Student-Led Exploration Fosters Perseverance & Peer Relationships

Report on 2022-2023 Data Collection

November 1, 2023

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Background

Early K-12 STEM education is important for cultivating STEM interest and proficiency as well as career exploration (littleBits & YouGov, 2018; National Science Board, 2022). While research suggests that middle school is an optimal time for STEM learning, only 17% of eighth graders report frequent engagement in scientific inquiry-led classroom activities and less frequent engagement is linked to lower levels of science proficiency (NAEP, 2019; Thomas & Larwin, 2023). Students from socioeconomically disadvantaged communities are particularly susceptible to these issues and overwhelmingly attend under-resourced schools with less experienced teachers and fewer in-school STEM course options (Lynch et al., 2019; Tyson et al., 2007).

Research suggests that STEM programming focused on student-led, hands-on, real-world learning facilitated by "engaged adults" who believe in the potential of their students is most effective at cultivating STEM engagement and career interest (Bouvier, 2011). Learning settings that allow students the time and space to develop strong relationships with peers and adults are critical for student engagement (Grossman et al., 2007) and may enhance in-school academic achievement and improve student well-being (Kuperminc et al., 2019). Additionally, student-centered learning environments that encourage students to explore, experiment, express their ideas, and pursue their interests are found to increase levels of engagement, creative problem-solving, and collaboration (Kaput, 2018).

The Tulsa Regional STEM Alliance (TRSA) aims to amplify the impact of STEM programs and community-based organizations in Tulsa, Oklahoma. TRSA has cultivated a cross-community network of afterschool STEM providers, school systems, professional development organizations, and other stakeholders to increase access to high-quality STEM opportunities for students from all backgrounds (see **Box 1**). The Memorial Middle School (MMS) STEM Program is one program within TRSA that uses a student-centered approach to promote STEM and socioemotional learning.

Memorial Middle School STEM Program

The STEM program at Memorial Middle School aims to increase access to high-quality STEM learning opportunities, deepen understanding of the ways that STEM learning can take place, and create a safe place for students to gather outside of school. The STEM program is made up of three primary learning spaces: the afterschool STEM program, in-school elective course: "Gateway Technology," and summer STEM academy. In this report, we will focus on 2023 Summer STEM Academy data collection and outcomes.

Summer STEM Academy

The Summer STEM Academy is a two-week summer program that incorporates enrichment activities like teambuilding with STEM learning opportunities such as building robots, rockets, and drones (**Figure 1**). Rooted in inclusion and belonging, the MMS summer STEM academy intentionally nurtures a sense of belonging for all students, with a particular focus on students who may not have a safe and supportive place to spend their time over the summer.

Figure 1. Students designing, building, and constructing.

The majority of summer academy STEM learning takes place in a state-of-the-art STEM demonstration lab designed by students for hands-on learning using technologies like drones, 3D printers, a flight simulator, and a small-scale dragster racing track (Memorial Middle School, 2022). During the program, learning is entirely student-led. With access to materials and a supportive environment, students are free to pursue their own ideas, problem solve, and collaborate to design, build, and play. Rather than traditional teaching, the STEM program educators serve as guides that encourage students and push them to persevere in pursuit of their curiosities. Through a student-led inquiry-based approach, students emerge as natural leaders and problem-solvers.

Box 1. Tulsa Regional STEM Alliance (TRSA)

The Tulsa Regional STEM Alliance (TRSA) is an intermediary organization that aims to increase STEM access to close the opportunity gap by providing STEM learning experiences, equipping educators, and cultivating impactful cross-community partnerships. TRSA aims to build innovative and sustainable STEM pathways and "create a pipeline for future careers" (Tulsa Regional STEM Alliance, 2021).

To do so, TRSA works alongside its partner organizations to target Tulsa's STEM ecosystem at three levels: organizations, educators, and students. At the organization level, TRSA is building a cross-sector alliance that streamlines STEM resource sharing and serves as the connective tissue between an array of programs, resources, and services. At the educator level, TRSA provides training and professional development opportunities to strengthen educator capacity and confidence in facilitating high-quality STEM experiences. At the student level, TRSA collaborates with community partners to co-design STEM-related programming and education events.

Data Collection

In Summer 2023, MMS collected data from seventh through nineth grade students that attended the Summer STEM Academy using the Common Instrument Suite – Student Survey (CIS-S).

MMS administered the CIS-S at the end of the program in a Retrospective Self-Change (RSC) format. The CIS-S is a 56-item youth self-report measure of six STEM attitudes (STEM activities, career interest and knowledge, engagement, enjoyment, and identity) and four social-emotional or "21st-century" skills (critical thinking, perseverance, relationships with peers, and relationships with adults) (Allen et al., 2020; Noam et al., 2020; Sneider & Noam, 2019). Items on the CIS-S RSC are rated on a 5-point Likert scale from "Much Less Now" to "Much More Now." Reliabilities for the CIS-S scales are high, ranging from 0.82 to 0.92 across gender and age groups (Price, 2018).

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Table 1. Student Demographics (n = 11)

Variable	Sample size (%)
Gender	
Boys	10 (91%)
Girls	1 (9%)
Grade	
Seventh	6 (55%)
Eighth	3 (27%)
Nineth	2 (18%)
Race/Ethnicity	
African-American, Black	1 (9%)
American Indian, Native-American	1 (9%)
Latino or Hispanic	2 (18%)
White, Caucasian (non-Hispanic)	2 (18%)
Multi-Race	4 (36%)
Prefer to self-describe	1 (9%)
Primary Language	
English	8 (73%)
Non-English	2 (18%)
Prefer not to answer	1 (9%)

Common Instrument Suite Student Survey Findings

Demographics

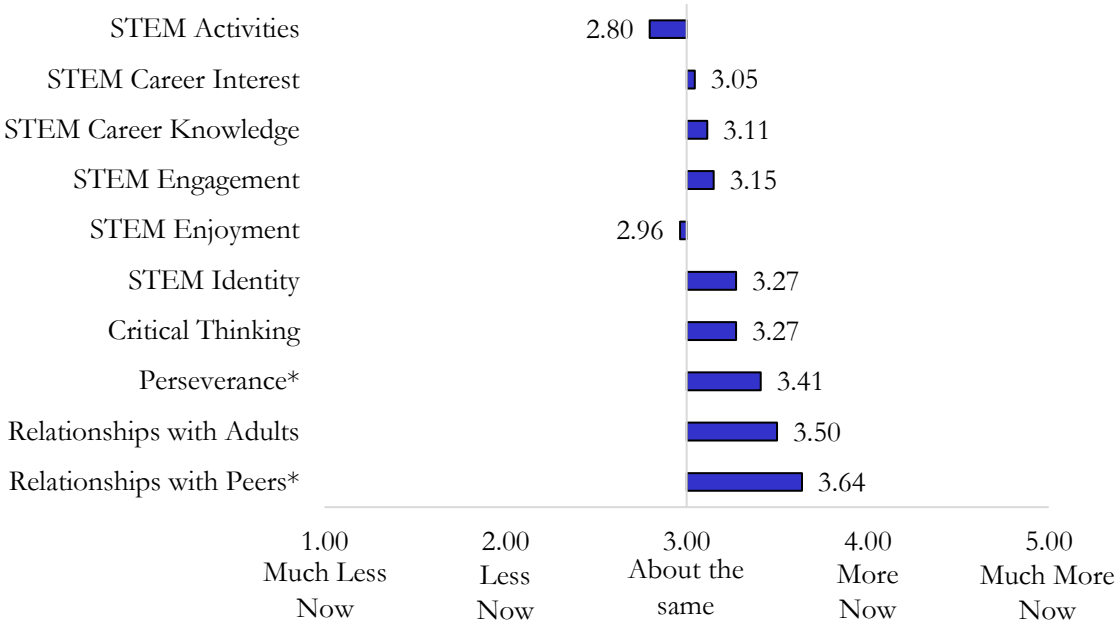
In Summer 2023, 11 Summer STEM Academy students in grades 7-9 completed the CIS-S RSC. **Table 1** reports the demographics of these students. The vast majority (91%) of students were boys. Only one student (9%) in the sample was a girl. Slightly over half of the students in the sample (55%) were in seventh grade, slightly over one quarter (27%) were in eighth grade, and the remaining students (18%) were in nineth grade. The distribution of students' racial and ethnic identities revealed that over one third (36%) of the students identified as more than 1 race (i.e., Multi-Race). Nearly one fifth (18%) identified as Latino or Hispanic and nearly one fifth (18%) identified as White, Caucasian (non-Hispanic). The remaining students identified as African-American, Black (9%), American Indian, Native-American (9%), or preferred to self-describe (9%). Nearly three quarters (73%) of the students spoke English as their primary language at home.

Student Outcomes

Students' average self-change scores for the CIS-S scales were analyzed to see if they differed significantly from 3, a rating of "About the Same." If the *p*-value of a given scale was below 0.05, its mean change score was "statistically significant," meaning the change was unlikely to be due to chance. Mean change scores greater than 3 indicated positive change; scores less than 3 indicated negative change; and those equal to 3 indicated no change.

We analyzed the results of the entire sample using a one-sample *t*-test. Overall, students reported statistically significant positive change (p's ≤ 0.05) on 2 CIS-S scales: perseverance and relationships with peers (**Figure 2**).

Figure 2. MMS Summer STEM Academy (n = 11), Overall CIS-S Results, 2023



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Key Features of the STEM Learning Environment

Figure 3. A student practices flying a drone.

In Fall 2022, we conducted an informal interview with the primary MMS STEM program educator, Abraham Kamara, to better understand the MMS Summer STEM Academy's, and larger STEM Program's, impact on STEM and 21st-century skills outcomes. Throughout the interview, Kamara shared how the MMS STEM program environment contributes to making learning fun, emphasizing that students in the MMS STEM program "become very proud of what they do… [they believe], 'I can contribute, I can help other kids … I matter in society.'" Kamara encourages students to evaluate their own interests and see how STEM fits into them. For example, he may suggest that a student interested in becoming a lawyer lead notetaking for an experiment and report findings to practice clear and concise communication.

Additionally, student voice and choice are key principles interwoven into every branch of the STEM program. Students are encouraged to learn through experimentation, collaboratively problem-solve, and pursue their specific STEM interest areas. For example, when a student expressed interest in flying drones (**Figure 3**), Kamara participated in a drone training so that this student, and many others, could learn more about and practice flying drones. Kamara also intentionally creates opportunities for students to share their knowledge with each other so that students can take on the role of learner and instructor. He may pair a student who enjoys coding with a student who enjoys building so that together they can build and program a robot. This peer-to-peer knowledge sharing not only promotes positive peer relationships but also increases student confidence in their STEM knowledge. As a result of this practice, Kamara's role mostly involves cheerleading and managing: "My job is to push them and encourage them [by saying], 'how can we make this better?'"

Program Impact

Memorial Middle School Summer STEM Academy student data demonstrates how participation in STEM activities increases students' perseverance and relationships with peers. Strong peer and adult relationships are key for student engagement and can support youth in establishing a positive STEM identity (Catalano et al., 2004; Shao & Kang, 2022). Perseverance has been linked to resilience and student well-being as well as long-term success in personal, academic and career goals (Kannangara et al., 2018; Totosy de Zepetnek et al., 2021). Although we did not see significant change on STEM attitudes scales in this sample, research suggests that 21st century skills, like perseverance and relationships, significantly influence STEM knowledge and learning (Han et al., 2021). Therefore, MMS is laying the groundwork for STEM learning through bolstering perseverance and connectedness.

Qualitative data from an interview with the primary STEM program educator highlighted the importance of inclusion, belonging, and student voice to STEM and social-emotional growth. Research suggests that inclusivity and student voice in STEM programs support a sense of belonging which in turn increases STEM engagement and confidence in using STEM to address real-world problems (Mitra, 2004; Mulvey et al., 2022). Through allowing students to take ownership of their learning experience and incorporating student perspective into all meaningful programmatic decisions, the MMS STEM program promotes STEM engagement and 21st-century skill development, and cultivates trusting relationships among students and educators.

Although these findings are valuable, it is important to consider their limitations. Due to the small sample size and lack of diversity across demographic variables (e.g., gender), we were unable to conduct analyses for outcome differences across any demographic variables. Future research efforts should focus on gathering more student data, as well as quantitative educator data and program quality data via observations, to create a deeper understanding of program impact through analyzing and synthesizing multiple perspectives.

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The Memorial Middle School STEM program is a compelling example of how creating a relationship-focused, student-centered learning environment promotes 21st-century skills. Through allowing students to pursue their curiosities, test their ideas, and collaboratively problem-solving, the MMS program is inspiring students to build connections, persist in the face of challenges, and be active participants in their own learning process.

Acknowledgements

We are grateful to TRSA for supporting this report. Thank you to the Memorial Middle School STEM program administrators and facilitators, and the families and young people who participated by completing surveys. We also thank the team at PEAR Inc. for their work in data collection, management, analysis, and reporting.

Learn More

- Visit the Memorial Middle School website
- PEAR's website to learn more about our STEM tools and services

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