teachers and educators and to improve STEM learning for children and youth. The website also showcases funding opportunities for educators and provides links to established STEM curriculum by grade level.

**Figure 11. TRSA Professional Development Heatmap (2017-2018)**



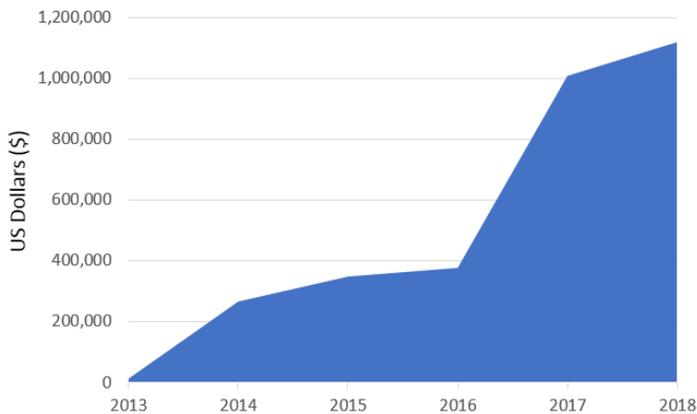


The TRSA works with educators from several different districts of various sizes, rural and metropolitan, providing training but also partnering with professionals to assess needs and challenges. They attend staff meetings regularly with the district STEM coordinators, teachers, and principals from various schools to reflect on strengths and challenges, to identify gaps, to action plan, and to offer support where needed. The TRSA team aims to empower educators through providing training, resources, networking, and funding opportunities—building their knowledge and confidence as STEM professionals. One TRSA staffer reflected on how the ecosystem’s efforts are encouraging a more holistic understanding of STEM in educational practice: *“I definitely started finally seeing a little bit of a paradigm shift, and also a mind shift, in teachers. Seeing that STEM isn't just four letters or four separate words, but seeing how it can be integrated, not just together, but as a teachers' practice as a whole . . . is very enlightening and uplifting.”*

**Funding and Partnerships.** Since participating in the national SLE CoP, advisory council membership has grown 72% (from 50 members in 2015 to 144 members in 2018). There has also been substantial financial growth, with a 7,366% increase in the TRSA’s operating budget—from \$15,000 in 2013 to nearly \$1,120,000 in 2018, primarily with support from local businesses and charitable organizations (Figure 12). One such example organization is Flight Night, which donated a record \$582,000 to two Tulsa groups in January 2018, with TRSA being one of the recipients (Public Radio Tulsa, 2018). Increases in funding between 2014 and 2018 have also increased the number of STEM programs participating in the data collection efforts organized by the TRSA in partnership with The PEAR Institute. Participation in data collection around quality and youth outcomes has grown 160%, from 10 afterschool/summer programs 2014-2015 to 26 afterschool/summer programs and school districts in 2018 to 2019.

Participation in data collection has diversified from informal programming only to both informal and formal programming, in an effort to ensure high quality STEM activities inside and outside of school.

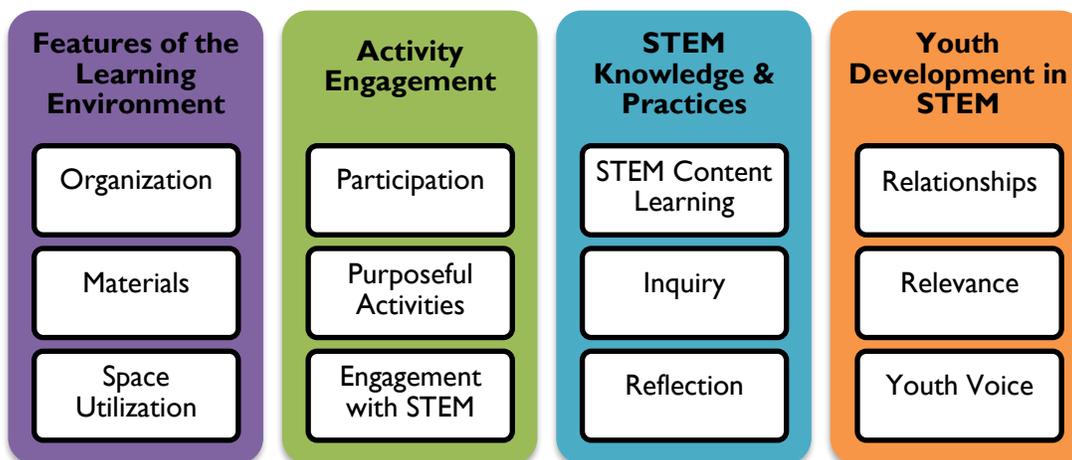
**Figure 12. Financial Growth of the TRSA (2013-2018)**



**Quality of STEM Programming.** Tulsa’s ecosystem has made significant investments to ensure youth are participating in quality programming. Starting in 2015, and now in its fourth year of implementation, the TRSA adopted a widely-used, evidence-based framework known as the Dimensions of Success developed by The PEAR Institute (DoS; Shah et al., 2018). DoS provides a common definition of high-quality practices for informal STEM activities based on broad categories of impact outlined in a National Science Foundation workshop report entitled *Framework for Evaluating Impacts of Informal Science Education Projects* (Allen et al., 2008) as well as the six-strand framework put forth by the National Research Council (NRC, 2009). Evidence indicates that young people participating in high quality afterschool STEM programming are more likely to report positive change in STEM-related attitudes like engagement and career interest than those participating in lower quality programming (Allen, Noam, & Little, 2017).

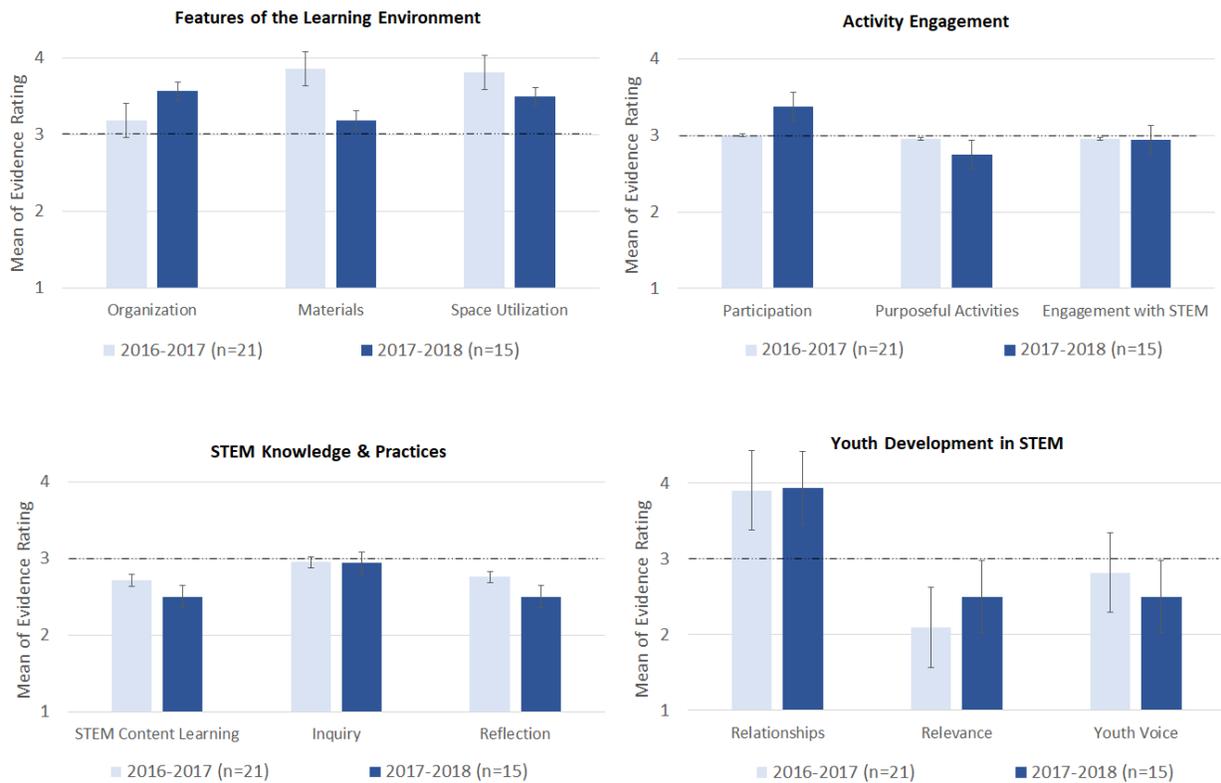
Afterschool and summer program partners in Tulsa’s ecosystem were provided with trainings around the DoS framework. Program directors and practitioners learned about 12 different dimensions of STEM program quality to aid in their planning of STEM activities using the DoS program planning tool (Peabody, Browne, Triggs, Allen, & Noam, in press) as well as to become certified in the use of the DoS observation tool to identify program strengths and areas for improvement (Shah et al., 2018). In 2015, the TRSA formed a local community of practice with afterschool and summer programs around the collection and use of data in informal STEM learning settings to continuously improve practice, particularly using the DoS observation tool (the DoS framework and dimensions per domain are displayed below in Figure 13) as well as the student (CIS-S) and educator (CIS-E) surveys.

**Figure 13. Dimensions of Success (DoS) Framework**



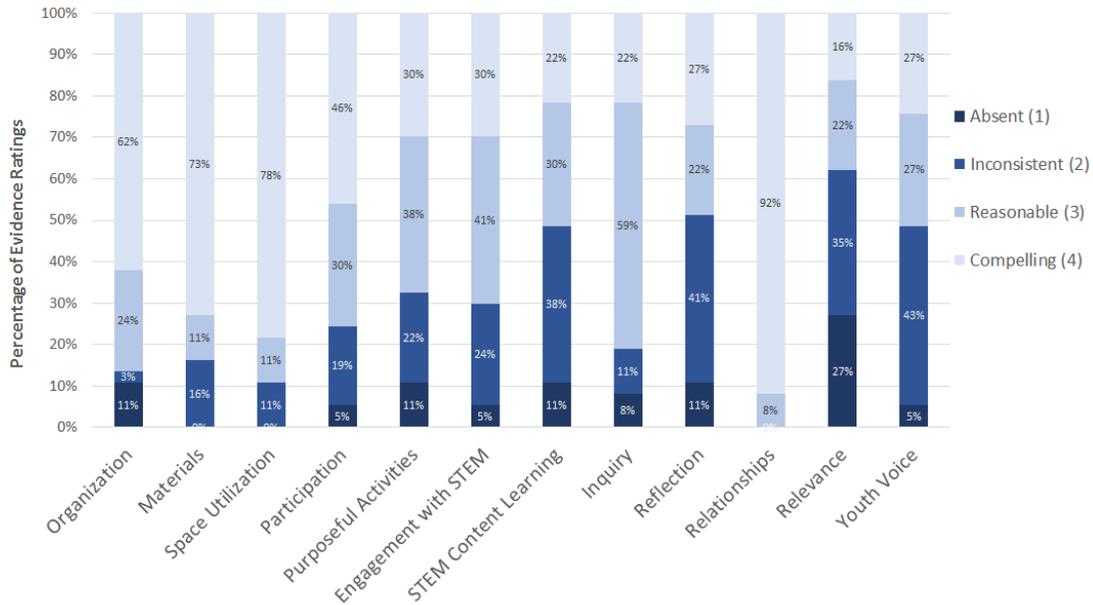
An examination of quality ratings measured using the DoS observation tool ( $n=36$  observations between 2016 and 2018), in afterschool and summer programs participating in the data community of practice consistently displayed reasonable to compelling levels of quality (i.e., ratings of 3.0 to 4.0, respectively) when observing features of the learning environment (use of space, materials, as well as specific dimensions related to activity engagement (especially participation) and youth development (i.e., relationships) (see Figures 14-15 and Appendix C for national comparisons). Persistently challenging areas of quality (i.e., ratings of 1.0 to 2.0, evidence absent or inconsistent, respectively) include STEM knowledge & practices (STEM content learning, inquiry, reflection), as well as dimensions within the youth development in STEM domain (relevance and youth voice).<sup>[3]</sup> These areas of quality have also been found to be challenging for other similar STEM programs across the U.S. (see Appendix C).

**Figure 14. Average Ratings of STEM Program Quality for TRSA-Supported Programs Measured Using the Dimensions of Success (DoS) from 2016-2018**



<sup>[3]</sup> It is important to note that there were different samples of programs and students from year to year, thus longitudinal analyses should be interpreted with caution.

**Figure 15. Percentage of STEM Program Quality Ratings for TRSA-Supported Programming Measured Using the Dimensions of Success (DoS) from 2016-2018**



The above stacked bar chart shows the proportion of ratings on a scale of 1 (Evidence Absent) to 4 (Compelling Evidence). TRSA aggregate results from 2016 to 2018 demonstrate that at least two out of three programs were rated as having reasonable or compelling levels of quality in the domains of Features of the Learning Environment and Activity Engagement. Most programs demonstrated reasonable to compelling evidence of quality for Inquiry (81%), and about half of programs exhibited reasonable to compelling evidence of quality for STEM Content Learning (52%), Reflection (49%), and Youth Voice (54%). Overall, for TRSA-supported programs, Relevance was the greatest challenge and Relationships was the greatest strength.

Related to the benefits of assessing program quality and improvement one educator shared, *“We have incorporated the DoS observation into our lesson planning process. That [planning] happens more during the school day, but there is also lesson planning that happens in the afterschool environment as well. We do a pre- and post- assessment in the afterschool setting. That's the biggest way the TRSA has impacted us. I feel like it has given us this great tool for looking at what we do and kind of assessing it because we feel that the DoS tool really is a good fit for what we're trying to do in the afterschool setting because it combines science with the 21<sup>st</sup> century skills . . . It is a good fit for us and has provided us with a common language and a common tool across sites to show our educators this is what we're going for and to talk about the different*



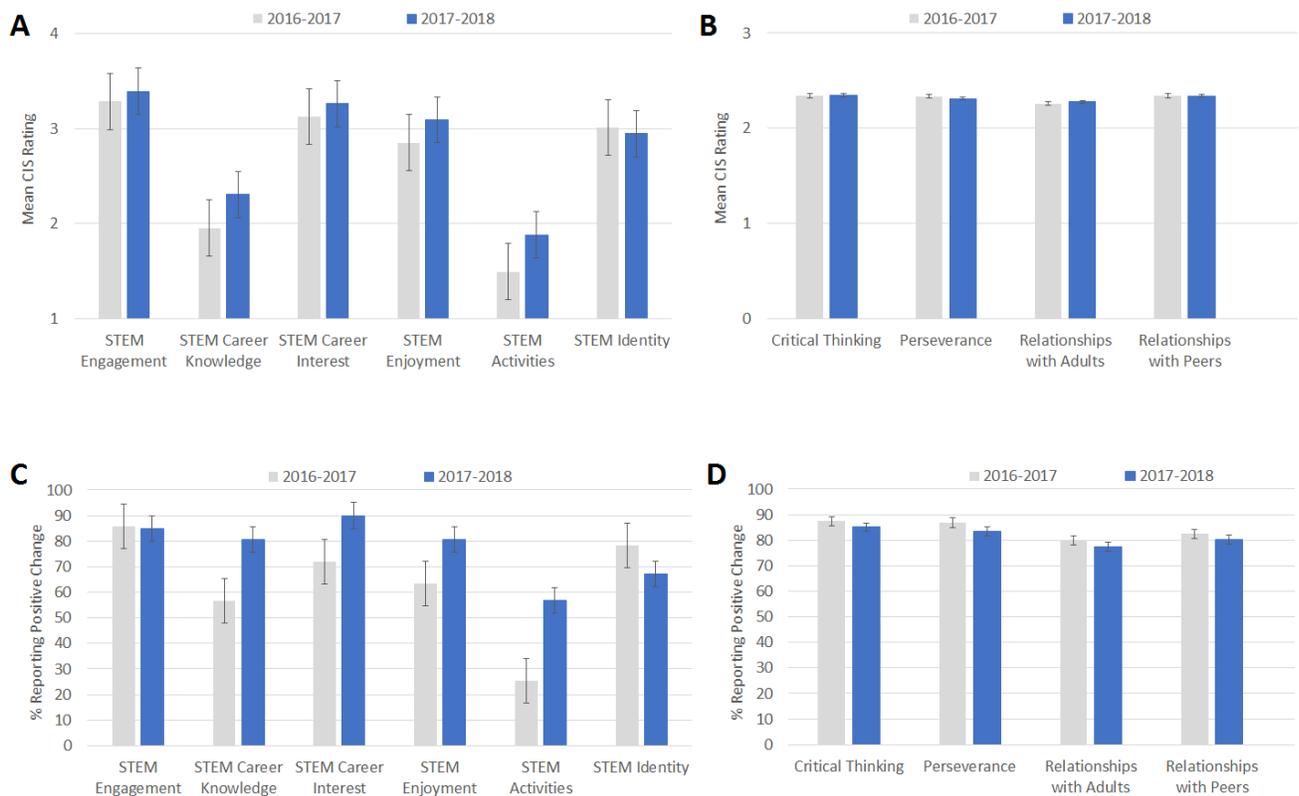
*pieces. It's been incredibly helpful to us and will continue to be so, especially as we continue to train more DoS observers."* During the same timeframe that DoS was introduced, the top three areas of professional development desired by educators completing the CIS-E survey included: programming ideas (48%), teaching and leading STEM activities (41%), and helping students with science (19%). Between 2016 and 2018, 85% of educators shared that they had an increased interest in leading/teaching STEM after their experience facilitating STEM activities.

**Youth Experiences.** Quantitative data demonstrated positive changes among youth participating in TRSA-supported programming. Exploring aggregated survey results from PEAR's CIS-S for programs supported by the TRSA from 2016-2018, results showed that, at the end of programming, Tulsa youth reported significantly more growth in all STEM-related attitudes and 21<sup>st</sup>-century skills measured (except STEM activity participation) relative to peers participating in similar out-of-school time programming across the U.S. (national standardization sample)(see Appendix D1). They also began their programs with significantly higher ratings for all four 21<sup>st</sup>-century skills and STEM engagement, career interest and knowledge, and identity. Further, data received by the TRSA revealed that underserved youth enrolled in Title 1 public schools who received mentorship support from local STEM professionals through the Me & My Math mentors program demonstrated a 4-point increase in state tests over peers not receiving mentoring support (Appendix D2). As they reported, students in the mentor program *"showed an average improvement of 17 points, while the national average improvement for 3<sup>rd</sup> graders is 13."*

Analysis of CIS-S data over time, from 2016 to 2018, showed positive trends in STEM-related attitudes and 21<sup>st</sup>-century skills (Figure 16a-d, below). Youth participating in programming were surveyed twice: once at the start of programming using a traditional pretest (Figure 16a-b, below) and once at the end of programming using a retrospective survey (a survey where individuals are asked to reflective or think back as they rate) that asks respondents to rate perceived levels of change (Figure 16c-d, below, and Appendix D1 for national comparisons). Tulsa children and youth reported significant gains in four out of five STEM-related attitudes, including STEM career interest, STEM career knowledge, STEM enjoyment, and STEM activities (Figure 16c, below). STEM identity ratings declined across the two years. However, when analyses excluded data from youth participating in programs with a duration of less than one week, levels of STEM identity increased across the two years (data not shown). Tulsa children and youth also reported significant, positive gains in the four 21<sup>st</sup>-century skills measured: critical thinking, perseverance,

and relationships with peers and adults. It is important to note that there were different samples of programs and students from year to year, thus longitudinal analyses should be interpreted with caution. To provide a point of comparison, analyses were performed to compare results of the CIS-S from Tulsa with national norms provided by The PEAR Institute. Findings from educator surveys collected during the same timeframe concur with students' results with 80% or more reporting growth in students' science, technology, engineering, and social skills. Math was rated noticeably lower with less than half of educators reporting growth (45%), a trend commonly seen.

**Figure 16. Youth Self-Reported STEM-Related Attitudes and 21<sup>st</sup>-Century Skills at the Beginning (a, b) and at the End (c,d) of Programming from 2016 to 2018**



### *Sustainability*

The TRSA has taken comprehensive strides to formalize goals and a mission to promote STEM in Tulsa, establish well-defined organizational and governance structures, build staffing and cross-cutting partnerships, secure funding streams, institute autonomy and independence as an

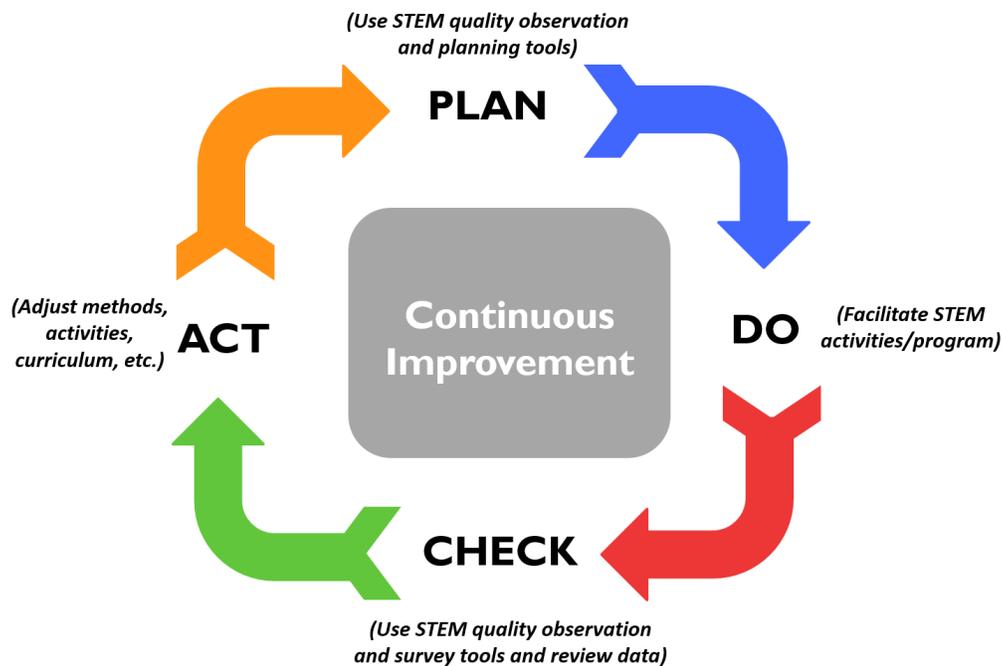


organization, and build capacity and sustainability for future success and growth. With the TRSA officially becoming an independent 501(c)(3) non-profit (activating its status in 2018), having an integral staff member become the Executive Director, entering its fifth year of existence as an alliance and fourth year as a national SLE CoP, the TRSA is at a significant transitional point in the evolution of their ecosystem.

**Expanding Partnerships to Serve All.** To promote sustainability of the TRSA now and in the future, key drivers to encourage a fertile culture and continuous evolution have been identified by key stakeholders. Most are connected to efforts already implemented and shared above but with the potential to advance even further. Deepening and expanding partnerships, including with STEM industry to support work force development and college and career readiness, is one such area identified as a key strategy in the TRSA's national SLE application, re-established in their 2016 domains and goals and shared by many interviewees. With such a STEM-rich environment encircling Tulsa, one which is continuously developing, potential cross-sector collaborations are abundant and fruitful for building new services, programming, and funding sources. Such initiatives identified included the new expansive Gathering Place riverfront park that promotes all Tulsans to engage and learn (nominated by US Today as best new attraction in 2018), The Opportunity Project (a new citywide intermediary focused on expanded learning opportunities for all youth in Tulsa), and New Tulsans Initiative (aimed at implementing a comprehensive roadmap for building a more equitable Tulsa while fostering connections between all immigrants and long-term residents), to name a few. When a TRSA member was asked about their expectations for partnerships between the TRSA and area businesses one year from now (2018), they shared, *“A truly wonderful thing is happening in our business partnerships now where business partners are pulling aside their competitors, suppliers and other business partners and either telling them the story of TRSA's work or inviting our staff to meet with new businesses to present the work our Alliance is about. It's beginning to feel like less of a push from our side and we are beginning to feel a pull from the business community. I would expect in a year that TRSA would have ten new business partners and in five years TRSA would have grown the Alliance through new business partnerships so that most schools in northeastern Oklahoma would have strong business partners who are authentically engaged in support of getting all students STEM ready!”*

Regarding future partnerships and programming, including the goal of serving all – particularly those historically underserved – another individual stated, *“I hope we will have more offerings, and I hope we would have more things. I come from an elementary background, and a lot of the focus is on middle school and high school, and I feel like we need more elementary offerings for students and teachers and early childhood especially. I hope we have more teachers and student involved, more staff and more offerings. Broader too . . . reaching farther out in rural areas. We get a lot from Tulsa Public Schools because we are right in Tulsa, and I would like to see some of these schools, rural schools. I have reached out to a couple I know to see if I can come out and speak at some of their staff meetings to say: ‘Hey, this is what we do, and we are a resource for you.’ I am hoping we can bring in some of their students and teachers we have never reached before, not just getting the same group of students and teachers from the same schools.”*

**Figure 17. Continuous Improvement Model Used by TRSA**

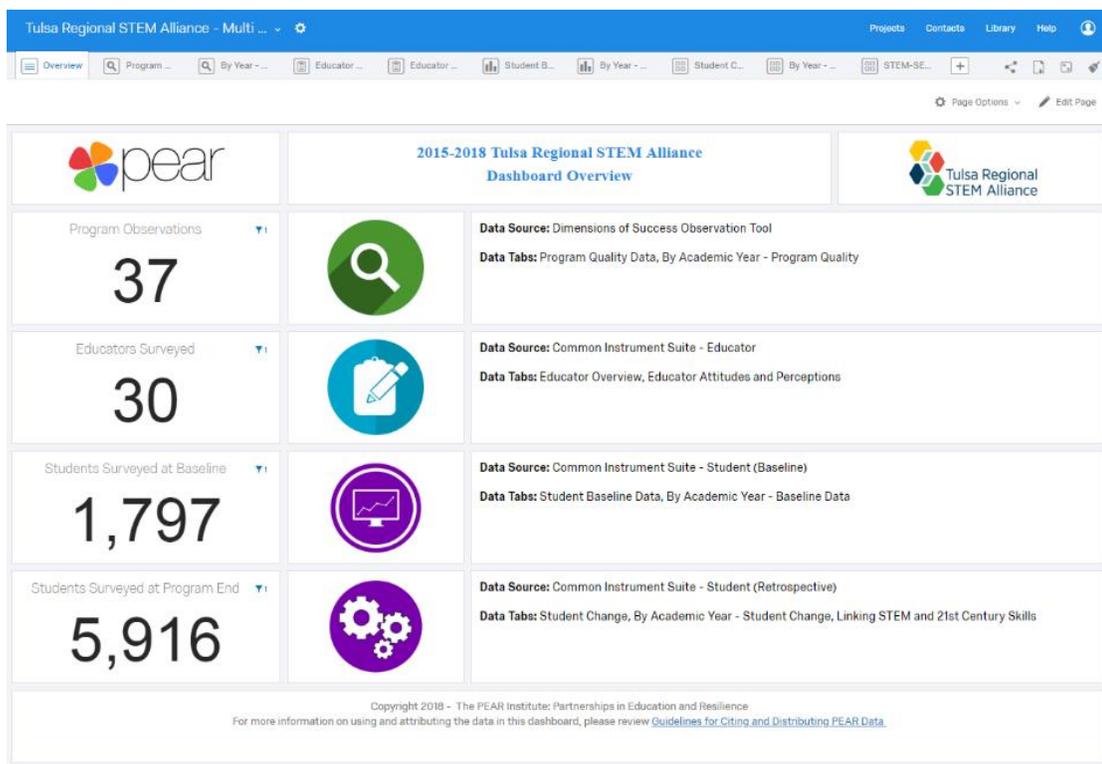


**Using Data to Inform Programming.** Overall, the TRSA has formed a local community of practice around data by collecting and sharing data from all STEM-related programs and events to understand their successes and areas for improvement and to inform new programs, professional development, and resources. Importantly, the TRSA also encourages its membership to use the same science-based approach to their practices by providing a common framework around

measurement from The PEAR Institute to communicate strengths and areas for improvement in program quality and youth and educator outcomes. The TRSA has implemented a continuous program and outcomes improvement model using PEAR’s STEM tools (Figure 17, above).

This model begins with: (1) program planning using feedback from DoS observations or using the DoS Program Planning Tool, (2) facilitating STEM programming with children and youth, (3) checking the quality of programming with feedback from DoS observers and/or reviewing the outcomes reported by youth completing the CIS-S and/or reviewing the outcomes reported by educators completing the CIS-E, and (4) adjusting or revising methods, materials, curricula, or activity plans to increase quality of the STEM activity. To facilitate program staff’s review of the data, as of 2018, The PEAR Institute provided the TRSA and TRSA-supported programs with interactive and secure online dashboards that pull together all sources of data (i.e., DoS, CIS-S, CIS-E) so that they can be displayed in one place (see Figure 18). Additionally, the dashboard includes filters that allow users to explore trends in the data, such as examining results by year, dosage/duration, gender, or grade-level (see Figure 18).

**Figure 18. STEM Data Dashboard Displaying Survey and Observation Data for Informal STEM Programs Supported by the TRSA**





The TRSA is also considering working with partners to collect more data to inform on the overall growth, success, and sustainability of the ecosystem as well as to identify opportunities and areas for improvement, as one individual succinctly summarized, *“I think that our partnerships are going to become more strategic. That would probably be the best word I would use . . . at some point in time we are going to do asset mapping and a gap analysis. We are going to try to figure out where we have weaknesses in our ecosystem fabric, and I know that in both the near term as well as in the future we are going to understand as an alliance who can plug into those gaps. We will reach out to them and invite them to become a part of the larger community. A key thing around all that is that we have to be good about the expectation of continuous improvement and the expectation of a data-driven, evidence-driven organization. Every time we engage, we have to be very intentional about what kind of data we are able to gather and want to gather . . . making adjustments based on the evidence we are seeing.”*

**Implementing Accountability Measures.** Measures of accountability have been built into the TRSA model to keep partnerships established and efforts on track. The collection, analysis, and use of data to guide next steps is one example, and weekly meetings with TRSA staff to calibrate efforts and plan proactively is another (referred to as ‘backyard meetings,’ which are used to define each staffer’s roles and responsibilities on any given project). Regular meetings with the advisory council and board to communicate information widely across sectors, to discuss strategies, and to make decisions allows an opportunity for all partners to share their voice and also ensures accountability. While the TRSA, through its increasingly vertical governance structure and paid positions, has mechanisms to ensure accountability, interviews with partners who did not have a leadership role or paid position with the TRSA were unsure about how members would be held liable if they were negligent in their roles and responsibilities. Some also shared that they did not feel everyone had an equal voice within the alliance and that some sectors were heard more than others. The TRSA is aware of these sentiments and has been working to balance the voices of partners as well as to increase the diversity of its membership to be more representative of the community. Among those interviewed, there has not been any substantial disagreements or need for formal accountability among partners; many chalked this up to the positive, hard-working, “*can-do*” culture of the ecosystem.

**Actively Engaging in National SLE CoP.** Finally, involvement in the SLE CoP is viewed as integral to the continued sustainability and future planning of the TRSA, as summarized by one



member. *“It is just incredible on so many levels to go and meet with people who are trying to do the exact same thing you are trying to do. It is just super valuable because there are days you think I don't think anyone else in Tulsa really understands . . . during a Community of Practice, the whole room is trying to do the same thing [we are]. So, not only do you have that camaraderie, you have leading experts presenting emerging best practices, discussing ‘have you tried this, tried that,’ and discussing ‘this is what we tried, and it totally flopped’ or ‘this is what we tried, and I am excited’ . . . So, today I could pick up the phone and talk to someone in Cape Cod or Orange County or Omaha, Nebraska, and we could pick up right where we left off, and I think that is incredibly valuable for our country.”*

When asked to describe the benefits of working with the national SLE CoP, individuals highlighted how the TRSA’s involvement allowed them, as well as their organizations to: (1) embrace a broader, national perspective (i.e., get out of their city and think nationally, as opposed to locally, and see different perspectives and approaches of different people and ecosystems), (2) share learnings and resources (68 ecosystems to learn from and network with, all in different stages of development with different models, successes and failures, enabling programs to avoid reinventing the wheel or working in silos), and (3) participate in monthly virtual learning events and the biannual in-person SLE CoP events. Having Tulsa’s ecosystem used as a best practices model was also highlighted as a benefit of participating in the national initiative because it fostered more of a drive to succeed and more value to the importance of the work we are doing. Regarding the TRSA’s ecosystem model, *“it's been a blue chip where people have modeled their ecosystems off of ours because it was so successful.”*

**Being Reflective and Strategic.** Moving forward, to further their establishment and scale up their work, the TRSA is focused on being reflective, promoting intentional engagement, and communicating effectively. They are trying to be more visionary and future-oriented in the ultimate outcomes by planning and mapping long-term goals and by acknowledging that they are strong programmatically, but as a convener, must be even more inviting and informative to all STEM members. They must continue to grow partnerships in all sectors, including the various K-12 school districts throughout Tulsa, and continue to strive to reach all students, especially those historically underserved in STEM. They recognize the need to grow at the right pace, while still working to meet the requirements of participants, including those with different priorities and interests. Further, they recognize the importance of functioning as an ecosystem in Tulsa, while



simultaneously supporting national efforts focused on the promotion of STEM literacy through ecosystems.

One stakeholder shared the benefit of being part of the ecosystem model, *“I love the fact that we are part of a STEM ecosystem. And, the word ‘ecosystem’ is absolutely critical to describe Tulsa on a local level, on a state level, and particularly on a national level. Because ecosystems have to be nurtured—they’re alive, they have to be fed, and think of all the things that are required to be alive . . . . adaptability is probably the number one characteristic that everyone one of us has to have in this very changing environment. But we are alive, and we can’t be treated like just a model or something that can be done by . . . Watson, the super computer. We’re just a bunch of people trying to accomplish something. And things, and organizations like the Tulsa Regional STEM Alliance, make sure our organism is in balance.”*

## **Discussion**

The development and enrichment of strategic partnerships through STEM learning ecosystems has been identified as one of the key pathways to success by the U.S. Federal Government in its latest five-year strategic plan for STEM education (National Science & Technology Council, 2018; Levy et. al., 2018). With this new national attention and the rapid scaling of the *STEM Learning Ecosystems (SLE) Community of Practice (CoP)*, there is an urgent need to study ecosystems to understand their potential to transform STEM education models. The present study increases the field’s understanding of how ecosystems form and develop through the lens of a partnership framework. We explored and documented assets and resources, origin story and developmental trajectory, partnership stages, SLE theory in practice, program quality, youth experiences, opportunities and barriers, and indicators of sustainability in Tulsa, Oklahoma, one of the first U.S. STEM learning ecosystems. Although this case study is rich in findings, we focus this discussion on key results that help inform future directions for Tulsa’s ecosystem, as well as others participating in the SLE CoP.

### ***Paradigm for the Field***

Tulsa, Oklahoma’s ecosystem is a powerful example of how individuals, groups, and organizations from a community took initiative and created an organization and system of strong



partnerships within and between sectors to improve access to quality STEM learning opportunities for children and youth. The TRSA, the lead organization of Tulsa’s ecosystem, is an exemplary model for the national initiative with evidence showing how all four SLE CoP strategies and most of the design principles have been implemented. By leveraging strategies from the SLE CoP to partners—especially afterschool and summer programs, businesses, funders, school districts, and community organizations—the organization has grown and scaled a variety of ways outlined in this report. There has also been a substantial increase in the number of funders and the amount of funding to support the TRSA (more than 7,000% increase since 2013), in the numbers of partners and advisory council members that participate in the ecosystem (more than 188% increase since 2013), and in the numbers of children and youth engaged in STEM activities and events sponsored by the TRSA (more than 1,800% growth in TRSA’s direct and indirect engagement with youth since 2013). When TRSA funding, membership, and youth participation are plotted on a graph over time, the slopes of the line grow steeper after 2016, a year after the TRSA formally joined the SLE CoP. Interviews and exit surveys revealed that partners feel that being part of the national community has benefited Tulsa the most by bringing more awareness to STEM and the ecosystems in Tulsa and by increasing the ability of the local community to obtain funding, build partnerships, and improve STEM achievement among children and youth. Although it is not possible to make a causal statement, converging evidence suggests the success of the TRSA is due in part to the organization’s consistent and active engagement in the SLE CoP and the way it has translated those strategies in practice.

### ***Partnerships and Culture***

Cross-sector partnerships, the first strategy of the SLE CoP, were foundational to the formation and evolution of Tulsa’s ecosystem. Early design and planning sessions fostered cohesion among a diverse group of people who would soon take on leadership roles in the TRSA. While the TRSA was under the wing of a larger non-profit organization, a champion organizer and dedicated funder worked together to connect partners and sectors across the community. Funding initially brought like-minded partners together, something we call opportunity-based partnerships, but the positive, “*can-do*” culture of the TRSA’s leadership created camaraderie among the partners so that many began sharing common goals and planning STEM-rich programs and events



together (called collaborative partnerships in our framework) – with many still at the table today. When considering the ecosystem in parts, partnerships are in different developmental phases. Out-of-school time organizations (i.e., afterschool and summer programs, science centers and museums) that work more closely with the TRSA (because of their role as a professional development and program provider) have strong collaborative relationships and show signs of interconnected partnerships—members know and like each other, take pride in their collaborative work, feel they accomplish more together than on their own, and celebrate shared accomplishments together. Organizations from other sectors, such as K-12 school districts and businesses, have also been found to have evidence of collaborative partnership types, but there is more within-sector variability. This is based on the findings that the TRSA has established deep collaborations with some K-12 and business partners, whereas other K-12 and business partners appear more likely to collaborate for functional reasons (e.g., networking opportunities, common funding), with the latter reporting being more autonomous and less familiar with other partners involved with the TRSA or feel that other partners’ goals or interests are better represented in the ecosystem than their own. We also found evidence for how crisis or opportunity can result in sectors oscillating between opportunity-based and collaborative partnerships (an example of a crisis for K-12 included significant education budget cuts and teacher strikes). Suffice it to say that, like light reflecting through a prism, SLE CoP strategies (especially strategies two to four related to creating and connecting STEM-rich learning environments, equipping educators, and supporting youth pathways) are more clearly reflected in practice as partnerships within and between sectors strengthen and the goals and understandings between organizations become clearer.

### ***Evidence-based Approach***

Pivotal decisions the TRSA made early on in its history were to engage the research community, adopt a common framework and language to understand STEM quality and outcomes, and invest in evidence-based assessments to ensure that STEM activities are delivered to young people in a high-quality way. The collection of data was pervasive throughout all the activities performed by the TRSA, but it was especially evident in out-of-school time programming that takes place in afterschool and summer programs, science centers, libraries, and museums (but is growing in school setting, as of the fourth year of the TRSA/PEAR partnership). The TRSA adopted widely-used tools with national comparison samples, including a STEM program quality



observation tool (Dimensions of Success, DoS), a student survey (Common Instrument Suite for Students, CIS-S), and an educator survey (Common Instrument Suite for Educators, CIS-E), to determine whether activities are providing meaningful learning experiences that are stimulating cognitively (e.g., increasing STEM content learning), emotionally (e.g., increasing interest and excitement about STEM), and socially (e.g., increasing the quality of relationships with peers and adults, especially given the importance of teamwork and collaboration in STEM professions). Together, with technical assistance and support of The PEAR Institute, these tools are used in a continuous improvement process that informs programs of their strengths and areas for improvement so that directors and educators can set goals and modify facilitation, curriculum, activities, or materials. One partner summarized the importance of continuous improvement in Tulsa: *“We have to be good about the expectation of continuous improvement and the expectation of a data-driven, evidence driven organization. Every time we engage, we have to be very intentional about what kind of data we are able to gather and want to gather . . . making adjustments based on the evidence we are seeing.”* It is promising to see a STEM learning community leverage STEM to support and grow its own efforts.

Importantly, national work has shown how investments in program quality (using the DoS framework) translates to better outcomes for youth (using the CIS-S; Allen et al., 2017). Until recently, this local community of practice formed around data in Tulsa has only been implemented in programs held outside of school, but there are currently efforts underway to involve school districts. Over time, it will be important to determine whether national trends showing a strong correlation between quality and outcomes can be replicated to show that investment in quality is fostering STEM identity, engagement, career interest, and skills in Tulsa. It will also be important to determine whether cross-sector partnerships, such as afterschool and K-12 school districts, can impact academic performance or STEM skills or future STEM-related decisions like college majors and careers, especially given persistent challenges observed in math and science performance in public schools around Tulsa.

### ***Data Systems for Research and Practice***

The TRSA has already done exemplary work in building systems around the collection of data, and the ecosystem would benefit from expanding data collection efforts such as by bridging



the formal and informal learning environments (e.g., K-12 and afterschool). Over the last four years, and with training and technical support from The PEAR Institute, the TRSA have channeled their program quality observation data and youth and educator survey data into a comprehensive online database. Results are visualized and triangulated using a dynamic virtual dashboard designed and managed by The PEAR Institute, and the TRSA works with partners in the community to understand their data as well as to put them into action. The system is adaptable to include as many sources of data as the TRSA needs to integrate, and it provides for filtering so that users can drive their own analysis of trends.

In the positive spirit of the TRSA, end-of-year data reviews are called “celebrations” because the collection of data involves a significant effort and an accomplishment that should be celebrated community-wide. Further, in addition to continuous improvement of STEM programming, interviewees shared how each TRSA meeting integrates the review of data findings to guide organizational planning, decision-making, and ongoing capacity building. This represents an important culture shift—the TRSA is removing anxiety or fear from assessment (especially given the souring around standardized tests in schools) by focusing on strengths and taking a proactive approach to address areas for improvement throughout the ecosystem.

### ***Lessons for Sustainability***

This case study research has identified several strengths of the ecosystem’s lead organization (the TRSA), several signs of success and sustainability for the ecosystem, and several areas for growth and improvement to support the longevity of the initiative. The TRSA has made significant inroads toward the goal of developing strong partnerships to transform STEM education in Tulsa. Partnerships have been facilitated by *“hearty, generous, and collaborative citizens who possess a “can-do” spirit,”* generous funding from the Charles and Lynn Schusterman Family Foundation (CLSFF) and the foundation’s encouragement of other area funders to support the TRSA; a landscape rich with STEM businesses and industries; close proximity to many STEM-rich institutes that support a *“collective impact around STEM education,”* and deep partnerships with several Tulsa public school districts to promote quality STEM education, professional development, programming, and funding. There is also evidence for high quality programming, positive youth experiences, and funding to expand opportunities and increase access to new



opportunities, and an established data system with common assessments and community of practice around data to inform continuous improvement efforts.

Nevertheless, the work of the TRSA is ongoing. Key stakeholders reported that Tulsa's ecosystem would benefit from: developing stronger partnerships with more organizations within key community sectors, including K-12 schools and businesses; improving messaging and communications to reach all audiences to raise awareness of the TRSA and ecosystem efforts; diversifying funding streams and balancing the goals of funders with the goals of other members of the community; changing up leadership and inviting new voices to join the board of directors and the advisory council, especially voices representative of Tulsa's diverse community; ensuring stakeholders are aligning actions to the mission and aspirations of the ecosystem; ensuring all members feel equally involved in goal-setting or decision-making; developing and implementing new strategies to increase reach and capacity while minimizing burden on staff during a rapid period of organizational growth; and expanding STEM-rich learning opportunities to underrepresented and underserved youth.

The ecosystem would also benefit from improving areas of quality that have been persistently challenging, both locally and nationally. Specifically, more professional development is needed to facilitate activities that provide young people with more opportunities to review learning (reflection), to express ideas and make decisions (youth voice), to connect content to everyday lives (relevance), and to practice skills used by STEM professionals in the "real world" (inquiry). Additionally, Tulsa's ecosystem would benefit from connecting sectors more meaningfully to grow STEM skills in young people as well as educators, such as through internships and apprenticeships for students and additional externships for teachers (something the TRSA currently offers to educators but could expand further through their diverse partnerships). Lastly, the ecosystem would benefit from expanding its data-driven community of practice from afterschool and summer program providers to generate data across sectors. To begin to identify and develop indicators of ecosystem sustainability, it will be essential to track data over time and across sectors of the community using a common database (e.g., What percentage of youth in K-12 are considering careers in STEM? What percentage of young adults in college select majors in STEM? Do percentages differ by student background characteristics, like socioeconomic status?).

The TRSA has already started this work by adopting an evidence-based framework and common assessments used across afterschool and summer programs. A holistic, longitudinal



approach is needed to understand whether Tulsa’s ecosystem is moving the needle in terms of math and science performance and persistence in the STEM pathway towards college majors and careers. Tulsa’s ecosystem has accomplished so much and has covered an impressive amount of ground in its short history. We recommend in the next chapter of the ecosystem’s work to focus on the breadth and depth of its work, thinking strategically about how to leverage partners in the community more, including encouraging more family engagement, diversifying funding and resources, developing meaningful partnerships, improving quality of activities in school as well as outside of school, and tackling STEM performance head-on.

### **Summary and Conclusions**

Partnerships were foundational to the growth and development of Tulsa, Oklahoma’s STEM learning ecosystem. The partnership framework used in this study revealed that Tulsa’s ecosystem has moved far beyond an opportunity-based type with many of its sectors, which is usually found in early stages of partnerships when a funding opportunity pulls organizations and people toward a joint application. Opportunity-based partnerships often lead to postponing the foundational work of partnering to the future, which can be the cause of many problems once the funding becomes available because relationships have not been fully developed before organizations begin their work together. On the other extreme, ecosystems and partnerships can be so powerful that they transform the practices—and even the identity—of many of the partnering organizations (identified as a transformational partnership and is challenging to attain). While there is evidence that the TRSA is moving in this direction, it will be interesting to watch this level of partnership evolve as they continue to progress in their development of partnerships.

By going into depth with this case study, we can see how the ideas and principles of the SLE CoP have contributed to Tulsa’s STEM learning ecosystem. The TRSA had many fertile elements that contributed to its growth, including strong leadership, demonstrated philanthropic will, companies and school districts ready to partner for the benefit of the youth they serve, and an overall dedicated, can-do attitude. As the first case study of a SLE CoP, we believe this report can be an example for other communities and funders; a scaffold to guide their programming, strategies, and approaches within their ecosystems. Examining dozens of communities at a time will not provide the same level of insight that can be gleaned from an in-depth study of one robust community. The work done in Tulsa’s ecosystem is just the beginning; they must now



take the measures and quality indicators used in OST environments into the school day and across districts to better serve all students, especially those traditionally underserved. The initiative must not end with improvements to OST STEM opportunities but with a core transformation of STEM education across all learning environments. This vision includes more project- and engagement-oriented learning opportunities that have support in the home, in the community, and in the classroom.

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## Appendices

### Appendix A

#### STEM Learning Ecosystem (SLE) Design Principles and Key Stakeholders

The following guidance is given from SLE organizers ([www.stemecosystems.org](http://www.stemecosystems.org), as of January, 2019):

##### Design Principles:

- There is no one right way, no ‘correct model’ for cultivating STEM Learning Ecosystems.
- Ecosystems are complex and messy, and not necessarily linear. The goal of ecosystem cultivation is not to design the same STEM experience for all young people—but to maximize, grow and connect STEM learning opportunities so all young people have access to robust and connected learning experiences along pathways that are individualized according to their own interests.
- Cultivating ecosystems requires a credible, highly engaged lead organization committed to collaborative practice.
- Ecosystems cultivation features dynamic partnerships and diverse partners who share respect for each others’ roles across sectors. The collaboration works by attending to the ‘enlightened self-interest’ of all partners.
- Ecosystems cultivators embrace the values, beliefs, interests and strengths of diverse cultures representative of the communities they serve. Stakeholders welcome non-traditional partners and experiment with creative new ways to partner across sectors.
- Identifying and eliminating barriers to equitable access to high-quality STEM learning for all young people is a key driver of ecosystem cultivation.
- STEM learning ecosystems are grounded in the National Research Council’s Framework for K12 Science Education, *Surrounded by Science: Learning Science in Informal Environments and Community Programs to Promote Youth Development*, as well as other research about how young people learn and develop.
- Practices promote active, inquiry-based learning to 1) build students’ competence and self-efficacy in STEM; 2) deepen their understanding of their current and future potential to solve complex problems; and 3) strengthen their social-emotional skills, including persistence, resiliency, creativity, problem-solving and collaboration.
- Ecosystem cultivators value transparency and understand that data sharing and data-based decision making are critical.
- Collaborators prioritize time for reflection and peer exchange, among and between practitioners engaged in implementing cross-sector strategies and organizational leaders focused on sustaining these efforts.

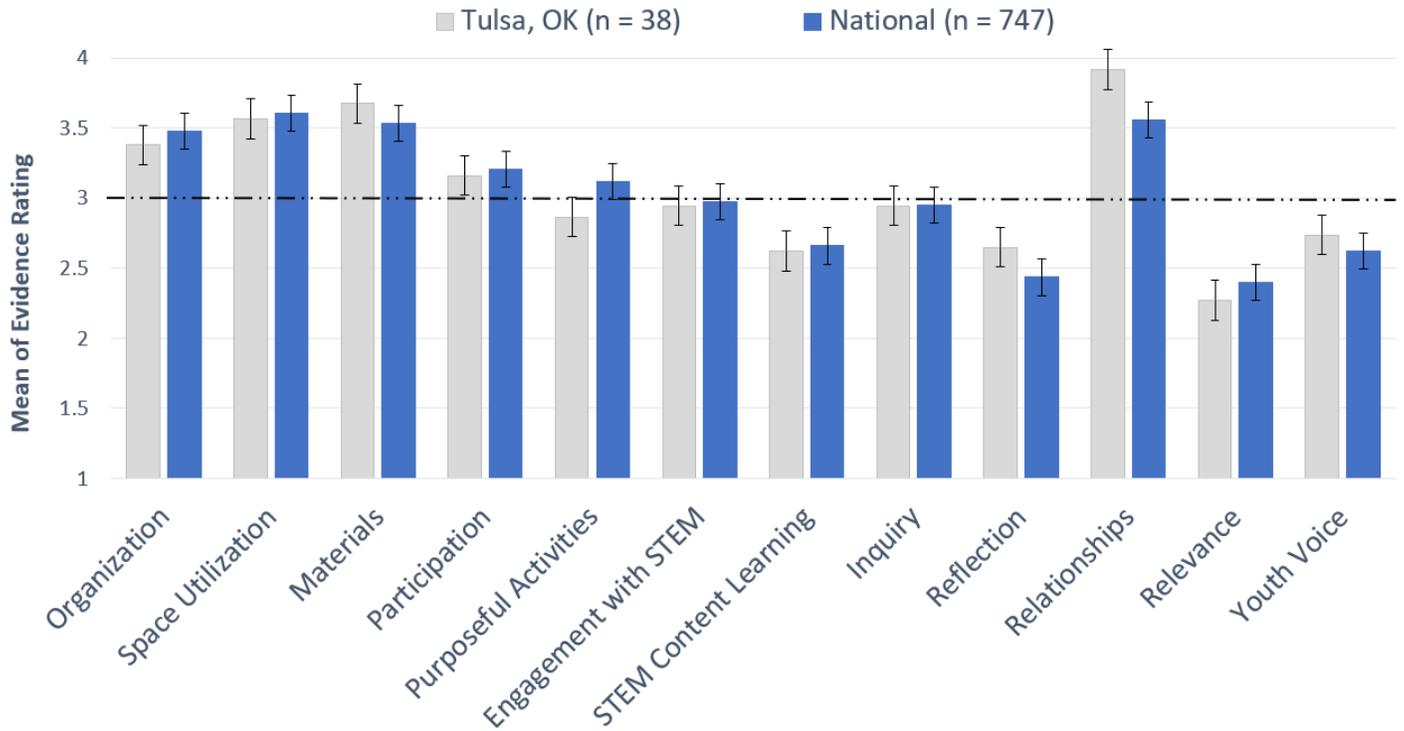
##### Key Stakeholders:

- A credible, highly engaged lead organization committed to collaborative practice
- Schools and school districts
- Out-of-school time (OST) systems/programs
- STEM-expert museums and science centers
- Institutions of higher education
- STEM-related companies
- Businesses that recognize the need for STEM competencies
- Libraries
- Community-based organizations
- Philanthropies
- Families and parent organizations
- Youth organizations



### Levels of STEM Program Quality in TRSA-Supported STEM Programming

**Figure C1. Dimensions of Success (DoS) Observation Ratings of Quality for TRSA-supported STEM Programs (2015-2018).** Mean +/- SEM quality ratings of TRSA-supported programs relative to similar STEM programs across the U.S. (national sample,  $n=747$ ).

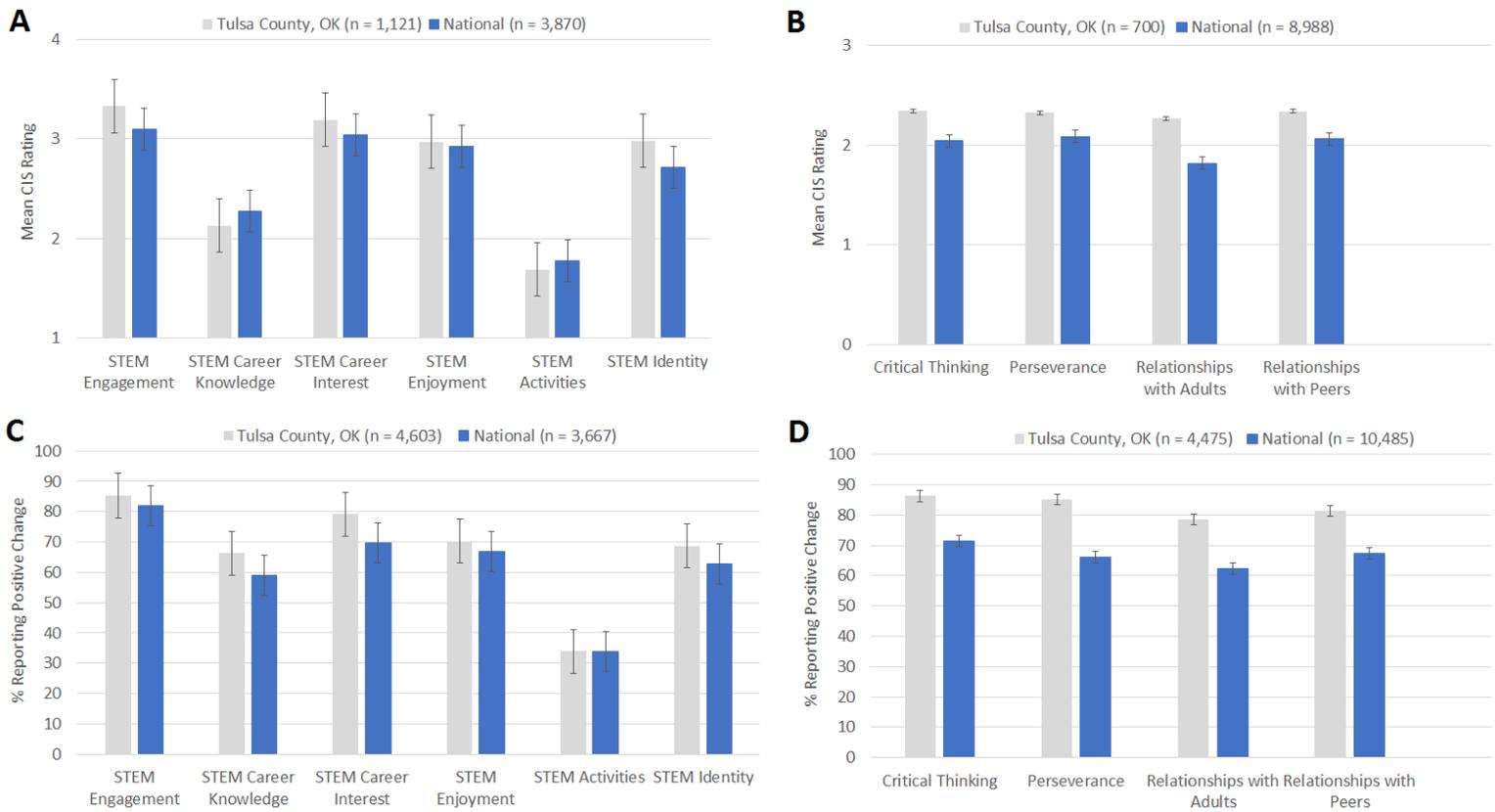


To calculate the strength of evidence, certified observers quantify evidence from their field notes using a standard rubric that has a 4-point scale from low (1, Evidence Absent) to high (4, Compelling Evidence).

Appendix D

Youth Data: STEM Attitudes (D1) and Academic Performance (D2)

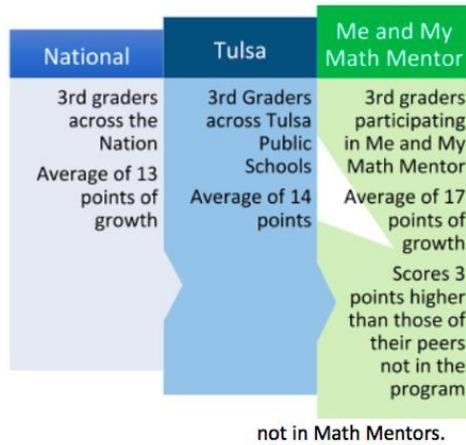
**Figure D1. Aggregated Common Instrument Suite-Student (CIS-S) Survey Results for Programs Supported by the TRSA from 2016-2018.** Surveys were administered at the start of programming in traditional pretest format to measure baseline attitudes toward STEM (a) and 21<sup>st</sup>-century skills (b) and again at end of programming in retrospective format to gauge the percentage of students experiencing positive change in STEM (c) and 21-stcentury skills (d). At the end of programming, Tulsa children and youth reported significantly more growth in all STEM-related attitudes (c) and 21<sup>st</sup>-century skills (d) measured (except STEM activity participation) relative to peers participating in similar out-of-school time programming across the U.S. (national standardization sample). They also began program with significantly higher ratings for all four 21<sup>st</sup>-century skills (b) and STEM engagement, career interest and knowledge, and identity.





### Figure D2. Effect of Early Childhood Mathematics Mentoring Programming on Academic Performance.

Data provided by the TRSA, based on a study conducted with a university partner, indicating significant improvement in math achievement scores among children participating in the TRSA-supported “Me & My Math Mentor” program



**Tulsa Students in the Me and My Math Mentor program showed an average improvement of 17 points, while the national average improvement for 3<sup>rd</sup> graders is 13.**

On average, Math Mentors students showed a **3 point increase** when compared to their peers at the same school who were

