

Bridging Gaps in STEM with Science Outreach

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ABSTRACT: Fewer students are pursuing careers in science, technology, engineering, and mathematics (STEM), creating a “leaky pipeline” that hinders innovation, economic progress, and global development. Contributing factors include declining interest and preparedness as students progress from elementary to high school, limited retention through the STEM pipeline, and the underrepresentation of historically marginalized groups pursuing STEM careers. To address these challenges and gaps in STEM, Think Like a Scientist (TLaS), a STEM educational outreach program for elementary-aged students surrounding the University of Colorado Anschutz in Aurora, Colorado, was developed. TLaS provides free STEM exposure, fosters development of science skills, and makes science accessible and enjoyable for elementary-aged students through interactive lessons and hands-on experiments. Data collected from post-pre surveys reveal positive responses, suggesting that interactive and active learning enhances student engagement and supports program effectiveness. Thus, TLaS serves as a model for a successful STEM educational outreach program. TLaS underscores the impact of elementary STEM engagement in fostering a future generation of scientists and its contribution to the scientific community’s ongoing efforts to increase access and representation in STEM.

INTRODUCTION

Lack of Interest in STEM. Despite showing early curiosity, the number of students interested in pursuing careers in science, technology, engineering, and mathematics (STEM) continues to decrease internationally (Archer & DeWitt, 2016; Organisation for Economic Co-operation and Development (OECD), 2016, 2019). Although pre-adolescent students find science interesting and enjoyable, many disengage when science courses are no longer required beyond secondary education (Archer Ker, 2013; DeWitt et al., 2013; National Academy of Sciences: Committee on Science Engineering and Public Policy, 2005; Treasury, 2006; Ward, 2015). As students enter adolescence, their science self-efficacy—defined as the belief in one’s ability to successfully complete scientific activities—diminishes, reducing their interest in pursuing STEM careers (Archer, 2020; Carroll et al., 2024). By high school, generating interest in STEM

may be too late, as beliefs about science are less malleable in adolescence (Carroll et al., 2024). By the undergraduate level, the fast pace and heavy content load of science courses further discourage the pursuit of STEM (Musgrove et al., 2024). This trend is compounded by the consistent decline in student performance across all levels of STEM education (DeWitt et al., 2013; Ward, 2015).

Low engagement in STEM may also arise from negative perceptions of science. Popular culture and social constructs often portray scientists through a narrow stereotype: an isolated white male wearing a lab coat with goggles or glasses, creating chemical explosions in a laboratory (Brumovska et al., 2022; DeWitt et al., 2013; Dickson & McMinn, 2022). Exposure to this stereotype is unavoidable in early childhood because of its prevalence in mass media. It shapes children’s perception of scientists, influencing their motivation

to pursue STEM education and careers. Consequently, students' own perception of scientists begins to replicate societal stereotypes, reinforcing rather than challenging existing constructs.

Lack of Representation in STEM. The negative stereotype of scientists contributes to dwindling numbers of historically underrepresented groups (HUGs) in STEM (Marshall et al., 2024). HUGs include cultural identities whose representation in STEM education and employment is lower than their representation in the United States (U.S.) population, including Blacks/African Americans, Hispanics/Latinos, and American Indians/Alaska Natives (National Center for Science and Engineering Statistics (NCSES), 2023). Although representation among healthcare providers has modestly improved to address health disparities, it still lags behind national demographics (Johnson & Bozeman, 2012). In 2021, fewer than 6% of practicing licensed physicians identified as Latino, compared to 27% in the U.S. population (Lucero et al., 2021). As the U.S. Census Bureau estimates continued growth in minority populations within the U.S., this discrepancy in STEM will likely widen (Johnson & Bozeman, 2012).

The below-average representation of HUGs in STEM contributes to the “leaky pipeline” as they are more likely to leave STEM fields than their peers (Lin et al., 2023). Further, HUGs experience higher dropout rates and earn fewer STEM degrees than their peers; in 2019, only 16% of HUGs entering college planned to major in STEM, and only 8.7% of Black/African American students and 16.3% of Hispanic/Latino students earned a bachelor's degree in STEM. Fewer than 10% of those graduates later pursued doctoral degrees (Schwartz et al., 2020). That same year, HUGs comprised only 11.7% of U.S. STEM research doctorates; just 5.1% of the STEM workforce were Black/African Americans and 7.6% were Hispanic/Latinos, respectively (Anfuso et al., 2022; National Science Board, 2022).

Barriers That Contribute to the “Leaky Pipeline” in STEM. Underrepresentation in STEM resides in educational and societal inequities. HUGs more frequently face overlapping barriers that impact their self-expectations and beliefs in STEM such as living in low-income communities disproportionately affected by physical, socioeconomic, and psychosocial barriers (Chuisano et al., 2023). These barriers include English language learning, limited academic preparation, lack of or failure to complete advanced courses, poverty, and a lack of role models in STEM (Johnson & Bozeman, 2012). Restricted access to resources and opportunities further disadvantages these students (Rocha et al., 2022). In low-income districts, science curricula are often neglected or reduced to focus on state testing standards, limiting exposure to STEM education (Dizbay-Onat & Wyss, 2018; Duo-

du et al., 2017; National Girls Collaborative Project, 2024). Limited access to quality STEM programs can make science appear difficult and unattainable, weakening connections between STEM education and future careers (Clark, 1996; Phelan et al., 2022). These barriers leave students with few opportunities to form STEM identities, which often leads to them losing interest and persistence in STEM despite academic potential (Johnson & Bozeman, 2012; Marshall et al., 2024). Thus, these cumulative barriers highlight the critical need for the scientific community to respond to the demands to increase access for all (Johnson & Bozeman, 2012).

Global Impact. Decreased interest in STEM is problematic given society's reliance on STEM industries for local and global economic growth and development (Brumovska et al., 2022; Johnson & Bozeman, 2012). In addition, multidisciplinary scientific teams drive innovation by combining unique experiences, perspectives, and approaches, highlighting the importance of increasing representation in scientific teams to enhance innovation, collaboration, and productivity (Johnson & Bozeman, 2012). Moreover, increasing scientific interest and literacy could empower the public to make better, more informed decisions related to health, their communities, and the environment (Archer & DeWitt, 2016).

Community Outreach in STEM as a Solution. Since 2000, STEM educational outreach programs have aimed to increase access to STEM and overcome persisting STEM stereotypes (Chuisano et al., 2023; Clark, 1996; Crews et al., 2020; Drazan, 2020; Duodu et al., 2017; Hartley et al., 2019; Kirchhoff et al., 2022; Krecko & Jung, 2022; Lin et al., 2023; Marshall et al., 2024; Omoijuanfo et al., 2022; Phelan et al., 2022; Reynolds et al., 2018; Riggs et al., 2019; Rocha et al., 2022; Rodriguez et al., 2018; San Miguel et al., 2019; Santoso et al., 2021; Schiefer et al., 2020; Schwartz et al., 2020; Toledo et al., 2020; Ward, 2015; Zucker et al., 2022). These programs address STEM imbalances by recruiting and retaining underrepresented students while simultaneously creating supportive and inclusive learning environments (Krecko & Jung, 2022; Marshall et al., 2022). They are crucial in low socioeconomic areas experiencing limitations to STEM accessibility and affordability, and have been shown to increase science participation, interest, knowledge, confidence, and literacy (Drazan, 2020; Santoso et al., 2021; Toledo et al., 2020). By fostering connections between scientists and participants, these programs also strengthen community trust in science, and encourage all participants to consider STEM careers, ultimately increasing representation in STEM (Santoso et al., 2021).

For example, a Canadian research team launched the first community-based STEM program in Ontario, Canada where low socioeconomic status correlated with underachievement in STEM education (Duodu et al., 2017). To minimize bar-

riers and maximize participation, the team provided a free, weekly STEM educational outreach program for low-income and marginalized students. Organized in recreational and communal spaces outside of school hours, the program created a relaxed and experiential learning environment that established a positive relationship with the community and correlated with improved academic achievements and graduation rates (Duodu et al., 2017). This example illustrates the transformative power of community-based STEM outreach.

Although many STEM educational outreach programs are successful, they often face limitations. Many are not free or open to the public, do not specifically target underrepresented groups, and/or rely on external incentives such as rewards or payments, which attract participants with non-intrinsic motivations and may not promote long-term retention. Additionally, most programs focus on older students, neglecting the formative years of elementary school and missing a critical opportunity to shape children's interests, beliefs, and attitudes toward STEM. Research shows that even when young students find science challenging, they still enjoy and value it (Carroll et al., 2024; DeWitt et al., 2013). Children as young as eight recognize the importance of science, suggesting that interest in science can be cultivated early (Schiefer et al., 2020). Because beliefs and attitudes toward science solidify by secondary school, elementary STEM exposure is crucial for fostering lasting interest (Wai, 2010).

Think Like a Scientist (TLaS) STEM Educational Outreach Program to Address STEM Gap. The majority of students in the Aurora Public School (APS) district in Aurora, Colorado qualify for the Free and Reduced Lunch (FRL) Program, reflecting the district's low socioeconomic status (Aurora Public Schools, 2022). Many APS schools consistently underperform on standardized state testing and, as a result, have completely or partially removed science curricula to focus on increasing state math and literacy test scores, as has been seen at the national level (Dizbay-Onat & Wyss, 2018; Duodu et al., 2017; National Girls Collaborative Project, 2024). This reduction or removal of science education deprives students of acquiring a foundational understanding of STEM. To address this gap, Think Like a Scientist (TLaS) was established as a STEM educational outreach program to serve elementary schools near the University of Colorado Anschutz (CU Anschutz) in Aurora, Colorado. TLaS is a non-profit, volunteer-run, after-school program offered free of charge to fourth- and fifth-grade students.

The mission of TLaS is to invest in elementary education to empower the next generation of scientists by sparking interest in science, cultivating skill development, and making science accessible and enjoyable through interactive lessons and hands-on experiments (Figure 1). The program fosters active learning, critical thinking, and curiosity—en-

couraging student participants to “think like a scientist.” It also advocates for STEM outreach, inspires community engagement, and highlights CU Anschutz's role as a hub of discovery and education, rather than solely a clinical center. By connecting students with an array of volunteer STEM professionals, TLaS emphasizes that anyone can pursue a science career. It also offers volunteers the opportunity for outreach and teaching experience. Ultimately, TLaS enables student participants to envision themselves as future scientists and serves as a model for a successful STEM educational outreach program in an under-resourced and low socioeconomic community, providing a framework to guide similar initiatives nationwide.

The aim of this study is to evaluate the efficacy of TLaS in achieving its defined goals and core values (Figure 1). Specifically, the study examines whether TLaS addresses the STEM educational gap in partnering schools, assesses its impact on student participants, volunteers, and the surrounding community, and informs program improvements.



Figure 1. Core Values of Think Like a Scientist. Graphic representing the core values integrated into the mission of the TLaS educational outreach program. The central hexagon represents TLaS as the core, while surrounding hexagons radiate outwards to highlight the program's impact within the community. Starting at the top and moving clockwise, the hexagons represent the aims to provide education in foundational science concepts and inspire student participants to pursue STEM; to support the community; to humanize science through exposure to real scientists that work side-by-side with student participants; to support accessibility and remove barriers to science education; to make science fun through experiments, activities and lessons; and to engage student participants from a range of backgrounds to increase representation in STEM.

METHODS

Partnering School Classification. TLaS partners with four Title I elementary schools in Aurora, Colorado: Boston P-8 School, Crawford Elementary School, Elkhart Elementary School, and Paris Elementary School. Schools with Title I classification receive federal funding to improve education and ensure equal opportunities to increase proficiency on state academic standards and assessments (Aurora Public Schools, 2024; Colorado Department of Education [CDE], 2025). These funds specifically support students at risk of not meeting state academic standards or English language proficiency benchmarks. Students in the schools that TLaS serves are primarily underrepresented, low-income, and underperforming on state assessments, which motivated TLaS to partner with these schools.

Curriculum. TLaS offers a six-week program with weekly 90-minute sessions featuring interactive science lessons and hands-on experiments designed for fourth- and fifth-grade students (Table 1). Before each session, volunteers prepare materials and snacks, then sit with student participants to interact and establish a connection. A typical group size is 15–20 students, with an approximate 2:1 student participant-to-volunteer ratio. Sessions begin with a “Meet the Scientist” segment where volunteers present a brief introduction slide and answer both science-related and personal questions (e.g., favorite animal or food, pet names). This activity supports the program’s belief that anyone can be a scientist by humanizing volunteer scientists.

Each lesson begins with a guiding question and a re-

al-world problem. Presentations are led by a former middle school science teacher who now works at CU Anschutz and volunteers with TLaS. Interactive, lecture-based lessons foster student participant engagement and inquiry, creating an active, student-centered learning environment. The first four lessons of the six-week program combine direct instruction with an experiment. Given the limited exposure to science in partnering schools, lessons focus on foundational scientific principles and foster exploration, curiosity, and enjoyment of science rather than content-heavy instruction. Weekly topics introduce core science concepts: definition of science (week 1), scientific method (week 2), experimental design (week 3), spotting fake news (week 4), creativity, collaboration, and communication in science (week 5), and science communication (week 6). Each topic is paired with an activity—jellybean taste test (week 1), lemon volcano (week 2), crazy sandwich recipe (week 3), exploding ‘ninja star’ (week 4), design a poster (week 5), and present a poster (week 6) (Table 1). Importantly, TLaS pedagogy and content were intentionally designed for this community rather than retrofitted and were developed in direct response to the community’s educational needs.

After the presentation, the leader provides a detailed, step-by-step explanation of the experiment. Student participants formulate hypotheses and pose research questions prior to conducting experiments. They record their questions and hypotheses in a provided folder containing lesson and experiment materials. Student participants then divide into small groups to perform the experiment with volunteers providing guidance as needed. Through these experiments, student participants practice core components of the scientific method: asking questions, crafting hypotheses, writing protocols, executing investigations, collecting and recording data, and drawing conclusions. Volunteers can also support student participants who wish to explore questions beyond the lesson plan, fostering dynamic inquiry that generates science enthusiasm and curiosity. Each session ends with a group discussion led by the instructor to debrief outcomes, conclusions, and key takeaways.

During the final two lessons of the six-week program, student participants work collaboratively in pairs to create a poster showcasing their favorite experiment (Figure 2). Pairs orally present their poster to invited friends and family on the last day of the program, where student participants learn to communicate science to non-scientists while building confidence in taking on the role of a scientist. Each student participant receives a certificate of completion and a photo of themselves wearing a lab coat as a reminder that anyone can become a scientist. Altogether, the curriculum encourages the student participants to “think like a scientist” through engaging, creative, and exciting science activities. The TLaS curriculum is publicly available on the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) open education resource.

Table 1. Lesson Plans, Experiments, and Learning Objectives for Think Like a Scientist.

Lesson Plan	Experiment	Learning Objectives
What is science?	Jellybean Taste Test (olfactory senses)	- Define science - Identify different kinds of science
The Scientific Method	Lemon Volcanoes (chemistry)	- Explain the scientific method - List the steps of the scientific method
Experimental Design	Crazy Sandwiches (scientific method)	- Explain the process of experimental design - Describe the importance of detail
Fact or Fake? How to Spot Fake News!	Exploding ‘Ninja Star’ Popsicle Sticks (potential and kinetic energy)	- Differentiate between facts and fake news - Describe the importance of truth - Kinetic and potential energy
Creativity, Collaboration, and Communication	Poster Design (collaboration, creativity)	- Collaborate with student colleagues - Create a poster
Science Poster Presentation and Celebration	Poster Presentations (communication)	- Communicate science through a poster - Celebrate accomplishments

Weekly lesson plans (column 1) are followed by a hands-on experiment (column 2), connected to the lesson, and aligned with specific learning objectives (column 3).

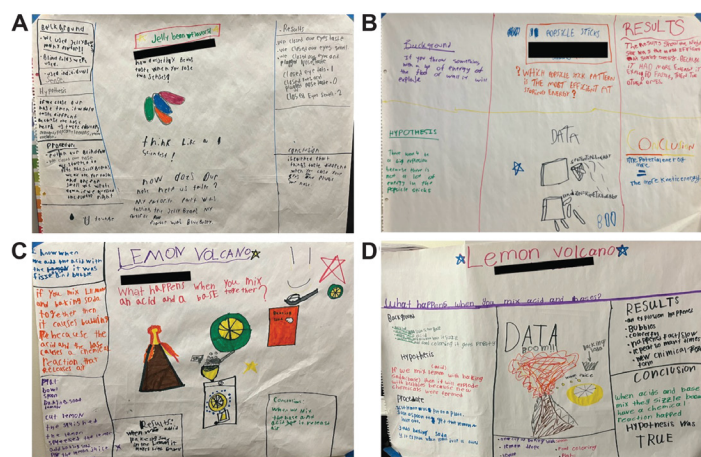


Figure 2. Examples of Think Like a Scientist Student Participant Posters. Representative posters created by student participant pairs showcasing their favorite experiment during TLaS. **A.** Poster about the jellybean taste test from Lesson 1 (What is science?) Experiment 1 (olfactory senses). **B.** Poster about the exploding ‘ninja stars’ popsicle sticks from Lesson 4 (Fact or Fake? How to Spot Fake News!) Experiment 4 (potential and kinetic energy). **C.** and **D.** Posters about the lemon volcano from Lesson 2 (The Scientific Method) Experiment 2 (chemistry). Names have been obscured to protect student participants’ identities.

TLaS Lessons Align with State Standards. The Colorado Measures of Academic Success (CMAS) assessment evaluates literacy and mathematics, but not science. These scores are used to determine a school’s annual progress and performance rating (CDE, 2024). Although this is an imperfect metric for student success, schools must decide between retaining science instruction or reallocating limited time and resources toward literacy and mathematics requirements. To increase CMAS scores, schools often respond by partially or completely removing science curriculum. This issue is evident in TLaS partner schools Boston P-8, Crawford Elementary, and Paris Elementary, which did not meet expectations in literacy and mathematics during the 2020–2021 and 2021–2022 school years (Figure 3; Appendix A, Table A1) (CDE, 2024). It is important to note that this reduction in science instruction reflects systemic constraints rather than a lack of commitment to student success. As such, TLaS serves as the only science instruction many student participants receive prior to middle school, filling a critical gap in early STEM education in these schools.

To address this need, TLaS provides instruction and activities that directly align across three branches of the Colorado Academic Standards: 3rd-5th grade Colorado Reading, Writing, and Communicating Standards, 3rd-5th grade Colo-

2022 CMAS Scores	Math Rating	Math Growth	Literacy Rating	Literacy Growth
Crawford	Does not Meet Expectations	Approaching Expectations	Does not meet expectations	Approaching Expectations
Paris	Does not Meet Expectations	Approaching Expectations	Does not Meet Expectations	Does not Meet Expectations
Boston*	Does not Meet Expectations	Insufficient Data	Does not Meet Expectations	Approaching Expectations
2023 CMAS Scores	Math Rating	Math Growth	Literacy Rating	Literacy Growth
Crawford	Does not Meet Expectations	Meets Expectations	Does not meet expectations	Approaching Expectations ^γ
Paris	Does not Meet Expectations	Approaching Expectations	Does not Meet Expectations	Approaching Expectations
Boston*	Does not Meet Expectations	Meets Expectations	Does not Meet Expectations	Approaching Expectations

Figure 3. Colorado Measures of Academic Success Scores for Think Like a Scientist Partnering Schools. The Colorado Measures of Academic Success (CMAS) scores range from 650 to 850 and represent the degree to which a student is considered academically prepared and on track or whether they will need additional academic support to succeed in the content area measured. Lower scores indicate a greater need for academic support and intervention to ensure future success. CMAS scores are ranked as follows: Does Not Meet Expectations = 650.0 – 722.2; Approaching Expectations = 722.3 – 739.4; Meets Expectations = 739.5 – 755.8; Exceeds Expectations = 755.9 – 850.0. All data presented are based on the 2021–2022 and 2022–2023 school years and were collected from the Colorado Department of Education website. *Boston is a P-8 school. ^γEnglish language learners’ scores met expectations.

Table 2a. Alignment of Think Like a Scientist Experiments with Colorado State Standards.

Experiment & Hands-on Activities	Content Standard Code and State Aligned Standards	CESSEP ¹	Literacy Standards
Week 1. Jellybean Taste Test	SC.MS.2.4 Sensory Receptors and the brain	SEP 1 SEP 3 SEP 4 SEP 6	RW.5.4.1 Professional Skills, Information Literacy
Week 2. Lemon Volcanoes	NA ²	SEP 1 SEP 2 SEP 3 SEP 6	RW.5.4.1 Professional Skills, Information Literacy
Week 3. Crazy Sandwich		SEP 1 SEP 3 SEP 6	RW.5.4.1 Professional Skills, Information Literacy
Week 4. Exploding Popsicle Sticks	SC.MS.1.5 Kinetic and Potential Energy	SEP 3 SEP 6 SEP 7 SEP 8	RW.5.4.1 Professional Skills, Information Literacy
Weeks 5-6. Poster Creation & Communication		SEP 4 SEP 6 SEP 7 SEP 8	RW.4.4.1 Short research projects through investigation

TLaS experiments align with third to fifth grade Colorado Science Standards, third to fifth grade Colorado Reading, Writing, and Communicating Standards, and sixth to eighth grade Colorado Science Standards. ¹Colorado Essential Skills and Science and Engineering Practices (CESSEP); ²Content areas discussing chemistry are not defined at the Elementary or Middle School level.

rado Science Standards, and 6th-8th grade Colorado Science Standards (CDE, 2020). By aligning with these standards, TLaS ensures that student participants meet grade-level expectations while acquiring the foundational knowledge and inquiry skills essential for future success. The Colorado Science Standards are organized into three categories: Academic Content, Science and Engineering Practices (SEP), and Cross Cutting Concepts (CDE, 2020). The Academic Content category provides the factual knowledge such as scientific vocabulary, laws of nature, and data. The SEP category addresses how students engage with science, developing skills for experimental design. The Cross Cutting Concepts category emphasizes broader, unifying themes like pattern recognition and cause-and-effect relationships. Each TLaS lesson and accompanying experiment integrates all three of these categories. This provides student participants with comprehensive, skill-based learning that builds confidence in their scientific abilities and a deeper understanding of scientific concepts.

At the 3rd-5th grade level, the development of SEP skills represents the highest learning target since these skills are foundational to all subsequent science classes independent of content. Students who do not acquire these skills early often struggle to comprehend science in later grades. To address SEP skill building, TLaS includes hands-on experiments in every lesson by guiding students through the development of hypotheses, data collection, analysis, and interpretation and fostering the habits characteristic of scientific inquiry. Moreover, TLaS curriculum introduces content at the 6th-8th grade level, which challenges 4th-5th grade student par-

ticipants to promote academic growth and inquiry beyond grade-level expectations (Table 2).

TLaS also aligns closely with the 3rd-5th grade Colorado Reading, Writing, and Communicating Standards. Through science instruction, student participants additionally practice literacy competencies such as reading comprehension, scientific writing, and oral communication. The final two lessons, in which students create and present a science poster, exemplify fourth-grade literacy objectives requiring students to plan, write, and present information using both text and visual components. By working collaboratively in pairs, students learn to structure scientific arguments, explain results to non-scientific audiences, and develop presentation skills critical to success across all academic disciplines. By integrating science with literacy and mathematics via active learning, TLaS not only complements CMAS objectives but also reinforces the intersection of these subjects.

Table 2b. Listing of Science and Engineering Practices.

Science and Engineering Practices (SEP)
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Volunteer Recruitment and Training. TLaS volunteers are recruited from CU Anschutz through campus-wide email listservs, online sign-ups, and posted flyers. CU Anschutz encompasses an array of professional schools – medical, dental, physician assistant, public health, nursing, pharmacy and graduate school – resulting in a multidisciplinary volunteer base composed of students, staff, and faculty. The range of backgrounds enhances the program’s ability to represent a broad spectrum of scientific careers and support widespread engagement.

Volunteer training materials are intentionally designed to meet the needs of the community and prepare volunteers to engage effectively with elementary-aged student participants. In accordance, TLaS provides two training videos: *Implicit Bias Training* and *Volunteer Overview*. *Implicit Bias Training* is a 37-minute YouTube video created by a former TLaS medical student leader in collaboration with an elementary teacher and Community School Coordinators. The video defines implicit bias, explains its influence on classroom dynamics and decision-making, and offers strategies to cultivate a culturally responsive, inclusive classroom environment. *Volunteer Overview* is a 12-minute YouTube video created by a different former TLaS medical student leader. This video introduces the TLaS mission, outlines the structure of a TLaS session, and reviews volunteer roles and responsibilities. Video lengths are brief to ensure that volunteers can complete the training in under one hour, addressing a previously identified barrier of limited volunteer participation due to time constraints for in-person training. All training materials (training videos, volunteer code of conduct, general expectations, lesson plans, experiment worksheets, and accompanying YouTube experiment demonstration videos) are emailed to volunteers at least one week prior to their volunteer session (Appendix A, Figure A1). These materials are also included in the calendar invite sent several weeks in advance to volunteers.

In addition, volunteers are required to create a “Meet the Scientist” introduction slide of their science using accessible language, images, and engaging personal details. This requires volunteers to break down their complex science into terms appropriate for elementary-aged students, which enhances volunteer science communication skills. It also humanizes scientists to the student participants, reinforcing the program’s core message that anyone can be a scientist.

Data Collection. Data were collected from student participants using anonymous, printed post-pre surveys evaluating program experience, impact, and effectiveness (Appendix A, Figure A2). The surveys were designed to use a set of identical questions asked about two points in time. Student participants answered what they now thought about a topic after completion of the program and what they believed they thought about the same topic before the program (Geldhof

et al., 2018). The survey was designed by a former TLaS leader who was previously a middle school science teacher with five years of experience before enrolling in medical school. Questions were intended to assess the program’s effectiveness in achieving its goals and gather feedback for future program improvement. To ensure accessibility and eliminate technological barriers, surveys were administered on paper. Surveys assessed student participants’ attitudes, beliefs, and confidence related to science before and after participation in TLaS. The first four questions used a Likert-scale (1–10) and asked: (1) How exciting do you think science is?, (2) How much would you say you know about the scientific method?, (3) How confident are you to make an experiment to test a question?, and (4) How easily do you see yourself becoming a scientist one day?. The survey offered six free-response questions for program improvement. Surveys were administered on the final day of the program, and data reflect matched pairs from the same student participant. Since its commencement in 2018, TLaS has served approximately 200 students. Surveys were incorporated two years after initiation, with data collected from winter 2020 to spring 2024. The analyses included 76 completed surveys from six cohorts of fourth- and fifth-grade student participants across four partnering schools: one at Boston P-8, two at Crawford Elementary, two at Paris Elementary, and one at Elkhart Elementary (Table 3). Data here reflects only surveys that were completed and legible. Surveys were excluded for incomplete program participation, illegible handwriting, or language barriers. Additionally, because student participants were not required to answer all survey questions, the total number of responses varied for each question. Student demographic information was collected from the APS website and partner school performance data was collected from the Colorado Department of Education website (Aurora Public Schools, 2022; CDE, 2024). Data for Elkhart Elementary School was unavailable.

Volunteers were emailed a voluntary, anonymous survey in Google Forms the day after their session (Appendix A, Figure A3). This survey assessed volunteers’ perceptions of program effectiveness and overall experience. Volunteers could select whether they strongly agreed, somewhat agreed, somewhat disagreed, strongly disagreed, were neu-

Table 3. Number of Completed Post-Pre Surveys From Each Partnering School.

School	Year	Number of completed surveys
Boston*	Spring 2024	12
Crawford	Spring 2023	15
Crawford	Fall 2022	15
Paris	Spring 2022	10
Paris	Fall 2021	9
Elkhart	Winter 2020	15

*Boston is a P-8 school.

tral, or not applicable (NA) with each statement. Additional and optional open-ended questions were offered for program improvement. Because survey questions were optional, the total number of responses varied for each question. Since 2018, more than 250 volunteers have participated in TLaS. The data reported here represents 90 unique volunteer responses with duplicates removed. As data were collected over multiple cohorts, volunteers represented here may have interacted with the same student participants, though not necessarily all 76 student participants. Volunteer demographic information was collected through TLaS registration forms containing optional demographic-related questions. Similar to the volunteer survey, Community School Coordinators were emailed an end-of-program survey to collect feedback from the school administration perspective (Appendix A, Figure A4).

Student participants and volunteers were informed that participation in the survey was voluntary. Prior to initiating data collection, the University of Colorado Institutional Review Board deemed the evaluation exempt, classifying it as program evaluation rather than human subject research.

Data Analysis. All graphs were generated using custom R code primarily with Tidyverse v2.0.0 and ggplot2 v3.5.1 libraries and executed in R version 4.4.1. For student participant survey data, a paired Wilcoxon test was used to determine statistical significance of data collected from the same individual. Data were adjusted for multiple comparisons among all student participant survey questions using a Bonferroni correction. Data distributions were visualized using box plots displaying the median, interquartile range, and minimum and maximum values. Any missing responses for a survey question were removed from the analysis, resulting in different sample sizes across graphs. For the volunteer demographics, the sample size exceeds the number of individual respondents, reflecting volunteers who identified with more than one group. All data are available in Supplementary Files 1-8 (Appendix B).

RESULTS

Student Demographics at *Think Like a Scientist* Partnering Elementary Schools. Publicly available data for the 2022-2023 academic year show that TLaS partnering schools serve a student population with a broad range of backgrounds. Across TLaS partnering schools, an average of 94.3% of students identified as belonging to an underrepresented background, with a nearly equal distribution of 50.6% male and 49.4% female students (Figure 4 and data not shown) (Aurora Public Schools, 2022). On average, the majority of students are non-white with 67% of students identifying as Hispanic, 14.6% as African American, 6.6% as Asian, 4.8% as White, 1.4% as American Indian or Native

Alaskan, 1% as Pacific Islander, and 3.2% as two or more races (Aurora Public Schools, 2022). As many as 28 primary languages (including English) were spoken at home among students and their families, reflecting the broad cultural and linguistic composition of APS (Figure 4) (Aurora Public Schools, 2022). Approximately 93% of students at partnering schools come from low-income households, as defined by Federal Poverty Guidelines (Figure 4) (Health Insurance Marketplace, 2024). According to the U.S. Department of Health and Human Services, families at or below 130% of the Federal Poverty Level qualify for the U.S. Child FRL Program, which provides nutritious meals to these students (Toossi, 2024). In accordance with this measure, the majority of students at Crawford Elementary (92.6%), Boston P-8 (92.6%), and Paris Elementary (94.4%) were enrolled in the FRL Program in 2023 (Figure 4) (Aurora Public Schools, 2022). Overall, students in TLaS partnering schools represent the cultural, linguistic, and socioeconomic characteristics of Aurora, Colorado, and are classified as historically underrepresented in STEM.

To address the range of student backgrounds, TLaS has adopted culturally responsive teaching strategies to meet varied needs. For example, lessons may include multilingual volunteers or publicly available translation tools like Google Translate. TLaS directly addresses the STEM educational gap in partnering schools by providing programming to an economically disadvantaged and underrepresented population. In doing so, TLaS advocates the need for broader representation in STEM. Therefore, TLaS strives to create an accessible learning environment, break current stereotypes, and increase STEM representation to meet the program's core mission to engage student participants from a wide range of backgrounds (Figure 1).

Student Participant Survey Responses. TLaS assessed its impact through anonymous, voluntary post-pre surveys distributed to student participants on the final day of the program across four partnering schools (Boston P-8, Crawford, Elkhart, and Paris) in Aurora, Colorado from winter 2020 to spring 2024. To determine program effectiveness in achieving learning outcomes, the survey compared student participants' attitudes and beliefs about science before and after the six-week program, using a Likert scale from 1 to 10, with 1 being the poorest and 10 the best. All student participants reported significantly higher Likert scale scores after program completion in every evaluation category. Knowledge of scientific method increased from a median of 5 to 8 ($p < .001$, $n = 74$), confidence of experimental design increased from a median of 5 to 10 ($p < .001$, $n = 76$), and interest in a science-related career increased from a median of 5 to 9 ($p < .001$, $n = 76$). Notably, all student participants reported high interest in science after the program, with a median score of 10 ($p < .001$, $n = 75$) (Figure 5). All survey questions showed

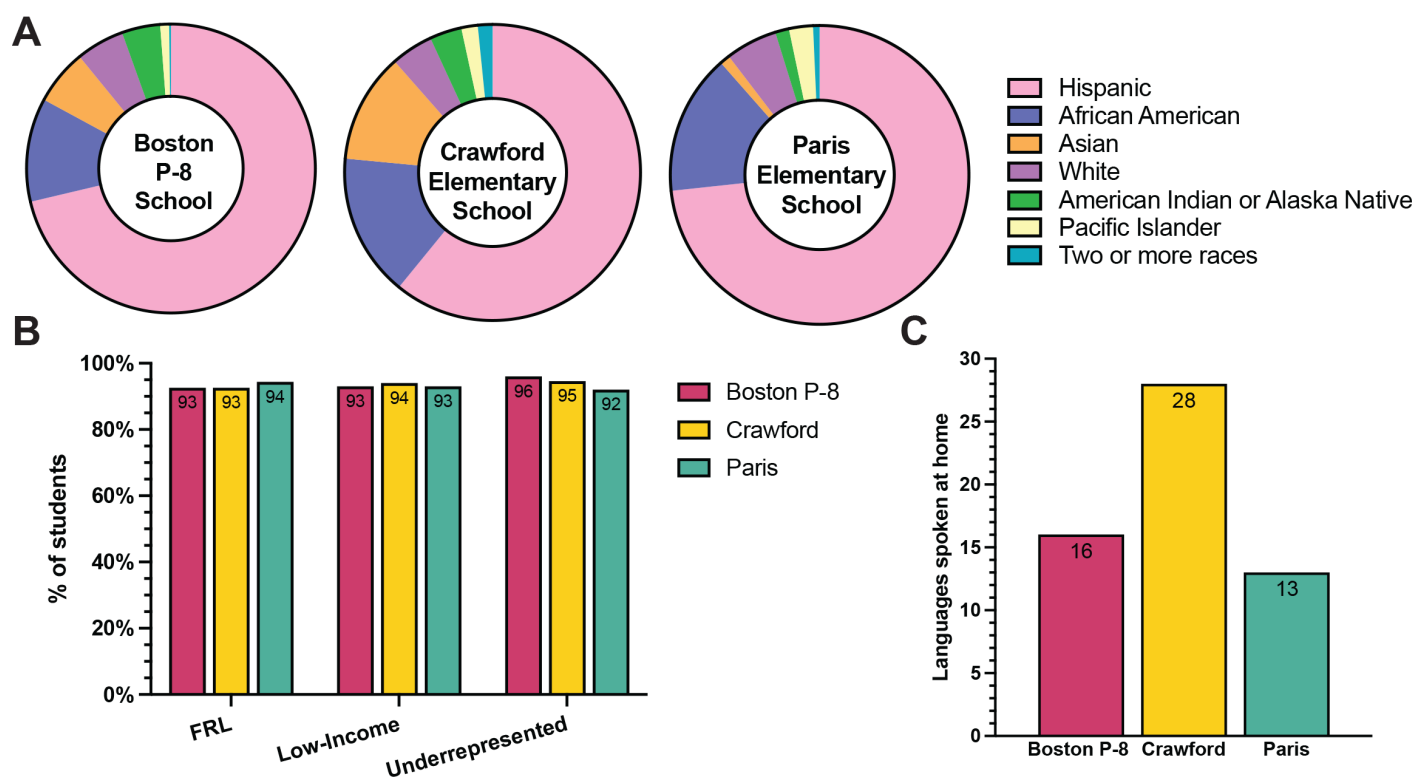


Figure 4. Demographic Characteristics of Students at Think Like a Scientist Partnering Schools. **A.** Donut charts representing the demographic composition of student populations in each TLaS partner school, where Hispanic and Black/African American identities represent the majority. **B.** Bar graph depicting the percentage of students at each TLaS partnering school that are eligible for the Free and Reduced Lunch (FRL) Program, meet the criteria for low-income households, and meet the criteria for underrepresented backgrounds in STEM. Numbers within bars indicate the total percentage of students at each school. **C.** Bar graph depicting the number of languages spoken at home by students in partnering schools. Numbers within bars indicate the total number of languages spoken at home at each school. $N = 1107$.

statistically significant improvements from before to after completion of TLaS (paired Wilcoxon signed-rank tests, $p < 0.05$), with consistently large effect sizes ($r \approx 0.75\text{--}0.80$) (Appendix A, Table A2). These findings indicate that student participants reported their science interest, knowledge, and confidence improved through TLaS. Thus, the program fosters scientific curiosity and self-confidence while promoting engagement in science. As a testament to this, a Crawford Elementary student participant exclaimed, “*I have so much fun in the science clubs. I love that I can take science ideas home with me and share with my family what I learned.*” Overall, TLaS is achieving its goals of inspiring students to consider STEM careers and making science engaging and enjoyable (Figure 1).

Volunteer Demographics. Volunteer survey results indicate that 62.76% are between the ages of 18 and 29 and 74.49% identify as female (Figure 6). Further, 50.51% were students, 26.53% staff, and 11.73% faculty at CU Anschutz (Figure 6). These findings demonstrate that TLaS volunteers are mainly young, female students, with representation across a range of roles, backgrounds and scientific disciplines. TLaS hu-

manizes science by connecting student participants to scientists who share their research and personal life stories, portraying the scientist as more approachable. In this way, TLaS illustrates that STEM is achievable for anyone (Figure 1).

Volunteer Survey Responses. Volunteer survey data further evaluated how effectively TLaS meets its goals and core values (Figure 1). Consistent with the student participant survey results, most volunteers strongly agreed that TLaS fosters a positive learning environment and positive representation of science for student participants (91.9% and 86.5%, respectively). All volunteers either strongly agreed or somewhat agreed that TLaS exposes student participants to science through hands-on activities that make science approachable and enjoyable. Moreover, 86.8% of volunteers strongly agreed that TLaS enhanced their professional experience (Figure 7). This suggests that the program not only benefits student participants but also enhances the professional and personal development of its volunteers. Thus, TLaS is a valuable experience for all involved. This finding is comparable to a similar study where volunteers gained communication, leadership, and professional skills (Toledo et al., 2020).

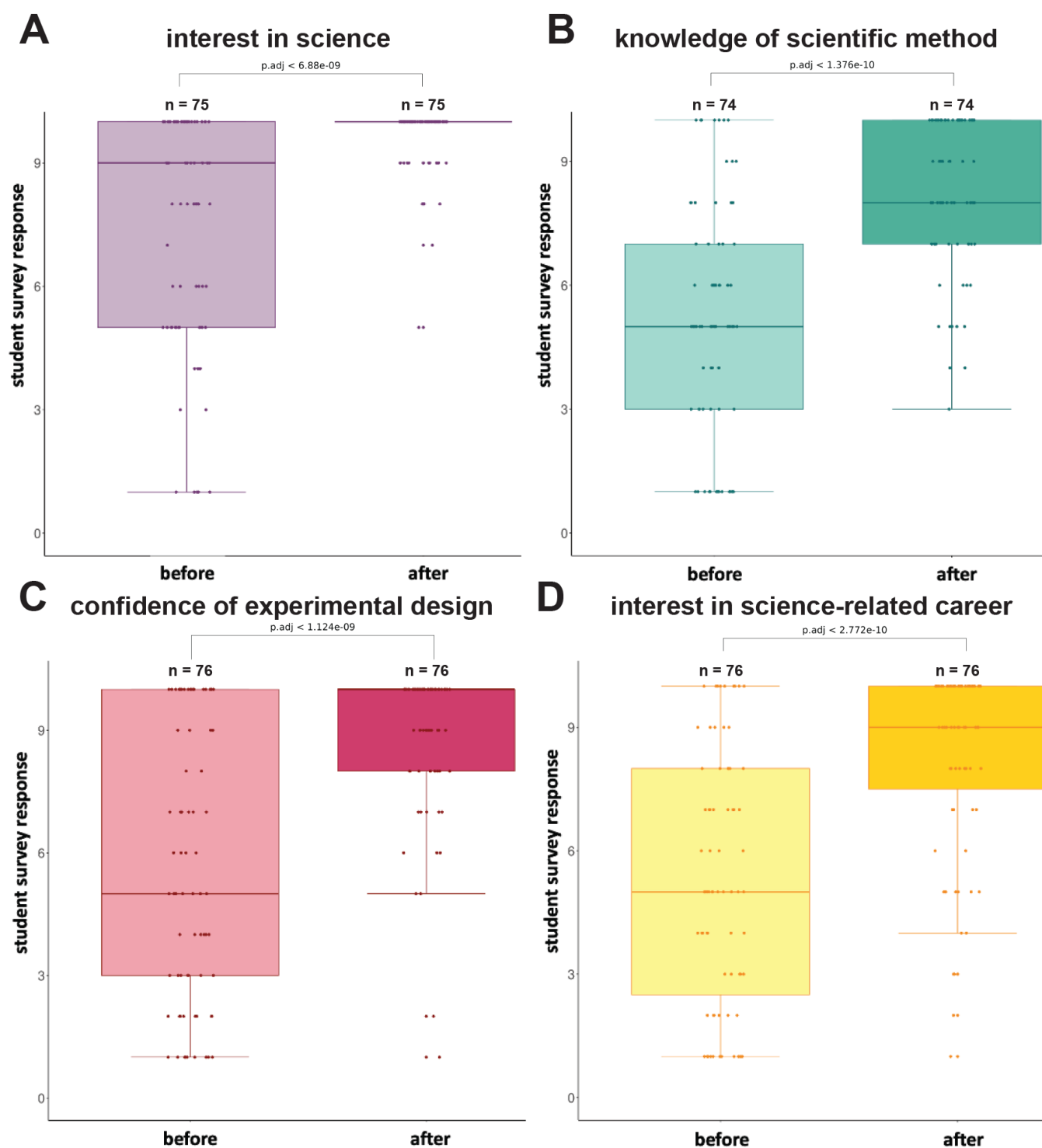


Figure 5. Think Like a Scientist Student Participant Survey Responses. Box plots displaying the median (line), interquartile range (box) and minimum and maximum (whiskers) scores from the post-pre student participant survey. Students were asked to rate their feelings regarding questions before and after the program. The survey asked **A.** “How exciting did you think science was? (interest in science), **B.** “How much would you say you know about the scientific method?” (knowledge of scientific method), **C.** “How confident are you that you would have been able to make an experiment to test a question that you have?” (confidence of experimental design), **D.** “How easily did you see yourself becoming some type of scientist one day?” (interest in science-related career). *n* and *p*-values are indicated in graphs; *p*-values were determined through a Wilcoxon test.

Volunteer satisfaction and engagement were also high. Nearly all volunteers strongly agreed that they would volunteer with TLaS in the future (94.6%) and recommend volunteering with TLaS to peers and colleagues (95.9%) (Figure

7). One volunteer shared, “I always leave the sessions so happy and seeing how these kids learn and talk to others gives me so much excitement for the future. [TLaS] is amazing and I can’t thank you enough for letting me be a part of

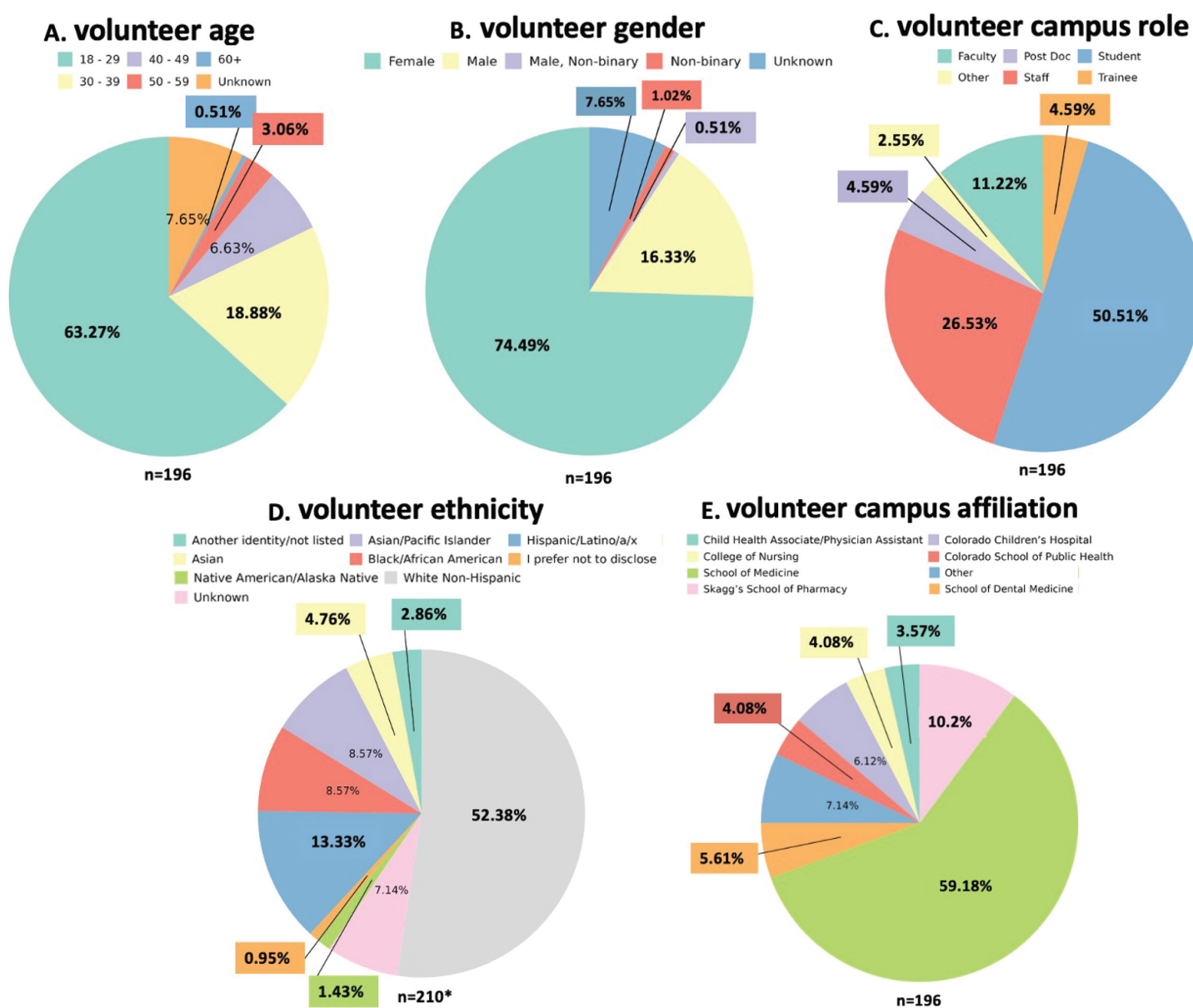


Figure 6. Demographic Characteristics of Think Like a Scientist Volunteers. Pie charts depicting the distribution of volunteers by **A.** age ($n=196$), **B.** gender ($n=196$), **C.** campus role ($n=196$), **D.** cultural identity ($n=210^*$), and **E.** campus affiliation at the University of Colorado Anschutz ($n=196$). *Volunteers could select multiple identities, making the sample size ($n=210$) larger than the number of individuals who completed the survey ($n=196$).

it.” One-third of volunteers ($n = 24$ of 74 ; 32%) reported as returning TLaS volunteers (Appendix B, Supplementary File 4). However, this number likely underrepresents true volunteer retention, as returning volunteers may be less likely to complete the same survey after multiple sessions. Even still, the data demonstrate that TLaS effectively maintains and expands its volunteer base, which is a crucial factor for program sustainability. Overall, these results validate that TLaS successfully achieves its goal of making science enjoyable and accessible to student participants while offering meaningful, skill-building experiences for volunteers.

Community School Coordinator Survey Responses.

All Community School Coordinators strongly agreed that TLaS positively impacted the participating school, and either strongly agreed or agreed that it positively impacted the participating students, making it an enjoyable and positive learning experience for student participants (Figure 8). Further, all Community School Coordinators strongly agreed or agreed that they plan to continue the partnership with TLaS, and all strongly agreed that they would recommend TLaS to colleagues and other programs (Figure 8). Feedback provided by coordinators further highlighted the program’s impact. One stated, “Our students loved participating in TLaS. This

Volunteer perception of the TLaS experience

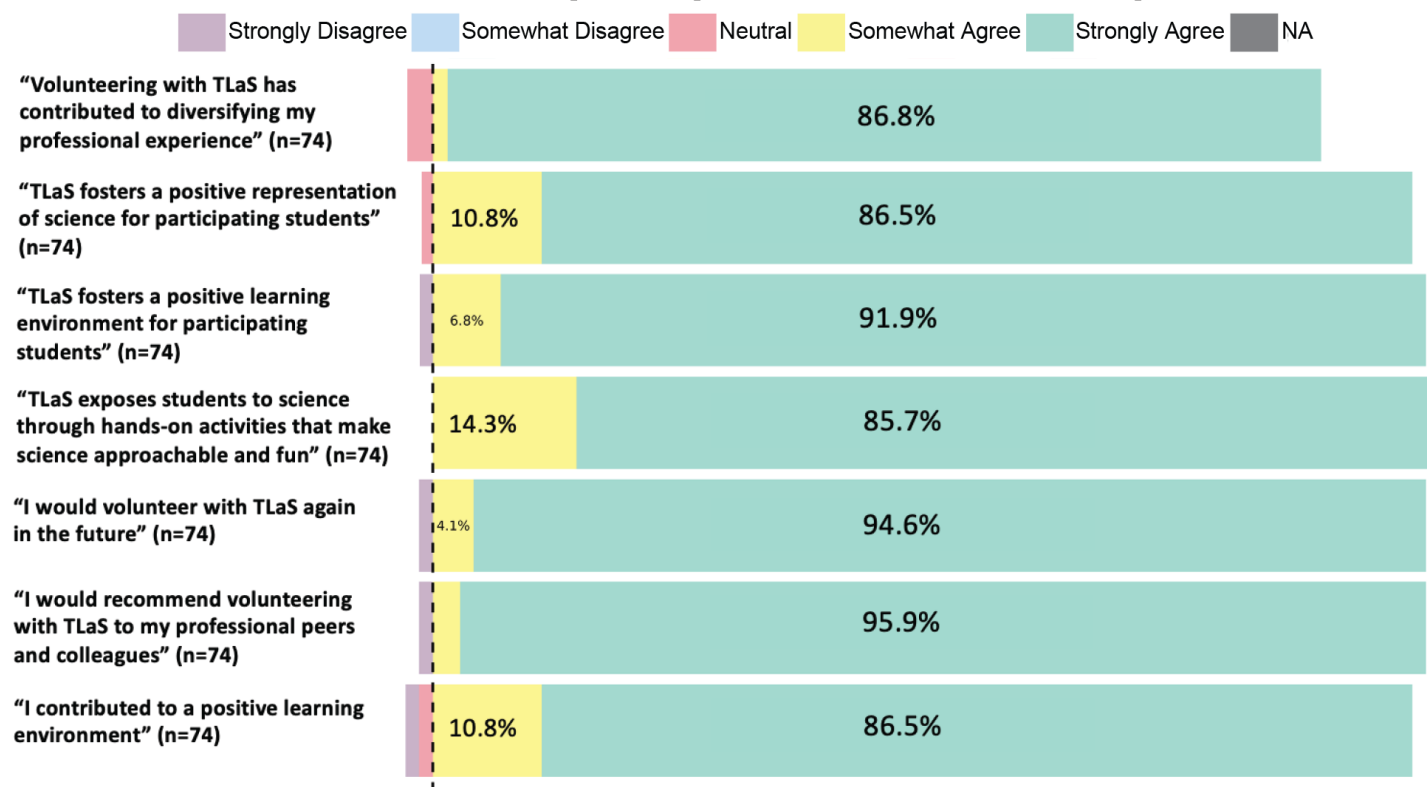


Figure 7. Think Like a Scientist Volunteer Survey Responses. Bar graphs depicting percentages of volunteer answers (*strongly disagree*, *somewhat disagree*, *neutral*, *somewhat agree*, *strongly agree*, or *not applicable* [NA]) for each statement regarding the program's impact. Percentages are represented in the bars; n= 74.

was a wonderful program for students to build self-concept as future scientists. Activities were engaging for students and got them excited about science." This reinforces that TLaS fulfills its core values (Figure 1) and positively impacts student participants, volunteers, and the surrounding community. Multiple Community School Coordinators also commented on the program's commitment to addressing and overcoming language barriers; "[TLaS] truly understands the importance of language equity by having volunteers that speak Spanish and volunteers that know how to use interpretation apps. [A student participant]'s smile yesterday and desire to return is a prime example." Another echoed "TLaS recruits volunteers that speak Spanish. Having someone speak the language they are most comfortable with and making new friends are comments we hear regularly from students and their families." Together, these comments validate that TLaS provides access to science education by removing barriers and engages student participants from a variety of backgrounds to broaden representation in STEM (Figure 1).

DISCUSSION

The findings presented here reveal several key implications regarding the student population in the APS district,

the educational environments of partnering schools, and how TLaS meets educational needs and impacts student participant outcomes. Overall, TLaS received positive feedback from all surveyed groups, indicating that the program successfully fulfills its core values, and benefits student participants with limited STEM exposure, volunteers from varied backgrounds, and partnering school administrations. While subjective, the survey responses provide valuable insights into the program's effectiveness in achieving its intended outcomes, affirming that TLaS is both engaging and impactful. By offering dynamic instruction and immersive experiences at the elementary level, TLaS fosters a positive identity in STEM, breaks down barriers to access, and enhances youth engagement, interest, and opportunities in STEM.

The success of TLaS lies in its intentional design to meet the specific needs of elementary-aged students, particularly within schools facing academic challenges as reflected by low CMAS test scores (Figure 3), and the school demographics (Figure 4). Survey data demonstrate that TLaS fosters scientific learning and skills and enhances foundational scientific knowledge, with all student participants reporting increased confidence in understanding the scientific method after program completion (Figure 5). Interactive lessons, direct and personal interaction with volunteers, and hands-on

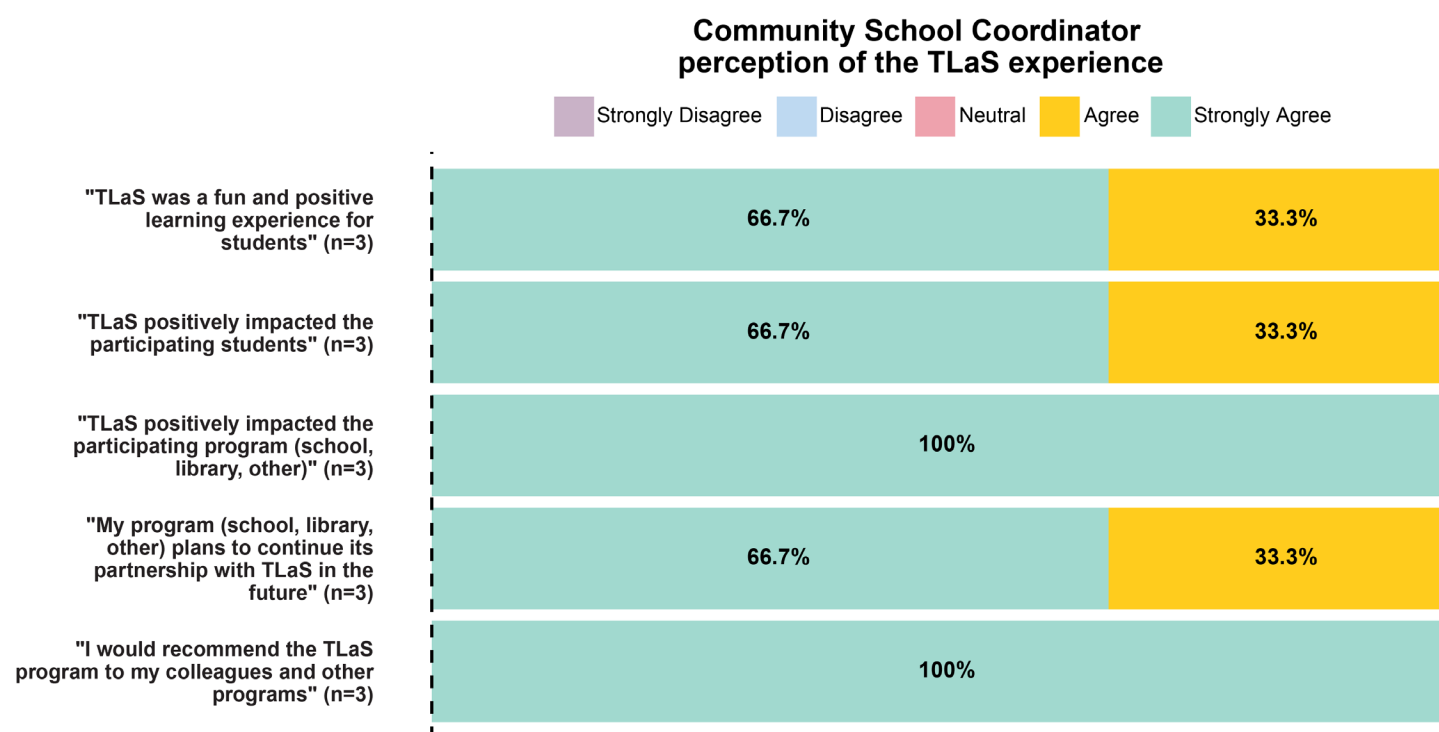


Figure 8. Think Like a Scientist Community School Coordinator Survey Responses. Bar graphs depicting percentages of Community School Coordinator answers (*strongly disagree*, *somewhat disagree*, *neutral*, *somewhat agree*, *strongly agree*, or *not applicable* [NA]) for each statement regarding the program's impact. Percentages are represented in the bars; $n = 3$.

experiments help build essential problem-solving and critical-thinking skills in student participants. Additionally, the "Meet the Scientist" portion humanizes scientists, counteracts stereotypes, and strengthens student participants' sense of belonging in STEM. Collectively, these outcomes validate the program's inquiry-based approach for supporting early STEM engagement.

A solution to the "leaky pipeline" in STEM is to provide educational outreach that boosts encouragement, enthusiasm, and awareness of opportunities in STEM (DeWitt et al., 2013; Johnson & Bozeman, 2012). Survey results suggest that TLaS develops student participants' STEM self-efficacy and promotes interest, motivation, and confidence in STEM (Figure 5) (Chuisano et al., 2023; Marshall et al., 2024). It has been shown that removing the gap in STEM at a young age, specifically at the elementary level, helps prevent dropout rates and boosts interest in higher education (Reynolds et al., 2018). Retaining science curriculum in elementary schools also supports improvements of state standardized test scores and overall academic performance. Thus, addressing the gaps and increasing representation in STEM begins with investing in science during elementary school, which continues throughout education, which may contribute to broadening the workforce and driving innovation (Marshall et al., 2022; Omoijuanfo et al., 2022).

A core tenet of TLaS is to generate curiosity and excitement for STEM through interactive instruction and

creative learning experiences that encourage questions, collaboration, and sharing of personal experiences. The curriculum—developed with input from current and former educators—incorporates real-world events into the scientific method and is tailored to address existing gaps in STEM education. All student participants reported the highest level of interest in science after program participation, underscoring the importance of active learning environments. Active learning, where students engage in discovery and discussion rather than passive observation, has been shown to increase retention of conceptual understanding and success in STEM (Cooper & Brownell, 2016; Driessen et al., 2020; Edwards et al., 2024; Freeman et al., 2014; Hartley et al., 2019). Likewise, all volunteers agreed that the hands-on activities make science approachable and fun for student participants (Figure 7), reflecting similar findings from other programs that demonstrated hands-on activities result in participants gaining more value (Carroll et al., 2024; Dizbay-Onat & Wyss, 2018). Nurturing students' interest in science early is vital for their success later in STEM, and encouraging the next generation to become science-passionate individuals is critical to global economic prosperity and innovation since society relies on STEM industries (Brumovska et al., 2022; Johnson & Bozeman, 2012). These findings suggest that STEM educational outreach for elementary-aged students is an essential investment to sustain future generations' interest in STEM. Importantly, while TLaS sparks interest

in STEM at a young age, engagement must be maintained throughout education in order to pursue STEM as a career; thus, it is critical that STEM outreach and engagement are continuously provided at all educational levels (Duodu et al., 2017).

Increasing representation in STEM careers requires addressing four factors: awareness of STEM careers, identification with STEM, demonstrated interest and engagement, and, ultimately, the decision to pursue a STEM career (Rocha et al., 2022). Survey data indicate that TLaS contributes meaningfully across all four of these domains. Student participants reported increased interest in pursuing STEM careers after completion of the program (Figure 5). This is further exemplified by Community School Coordinators strongly endorsing the program and its impact (Figure 8). Their intent to continue partnering with TLaS demonstrates the program's long-term, institutional value.

In addition to empowering student participants, TLaS positively impacts its volunteers (Figure 7). TLaS volunteers reported enjoying the perspectives and insights about science from student participants and, in most cases, received immediate gratification from volunteering as has been seen in other studies (Clark, 1996). That most volunteers are young, female students challenges gender stereotypes in a traditionally male-dominated field (Dickson & McMinn, 2022). This also offers relatable role models for students who may not otherwise see themselves represented in science.

Drawing from years of implementation and survey analysis, TLaS recommends several approaches for developing successful STEM educational outreach programs in underserved and underprivileged communities: (1) establish a committed and organized leadership team, (2) cultivate strong, lasting partnerships with schools and surrounding communities, (3) design engaging, inquiry-based learning activities, and (4) provide an environment where all participants feel supported and comfortable expressing themselves. Programs that minimize physical and human resource demands while maximizing scalability are more likely to succeed (San Miguel et al., 2019). Collectively, TLaS demonstrates that a well-structured, community-centered STEM educational outreach program can enhance community engagement, strengthen school partnerships, and inspire future generations into STEM.

Challenges and Limitations. Despite all of TLaS's successes, implementing STEM educational outreach programs in underserved communities is not without challenges and limitations. The rapid increase of English as a Second Language (ESL) students in APS has amplified the need for additional language support to ensure full participation in programs like TLaS. Student participants experiencing language barriers may require additional time for translation during lessons. To address this, TLaS strives to recruit at least one

Spanish-speaking volunteer per lesson to represent the top two languages spoken in the APS district (English and Spanish). However, given that 28 different languages are spoken at home in the district, full language representation remains difficult to achieve. Although frequently met, maintaining a 2:1 student participant to volunteer ratio requires consistent volunteer over-recruitment to offset volunteer scheduling conflict, emergencies, and/or lack of commitment.

Because students must register to participate in TLaS as an after-school activity, this study is limited by a selection pool that requires students or their guardians to be interested in STEM and/or extracurricular activities initially. Thus, the survey data may overrepresent students who are already inclined towards STEM. TLaS also competes with other after-school programs offered simultaneously. Additionally, each six-week program is limited to 20 students due to space and resource constraints. TLaS acknowledges that it is not serving every student. The absence of random assignment or a control group limits the ability to directly measure academic outcomes.

Survey-based evaluations introduce limitations, including incomplete responses, translation challenges for ESL students, and illegible handwriting as surveys were administered on paper to eliminate technology barriers. While Spanish-speaking volunteers offer translation, ESL students often opt out of taking the voluntary survey. While interviews may provide richer data, they were deemed impractical due to time constraints and the potential to intimidate students. Thus, surveys were chosen as the data collection method. Conclusions are therefore based on perceived knowledge and self-assessment rather than objectively measured knowledge. Also, self-evaluation can be limited by students' ability to accurately identify their own knowledge (Angell et al., 2024). TLaS intentionally minimizes performance pressure by offering no grades or credit, focusing instead on fostering curiosity, engagement, and empowerment in science rather than content mastery. Despite limitations, surveys remain valuable to assess the program's success and impact.

Finally, program sustainability depends heavily on financial and institutional support. Securing funding for TLaS has been challenging due to budget reductions and low institutional prioritization of community outreach programs. Further, implementation requires significant time, effort and resources. TLaS leaders and volunteers are unpaid and are motivated solely by a shared desire to positively impact the surrounding community.

Future Directions. Survey responses will continue to guide program evaluation and inform improvements to enhance program outcomes and impact. Survey questions will also be adapted to reflect the program's goals and the needs of the communities it serves. Future iterations of TLaS may benefit from incorporating input from a social scientist to refine

survey design and data interpretation. TLaS will also continue adapting lessons to align with updated Colorado state standards. Program expansion beyond Aurora, Colorado has already begun, led by former TLaS leaders who introduced the program in Guam through Manelu (Big Brothers, Big Sisters) and at the Glenville Branch Library in Cleveland, Ohio. Additional launches are planned in Durango, Colorado; Philadelphia, Pennsylvania; and San Diego, California. To further extend the reach of TLaS, hosting science nights that engage parents and guardians can promote family involvement, strengthen parent-child relationships, and increase awareness of STEM opportunities, which supports students outside of the program (Riggs et al., 2019; Zucker et al., 2022).

Conclusions. TLaS provides meaningful, growth-oriented experiences for both student participants and volunteers while fostering strong, sustainable relationships with partnering schools. Through its free, six-week, after-school program, TLaS introduces students to scientific concepts and addresses the need for greater access to STEM education by engaging them in hands-on experiments that spark curiosity and confidence. Survey results show improvement in participants' perception of understanding of the scientific method, confidence in experimental design, science curiosity, and interest in STEM careers. Volunteers also benefit by connecting with and making a difference in their local community. Thus, TLaS meets its goals to create a positive and impactful educational experience for all involved and remains committed to making science approachable and engaging. The program aims to increase representation in STEM by sparking interest in elementary-aged children during the formative years when ideas about and attitudes toward science are most malleable. TLaS also humanizes science and presents STEM professionals as individuals relatable to student participants, helping shatter the scientist stereotype and encouraging students to envision a career in STEM. In doing so, TLaS continues to inspire the next generation of scientists and strengthen the connection between science and community.

ASSOCIATED CONTENT

Supplemental material mentioned in this manuscript can be found uploaded to the same webpage as this manuscript.

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Author Contributions

The following outlines the contributions of each author to this manuscript: CM was responsible for conceptualization and analysis of the data, performed the literature review, and drafted and revised all versions of the manuscript. TB was responsible for the analysis and display of the data and review of several drafts of the manuscript. ZV, AF, and GA drafted specific sections within the manuscript and aided data collection. APB was the principal investigator and program coordinator, responsible for conceptualization, coordination, and analysis of the data and drafted and revised all versions of the manuscript. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article and its information files (Appendix B). Any additional datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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ABBREVIATIONS

CMAS: Colorado Measures of Academic Success; ESL: English as a Second Language; FRL: Free and Reduced Lunch; HUGs: Historically Underrepresented Groups; MERLOT: Multimedia Educational Resource for Learning and Online Teaching; SEP: Science and Engineering

REFERENCES

- Anfuso, C., Awong-Taylor, J., Curry Savage, J., Johnson, C., Leader, T., Pinzon, K., Shepler, B., & Achat-Mendes, C. (2022). Investigating the impact of peer supplemental instruction on underprepared and historically underserved students in introductory STEM courses. *International Journal of STEM Education*, 9(1), Article 55. <https://doi.org/10.1186/s40594-022-00372-w>
- Angell, D. K., Lane-Getaz, S., Okonek, T., & Smith, S. (2024). Metacognitive exam preparation assignments in an introductory biology course improve exam scores for lower ACT students compared with assignments that focus on terms. *CBE—Life Sciences Education*, 23(1), Article 6. <https://doi.org/10.1187/cbe.22-10-0212>
- Archer Ker, L., DeWitt, J., Osborne, J. F., Dillon, J. S., Wong, B., & Willis, B. (2013). *ASPIRES report: Young people's science and career aspirations, age 10–14*. King's College London. https://kclpure.kcl.ac.uk/portal/files/64130521/ASPIRES_Report_2013.pdf
- Archer, L., & DeWitt, J. (2016). *Understanding young people's science aspirations: How students form ideas about "becoming a scientist."* Routledge.
- Archer, L., Moote, J., Macleod, E., Francis, B., & DeWitt, J. (2020). *ASPIRES 2: Young people's science and career aspirations, age 10-19*. UCL Institute of Education. <https://discovery.ucl.ac.uk/id/eprint/10092041/>
- Aurora Public Schools (APS). (2023). *Enrollment & Demographics Reports 2022-23* [Documents].
- Aurora Public Schools (APS). (2024). Title I Schools.
- Ayers, K. A., Wade-Jaimes, K., Wang, L., Pennella, R. A., & Pounds, S. B. (2020). The St. Jude STEM clubs: An after-school STEM club for upper elementary school students in Memphis, TN. *Journal of STEM Outreach*, 3(1), Article 13. <https://doi.org/10.15695/jstem/v3i1.13>
- Benedetti, L., & Crouse, R. B. (2020). Flipped science fair: Engaging middle-school students in STEM while training researchers in science communication. *Journal of STEM Outreach*, 3(1), Article 10. <https://doi.org/10.15695/jstem/v3i1.10>
- Brumovska, T. J., Carroll, S., Javornicky, M., & Grenon, M. (2022). Brainy, crazy, supernatural, clumsy and normal: Five profiles of children's stereotypical and non-stereotypical perceptions of scientists in the Draw-A-Scientist-Test. *International Journal of Educational Research Open*, 3, Article 100180. <https://doi.org/10.1016/j.ijedro.2022.100180>
- Carroll, S., McCauley, V., & Grenon, M. (2024). Science self-efficacy beliefs of upper primary students in Ireland. *International Journal of Science Education*, 46(6), 503-523. <https://doi.org/10.1080/09500693.2023.2245947>
- Cascella, M., & Soares, T. A. (2022). Bias amplification in gender, gender identity, and geographical affiliation. *Journal of Chemical Information and Modeling*, 62(24), 6297-6301. <https://doi.org/10.1021/acs.jcim.2c00533>
- Chuisano, S. A., Rafferty, J., Allen, A., Chang, T., Diemer, M., Harris, K., Vaughn, L. M., Watkins, D. C., & DeJonckheere, M. (2023). Increasing representation and diversity in health research: A protocol of the MYHealth research training program for high school students. *PLoS One*, 18(9), e0281790. <https://doi.org/10.1371/journal.pone.0281790>
- Clark, M. R. (1996). A successful university-school-district partnership to help San Francisco's K-12 students learn about science and medicine. *Academic Medicine*, 71(9), 950-956. <https://tinyurl.com/66fe9vpr>
- Colorado Department of Education (CDE). (2020). *2020 Colorado Academic Standards: Science*. Denver, CO: Colorado Department of Education
- Colorado Department of Education (CDE). (2024). *CMAS - Mathematics, English Language Arts, Science, and Social Studies Assessments*. Colorado Department of Education. <https://ed.cde.state.co.us/assessment/cmas>
- Colorado Department of Education (CDE). (2025). *Title I Rank Order*. <https://ed.cde.state.co.us/fedprograms/titleiran-korder>
- Cooper, K. M., & Brownell, S. E. (2016). Coming out in class: Challenges and benefits of active learning in a biology classroom for LGBTQIA students. *CBE—Life Sciences Education*, 15(3), Article 37. <https://doi.org/10.1187/cbe.16-01-0074>
- Crews, D. C., Wilson, K. L., Sohn, J., Kabacoff, C. M., Poynton, S. L., Murphy, L. R., Bolz, J., Wolfe, A., White, P. T., Will, C., Collins, C., Gauda, E., & Robinson, D. N. (2020). Helping scholars overcome socioeconomic barriers to medical and biomedical careers: Creating a pipeline initiative. *Teaching and Learning in Medicine*, 32(4), 422-433. <https://doi.org/10.1080/10401334.2020.1729161>
- Danielson, R. W., Grace, E., White, A. J., Kelton, M. L., Owen, J. P., Fisher, K. S., Martinez, A. D., & Mozo, M. (2022). Facilitating systems thinking through arts-based STEM integration. *Frontiers in Education*, 7, Article 915333. <https://doi.org/10.3389/educ.2022.915333>
- DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, Brainy and Normal: Children's and Parents' Constructions of Those Who Are Highly Engaged with Science. *Research in Science Education*, 43(4), 1455-1476. <https://doi.org/10.1007/s11165-012-9315-0>

- Dickson, M., & McMinn, M. (2022). Children's perceptions of scientists and their work: The 'Draw a Scientist' Test in the United Arab Emirates. *Public Understanding of Science*, 31(8), 1079-1094. <https://doi.org/10.1177/09636625221096795>
- Dizbay-Onat, M., & Wyss, J. M. (2018). Preparing 8(th) grade students to excel in physical science: HandsOn Physics (HOP)! *Journal of STEM Outreach*, 1(1), Article 24. <https://doi.org/10.15695/jstem/v1i1.24>
- Drazan, J. F. (2020). Biomechanists can revolutionize the STEM pipeline by engaging youth athletes in sports-science based STEM outreach. *Journal of Biomechanics*, 99, Article 109511. <https://doi.org/10.1016/j.jbiomech.2019.109511>
- Driessen, E. P., Knight, J. K., Smith, M. K., & Ballen, C. J. (2020). Demystifying the meaning of active learning in postsecondary biology education. *CBE—Life Sciences Education*, 19(4), Article 52. <https://doi.org/10.1187/cbe.20-04-0068>
- Duodu, E., Noble, J., Yusuf, Y., Garay, C., & Bean, C. (2017). Understanding the delivery of a Canadian-based after-school STEM program: A case study. *International Journal of STEM Education*, 4(1), Article 20. <https://doi.org/10.1186/s40594-017-0083-2>
- Edwards, B. A., Bowen, C., Barnes, M. E., & Brownell, S. E. (2024). Christian student experiences during peer interactions in undergraduate biology courses. *CBE-Life Sciences Education*, 23(1), Article 7. <https://doi.org/10.1187/cbe.23-01-0020>
- Food and Nutrition Service. (2024). *National School Lunch Program*. U.S. Department of Agriculture. <https://www.fns.usda.gov/nslp>
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410-8415. <https://doi.org/10.1073/pnas.1319030111>
- Geldhof, G. J., Warner, D. A., Finders, J. K., Thogmartin, A. A., Clark, A., & Longway, K. A. (2018). Revisiting the utility of retrospective pre-post designs: The need for mixed-method pilot data. *Evaluation and Program Planning*, 70, 83-89. <https://doi.org/10.1016/j.evalprogplan.2018.05.002>
- Gregg-Jolly, L., Swartz, J., Iverson, E., Stern, J., Brown, N., & Lopatto, D. (2016). Situating second-year success: Understanding second-year STEM experiences at a liberal arts college. *CBE-Life Sciences Education*, 15(3), Article 43. <https://doi.org/10.1187/cbe.16-01-0044>
- Hartley, L. M., Ferrara, M. J., Handelsman, M. M., Rutebemberwa, A., & Wefes, I. (2019). Principles and strategies for effective teaching: A workshop for pre- and postdoctoral trainees in the biomedical sciences. *Journal of Microbiology & Biology Education*, 20(3). <https://doi.org/10.1128/jmbe.v20i3.1689>
- Health Insurance Marketplace. (2024). *Federal poverty level (FPL)*. U.S. Department of Health & Human Services. <https://www.healthcare.gov/glossary/federal-poverty-level-fpl/>
- HM Treasury. (2006). *Science and Innovation Investment Framework 2004-2014: Next steps*. <https://dera.ioe.ac.uk/id/eprint/14224/1/file40538.pdf>
- Johnson, J., & Bozeman, B. (2012). Perspective: Adopting an asset bundles model to support and advance minority students' careers in academic medicine and the scientific pipeline. *Academic Medicine*, 87(11), 1488-1495. <https://tinyurl.com/5eyu3mme>
- Kirchhoff, T., Wilde, M., & Großmann, N. (2022). "I've always thought that i was not good at experiments..."—The benefit of non-formal learning in terms of students' perceived competence. *Frontiers in Psychology*, 13, Article 882185. <https://doi.org/10.3389/fpsyg.2022.882185>
- Kompella, P., Gracia, B., LeBlanc, L., Engelman, S., Kulkarni, C., Desai, N., June, V., March, S., Pattengale, S., Rodriguez-Rivera, G., Ryu, S. W., Strohkendl, I., Mandke, P., & Clark, G. (2020). Interactive youth science workshops benefit student participants and graduate student mentors. *PLoS Biology*, 18(3), Article e3000668. <https://doi.org/10.1371/journal.pbio.3000668>
- Krecko, L. K., & Jung, S. (2022). Impacts of a clinical research program for high school students from groups historically excluded from science and medicine. *Health Equity*, 6(1), 873-880. <https://doi.org/10.1089/heq.2022.0050>
- Lin, M.-Y., Chen, H., & Golecki, H. M. (2023). HUG Initiative: Overcoming roadblocks on a research career roadmap of individuals from historically marginalized or under-represented genders [Mini Review]. *Frontiers in Astronomy and Space Sciences*, 10. <https://doi.org/10.3389/fspas.2023.1134327>
- Lucero, J. E., Finnegan, J., Wilcox, J., Crowther, D., Usinger, J., Dagda, R. K., & Ewing-Taylor, J. (2021). The community of bilingual English-Spanish speakers exploring issues in science and health: Experiences during the COVID-19 pandemic. *Journal of STEM Outreach*, 4(4), Article 5. <https://doi.org/10.15695/jstem/v4i4.05>
- Marshall, A. G., Neikirk, K., Stephens, D., Garza-Lopez, E., Vue, Z., Beasley, H. K., Doe, Y. J., Campbell, D., Fears, L., Alghanem, A., Spencer, E. C., Scudese, E., Owens, B., Vang, C., Morton, D. J., Conley, Z., & Hinton, A., Jr. (2024). A workshop to showcase the diversity of scientists to middle school students. *Advances in Physiology Education*, 48(2), 186-192. <https://doi.org/10.1152/advan.00117.2023>
- Marshall, A. G., Vue, Z., Palavicino-Maggio, C. B., Neikirk, K., Beasley, H. K., Garza-Lopez, E., Murray, S. A., Martinez, D., Crabtree, A., Conley, Z. C., Vang, L., Davis, J. S., Powell-Roach, K. L., Campbell, S., Brady, L. J., Dal, A. B., Shao, B., Alexander, S., Vang, N.,...Hinton, A. (2022). The role of mentoring in promoting diversity equity and inclusion in STEM education and research. *Pathogens and Disease*, 80(1). <https://doi.org/10.1093/femspd/ftac019>

- McLaughlin, J. E., Bush, A. A., Friedman, A. D., & Lai, S. K. (2020). Immersive research experiences for high school students aimed at promoting diversity and visibility in pharmacy education. *American Journal of Pharmaceutical Education*, 84(3), Article 7589. <https://doi.org/10.5688/ajpe7589>
- Musgrove, M. M. C., Ko, M. E., Schinske, J. N., & Corwin, L. A. (2024). Broadening Participation in Biology Education Research: A role for affinity groups in promoting social connectivity, self-efficacy, and belonging. *CBE—Life Sciences Education*, 23(1), Article 8. <https://doi.org/10.1187/cbe.23-01-0004>
- National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. National Academies Press. <https://nsf.gov-resources.nsf.gov/attachments/108276/public/RisingAboveExecSum.pdf>
- National Center for Science and Engineering Statistics (NCSES). (2022). *Science and Engineering Indicators 2022: The State of U.S. Science and Engineering* (NSB-2022-1). National Science Board. <https://ncses.nsf.gov/pubs/nsb20221>
- National Center for Science and Engineering Statistics (NCSES). (2023). *Diversity and STEM: Women, minorities, and persons with disabilities 2023* (Special Report NSF 23-315), National Science Foundation. <https://ncses.nsf.gov/wmpd>
- National Girls Collaborative Project. (2024). *State of girls and women in STEM*. National Girls Collaborative Project. <https://ngcproject.org/resources/state-girls-and-women-stem>
- Omoijuanfo, E. O., Williams, J. T., Qua, K., Cullen, J., Trapl, E., Owusu, C., Junk, D. J., & Berger, N. A. (2022). Disparities education strategies in the Case Comprehensive Cancer Center STEM Focused Youth Enjoy Science Program. *Journal of STEM Outreach*, 5(2), Article 7. <https://doi.org/10.15695/jstem/v5i2.07>
- Organisation for Economic Co-operation and Development (OECD). (2016). *PISA 2015 results (Volume I): Excellence and equity in education*. OECD Publishing. <https://doi.org/10.1787/9789264266490-en>
- Organisation for Economic Co-operation and Development (OECD). (2019). *PISA 2018 results (Volume I): What students know and can do*. OECD Publishing. <https://doi.org/10.1787/5f07c754-en>
- Phelan, K. D., Syed, M., Akhter, N., Huitt, T. W., Snead, G. R., Thomas, B. R., & Yanowitz, K. L. (2022). Bridging the technology divide in the COVID-19 era: Using virtual outreach to expose middle and high school students to imaging technology. *Journal of Visual Experiments*, (187), Article e64051. <https://doi.org/10.3791/64051>
- Reynolds, A. J., Ou, S. R., & Temple, J. A. (2018). A multicomponent, preschool to third grade preventive intervention and educational attainment at 35 years of age. *JAMA Pediatrics*, 172(3), 247-256. <https://doi.org/10.1001/jamapediatrics.2017.4673>
- Riggs, R. A., White, C. J., Kuenzi, T., Sifuentes, M., Garner, S. R., Gleason, R. A., Lee, J., Ziese, C. C., Berry, J., Garza, M. A., Vann, D., Fordtran, C. W., Grimes, K. K., Gray, J., & Evans, T. M. (2019). Engaging the community through science nights: An elementary school case study. *Journal of STEM Outreach*, 2(1), Article 6. <https://doi.org/10.15695/jstem/v2i1.06>
- Rocha, J., Castillo-Lavergne, C. M., Byrd, M. J., Carnethon, M. R., Miller, R., Lin, M., Marsh, E. E., Jackson, J. K., & Yancy, C. W. (2022). Reimagining educational equity through strategic alliance partnerships in response to the USA STEM-M diversity gap. *Health Promotional International*, 37(2), Article daab094. <https://doi.org/10.1093/heapro/daab094>
- Rodriguez, F., Rivas, M. J., Matsumura, L. H., Warschauer, M., & Sato, B. K. (2018). How do students study in STEM courses? Findings from a light-touch intervention and its relevance for underrepresented students. *PLoS One*, 13(7), Article e0200767. <https://doi.org/10.1371/journal.pone.0200767>
- San Miguel, S. F., McDavid, L., Parker, L. C., & Simons, M. C. (2019). Developing a scalable STEM career development program for elementary school-aged students. *Journal of STEM Outreach*, 2(2), Article 21. <https://doi.org/10.15695/jstem/v2i1.21>
- Santoso, A. P., Jupitz, S., & Lin, C. (2021). A framework for developing community-focused medical physics outreach programs. *Journal of Applied Clinical Medical Physics*, 22(10), 305-314. <https://doi.org/10.1002/acm2.13413>
- Schiefer, J., Golle, J., Tibus, M., Herbein, E., Gindele, V., Trautwein, U., & Oschatz, K. (2020). Effects of an extracurricular science intervention on elementary school children's epistemic beliefs: A randomized controlled trial. *British Journal of Educational Psychology*, 90(2), 382-402. <https://doi.org/10.1111/bjep.12301>
- Schneider, B., Chen, I. C., Bradford, L., & Bartz, K. (2022). Intervention initiatives to raise young people's interest and participation in STEM. *Frontiers in Psychology*, 13, Article 960327. <https://doi.org/10.3389/fpsyg.2022.960327>
- Schwartz, N. B., Risner, L. E., Domowicz, M., & Freedman, V. H. (2020). Comparisons and approaches of PREP programs at different stages of maturity: Challenges, best practices and benefits. *Ethnicity & Disease*, 30(1), 55-64. <https://www.ethndis.org/archive/files/ethndis-30-55.pdf>
- Toledo, M. A., Koochak, N., Gupta, A., López, L. N., Nieri, T., & Currás-Collazo, M. C. (2020). Interactive student-centered neuroscience workshops for sixth graders enhance science knowledge and education attitudes. *Journal of Undergraduate Neuroscience Education*, 18(2), Article A75-a85. <https://www.funjournal.org/wp-content/uploads/2020/08/JUNE-18-75.pdf>
- U.S. Department of Agriculture, Economic Research Service. (n.d.). *National School Lunch Program*. <https://www.ers.usda.gov/topics/food-nutrition-assistance/child-nutrition-programs/national-school-lunch-program/>

- Wai, J., Lubinski, D., Benbow, C. P., & Steiger, J. H. (2010). Accomplishment in science, technology, engineering, and mathematics (STEM) and its relation to STEM educational dose: A 25-year longitudinal study. *Journal of Educational Psychology*, 102(4), 860–871. <https://doi.org/10.1037/a0019454>
- Ward, A. R. (2015). Promoting strategic STEM education outreach programming using a systems-based STEM-EO model. *Research Management Review*, 20(2), 13–22. <https://tinyurl.com/2w4sxdzy>
- Zucker, T. A., Maldonado, G. Y., Assel, M., McCallum, C., Elias, C., Swint, J. M., & Lal, L. (2022). Informal science, technology, engineering and math learning conditions to increase parent involvement with young children experiencing poverty. *Frontiers in Psychology*, 13, Article 1015590. <https://doi.org/10.3389/fpsyg.2022.1015590>