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Increasing Representation of Minority Students in STEM Fields Through Multi-Generational Mentoring, Real-World Learning, and GIS Training

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ABSTRACT: Increasing enrollment in and graduation from science, technology, engineering, and math (STEM) majors in universities is key to fostering a healthy economy and advancing global competitiveness. However, there is a lack of representation of minority students in STEM fields. The US's changing demographics place young people of color at the vanguard of the next generation. While programs have been implemented to reduce gender and racial disparities in STEM programs and careers in the US, the effectiveness of youth mentoring programs is an area of ongoing inquiry. We implemented a year-long youth mentoring program for middle and high school students from a predominantly Hispanic neighborhood in Tucson, AZ. Younger students were mentored by near peers in learning geospatial analysis techniques to assess the quality of neighborhood parks. The project included four visits to the university campus, and outcomes were evaluated using student surveys and qualitative responses. Our results show that a youth mentoring program can potentially help increase minority interest in STEM and higher education. We offer lessons to improve the effectiveness of youth mentoring programs, and we recommend that universities—particularly those designated as minority-serving institutions—institutionalize programs that provide mentoring to minority K-12 students.

INTRODUCTION

Increasing the number of STEM majors in universities is a key component to enhancing resilience, fostering a healthy economy, and advancing global competitiveness (Arcidiacono et al., 2016), as well as ensuring homeland security, a pluralistic view of the global environment (Fakayode et al., 2019; Lee et al., 2024), and fostering innovation (Lee et al., 2024). To meet the US demand for STEM professionals, the number of students pursuing STEM majors needs to increase by 34% (Arcidiacono et al., 2016). The US's changing demographics place young people of color at the vanguard of the next generation, as 39% of people under 18 in the US are people of color, and this percentage is expected to increase (Anderson and Kim, 2006).

A growing concern is the lack of representation of minority students in STEM fields, with some roots in issues related to retention in higher education. Upon college entry, underrepresented minority groups (URMs—Black or African Americans, Indigenous or American Indians, Alaska Natives, Native Hawaiians or other Pacific Islanders, and Hispanic or Latinx) show similar preferences for STEM fields as white students, but their likelihood of persisting in these fields is much lower (Anderson and Kim, 2006; Seymour and Hunter, 2019). URM groups are also less likely to earn any bachelor's degree (STEM or non-STEM) than either whites or Asian Americans (Anderson and Kim, 2006).

Access to higher education is a key part of the problem. The low enrollment of minorities in higher education and their cumulative disadvantage in science involves a constellation of factors: poor K-12 schooling, low socioeconomic status, and a lack of social capital and knowledge about college or careers (Seymour and Hunter, 2019). Low graduation rates of women and URMs in STEM fields further enhance inequality, since STEM majors earn substantially more than those with other college degrees (Kinsler and Pavan, 2015) and have lower employment rates, more satisfying jobs, and increased opportunities to help family members (Seymour

and Hunter, 2019). For these reasons, increasing diversity in STEM fields has become a national priority in the US (Fakayode et al., 2019). The federal government, through the National Science Foundation (NSF) and the National Institutes of Health (NIH), is investing billions of dollars in programs that aim to increase the participation of minorities in STEM fields (Arcidiacono et al., 2016; Seymour and Hunter, 2019).

High engagement in STEM activities has been found to positively influence students' adoption of STEM careers (Franz-Odendaal et al., 2016). From science fairs to robotics competitions and alternate reality games, engagement efforts have aimed to increase K-12 students' interest in STEM (Gilliam et al., 2017; Vanado, 2021). Similarly, mentoring programs can increase diversity in higher education, as well as within STEM departments (Culpepper et al., 2021). Many programs have been implemented to address disparities in the STEM workforce in the US, yet the role of youth mentoring programs is still not fully explored. Building from previous work engaging underrepresented K-12 students (Gerlak and Zuniga-Teran, 2020), this program aims to inspire minority middle and high school students to pursue higher education and a STEM major.

There is evidence that higher adolescent spatial abilities—defined as "the ability to generate, retain, retrieve, and transform well-structured visual images" (Lohman, 1994)—leads to more participation (Hegarty, 2014) and success in advanced education and STEM occupations (Wai et al., 2009). Similarly, Uttal and Cohen (2012) argue that a lack of spatial skills can be a barrier to STEM. Spatial thinking abilities are developed within Geographic Information Systems (GIS) education (Lee and Bednarz, 2009), so GIS-based training should be prioritized to set up adolescents for success in STEM education and careers. The youth mentoring program outlined in this project employs various GIS technologies and training to advance student spatial abilities for future entry and success in STEM.

This paper begins with an overview of efforts to increase URM representation in GIS-based STEM majors in the US. The following sections describe the pilot program of our youth mentoring model and the assessment tool used to evaluate it. We then present the program evaluation results as a comparison between pre- and post-project outcomes. In our discussion, we outline some lessons learned and the challenges and opportunities for future programs that aim to increase the representation of URMs in STEM fields, then conclude with a summary of the effort.

BACKGROUND

Achieving diversity, equity, and inclusion (DEI) in higher education is a key factor in advancing justice. DEI in higher education can make people more comfortable with those from different racial and ethnic backgrounds (Sidanius et al., 2008), resulting in cross-cultural empathy (Bowman and Park, 2016) and overall satisfaction with the college experience (Bowman, 2013). In addition, increasing URM representation in higher education can close the racial income gap. A university degree plays an important role in people's wages, with higher wages for STEM graduates than any other major (Hur et al., 2019).

Historically, there has been a well-documented gap in participation in STEM fields for women, racial minorities, and first-generation college students in the US due to structural barriers (McGee and Robinson, 2019). These include socioeconomic disparities, gender and racial inequalities, deficient K-12 preparation for college, and cultural incompetency (Fakayode et al., 2019). Lack of racial, ethnic, and gender representation in the classroom and workplace is detrimental to the recruitment and retention of URMs. Minority representation in the classroom is critical because faculty serve as role models for students (Lee et al., 2024), yet minority STEM faculty are underrepresented (Culpepper et al., 2021). This underrepresentation—in K-12 schools, universities, and the workplace—contributes to decreased enrollment and retention of minority students in STEM majors (Subburaj et al., 2020). Many US universities have been striving to increase DEI but falling short, particularly in STEM (Lee et al., 2024), as there are efforts against DEI. For example, many states have recently introduced legislation to eliminate DEI initiatives, including mandatory DEI training and DEI administration offices, as well as diversity statements in faculty promotion and new faculty hiring endeavors (Lee et al., 2024).

Minority low-income students are also more likely to attend underfunded and ill-equipped schools, where teachers have limited development opportunities (Fakayode et al., 2019). To change this, there has been an influx of programs to introduce such groups—and young people more broadly—to STEM and motivate their continued engagement (Santos et al., 2019; Wilson-Kennedy et al., 2019). These programs are valuable, given the significant benefits that both individuals (Even et al., 2023) and the scientific community (Smith-Doerr et al., 2017; Benish, 2018) stand to gain from a more diverse STEM workforce.

Many programs target undergraduates, as this is a time when even STEM-interested students may drop out or change directions (Doerschuk et al., 2016; Burt et al., 2023). However, others are increasingly recognizing that early intervention is key. As early as primary school, STEM-focused, after-school activities can increase knowledge, skills, and interest among diverse participants (Moreno et al., 2016). Programs targeted at middle school students are critical because students start thinking about their college path around sixth grade (Fakayode et al., 2019). At this stage, they tend to experience declining interest in science. Research has shown

that middle school students may not fully grasp the importance of science and math requirements for future STEM careers (Franz-Odendaal et al., 2016). Timely interventions can slow or reverse this trend. For example, Studio STEM, a hands-on, afterschool science program, increased middle school students' valuation of science and their interest in pursuing college compared to their peers who did not participate in the program—and these changes persisted over time (Chittum et al., 2017).

Miller et al. (2018) found that participation in STEM competitions before college, including science fairs or robotics contests, can increase participation in STEM careers. Alternate reality games have also been implemented to increase URM's interest in STEM; they can harness the benefits of engagement, including building a social community and fostering peer support through teamwork and collaboration, with real-world application (Gilliam et al., 2017). In some cases, specialized schools have emerged to expose underrepresented students to STEM. However, while these seem to increase college readiness, there is still mixed evidence about how much they close gaps in academic achievement (Varnado, 2021).

Engaging students through partnerships—including educators, governmental actors, and community organizations—is also effective (Fakayode et al., 2019). University-community partnerships can be helpful in the development of mentoring programs, as university faculty can leverage resources and provide outreach opportunities for university students (Gerlak and Zuniga-Teran, 2020). University students mentoring younger students has been shown to improve learning for college students (Nelson et al., 2017).

METHODS

To increase the diversity of students in STEM, we developed a youth mentoring program. We engaged middle school students from Sunnyside Unified School District, where more than 90% of the students identify as Hispanic, 83% live in a low-income household that qualifies for free or reduced-price meals, and 2% identify as unhoused (Sunnyside Unified School District, 2022). Our main middle school educator has been participating in or leading community-engaged learning projects there for 12 years. During discussions with other teachers at weekly professional development meetings, she was able to identify two other teachers (a 7th-grade advanced math teacher, and a mixed-grade level Student Leadership teacher) who were also interested in a collaborative STEM inquiry, as were their students. Both teachers were new to integrated STEM inquiry and community-engaged learning. Our team of educators also included faculty from different colleges at the University of Arizona, which is designated as a Hispanic-Serving Institution (HSI).

Other members of our team included the non-governmental organization (NGO) CommunityShare, as well as local government officials. We partnered with representatives of the Southern Arizona Research, Science, and Engineering Foundation (SARSEF), who already had a history of working with youth on STEM-related initiatives. We engaged staff from the Parks in Focus® Program at the Udall Foundation, who connect youth to nature "through photography and outdoor learning" (Udall Foundation, n.d.). Finally, we invited government officials to serve as community leaders and engage with students at the front and back end of the program. Our multi-tiered mentoring model (Figure 1) included 80 middle school students (three middle-school advanced math, student council, and STEM classrooms), 10 high school students (alumni of that middle school), six undergraduate students, three graduate students, one postdoctoral researcher, three university faculty members, and three middle school teachers.

CommunityShare facilitated the initial partnership between middle school and university educators, and SARSEF provided mentor training. The Pima County School Superintendent's Office provided logistical and programmatic support. Local city and county officials working on urban planning initiatives provided content expertise on topics related to parks and greenspace. Staff from Parks in Focus visited the middle school on several occasions to train students on the use of photography to capture their individual perspectives when visiting parks.

We recruited university students, preferably bilingual and from Hispanic backgrounds, to work on this pilot program (about 70% of them identified as Hispanic). The cohort received training in mentorship, leadership, communication, and GIS-based spatial analysis. Through regular project meetings, university students designed the program

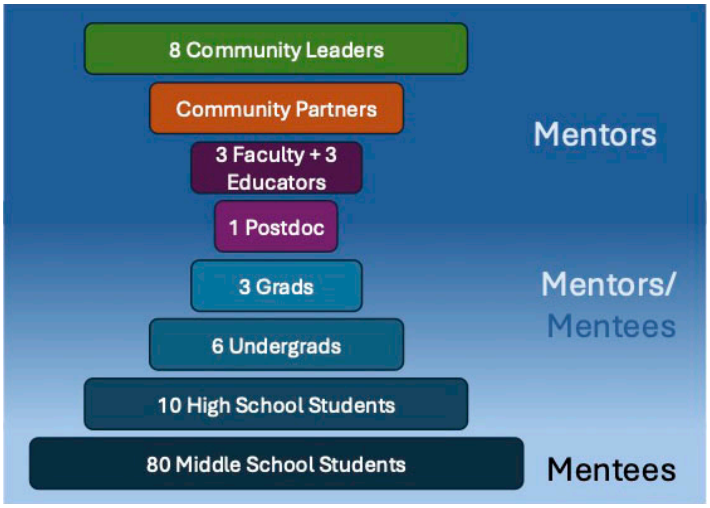

Figure 1. Multi-tiered mentoring model. Gradient background represents the level of mentoring (darker color means more mentorship). Community leaders, partners, educators, and postdoc served as mentors, while graduate, undergraduate, and high school students served both as mentors and mentees, and middle school students were the mentees.

activities to engage younger students. Ten high school students (alumni of the participating middle school) served as a bridge between university and middle school students. In tandem, both sets of university and high school student mentors coached and supported middle school students with their STEM projects and led team-building activities during events at the university campus.

The program took place over one academic year, from August 2023 to May 2024. We kicked off the project with a welcoming event at the university campus. About 100 middle and high school students visited the campus and met with university students and the rest of the team. This event began with welcoming remarks from university mentors and then engaged students in faculty-led, team-based STEM challenges. They included a timed build competition where students worked together to construct three-dimensional models of desert wildlife or vegetation and then calculating and presenting final dimensions. These activities promoted teamwork and creativity, spatial awareness, critical thinking, and problem-solving—all foundational pieces of GIS.

Other hands-on activities engaged middle school students in creative yet structured active learning games that helped them to connect to one another while working on enhancing their spatial skills; these equally served as foundational concepts for layering GIS technological skills throughout the life of the project. To build on this type of team building in STEM activities, university students introduced a panel of experts represented by our community leaders, who shared aspects of their STEM-related jobs they liked and their story of how they got those jobs. Community leaders also posed questions about parks in the city that would help them in their jobs. These questions served as prompts that students could use for the projects they were about to start.

Program activities sought to build capacity around spatial analysis using GIS and encourage new ways of thinking about space and place, so that students could see how to use these skills to answer more complex questions that would be the basis of their own school project. Students gained access to Environmental Systems Research Institute, Inc. (ESRI)'s suite of GIS software and training to learn basic GIS field data collection, analysis, and mapping skills. Throughout two training workshops, middle school students learned the basics of GIS, which they later used to assess the quality of parks in the city. The workshops took place at the university campus and consisted of four hours of activities led by university students and supervised by faculty. For example, ESRI's ArcGIS Survey123 was used to build a survey instrument that enabled students to collect data via fun scavenger hunts. Parents of middle school students accompanied the minors during every campus visit, serving as chaperones.

Middle school and high school students visited the university campus four times during the year-long program. During these visits, they walked through different parts of campus and became familiar with the main buildings (student union, library, etc.). They learned about resources available for URM students and how they could be supported to complete their studies at this institution. The visits included lunch at different locations across the school campus, which provided valuable opportunities for relationship-building among students at different academic and age levels.

Once the GIS training was complete, the students were tasked with a project where they could apply their new knowledge. Middle school students took a field trip to two parks in the city—one located in their neighborhood and another in a middle-class neighborhood. They chose one park feature to focus on (e.g., quality of restrooms or drinking fountains, number of trees, quantity and quality of artwork, trash, condition of sports fields) and mapped the selected feature using electronic tablets with GIS access. The students then created a StoryMap—a web page that enables the embedding of different types of information, including text, images, and interactive maps with their data—to showcase their findings by comparing the selected features in the two parks. Students also recorded video presentations of their StoryMaps and made posters to showcase during their student competition.

There were other mentoring sessions beyond university events. High school students visited the middle school during several Saturdays to mentor students on their projects. University students also visited the middle school to review final projects and provide feedback. Some of these mentoring sessions occurred via Zoom to address scheduling conflicts. Community leaders visited the middle school in-person or via Zoom to hear student presentations.

The program ended with a closing event and student poster competition at the university campus. Community leaders served as judges and used a rubric to assess GIS learning and application. During this event, community leaders handed out medals and trophies to the winners. Table 1 illustrates the outcomes of the top five student projects from the student competition; examples of winning posters are shown in Fig-

Table 1. *Top 5 projects from student competition.*

Project Title	Driving Question	StoryMap Links
Differences between Community Parks in Tucson, AZ!	This StoryMap is about 2 different types of parks I've been to this year in Tucson, AZ	https://arcg.is/0je9TK1
What are the pros and cons about Tucson parks?	How can we improve community parks?	https://arcg.is/1GHjfH0
Making Parks More Inviting	What Drives a Community To a Park?	https://arcg.is/191D99
How visiting the U of A changed my perspective	Going to the University of Arizona and talking to some of the students	https://arcg.is/0ySP8H
Community Equality is Important!	How can we design a community park that is equitable and accessible to all people?	https://arcg.is/1TmqiL
Adventures in public parks	What makes public parks special?	https://arcg.is/05HXiG

Figure 2a. Student project titled: "Making parks more inviting."

Figure 2b. Student project titled: "Community equality is important!"

ures 2a and 2b. These projects also won the top five awards for middle school story map projects in the 2024 Arizona ArcGIS Online Competition. Two high school mentors used ArcGIS skills for the first time to complete their personal STEM and mentor journeys.

After the competition, students at all levels shared their experiences with the project during a photo montage. We originally budgeted prizes for the top three winners of the student poster competition, but students instead chose to spend the money on an experience in which they could all participate—a picnic luncheon at a local park.

Students submitted their work to two different statewide ArcGIS StoryMap competitions. Five of the projects earned top prizes in the middle school category and a $100 prize at the Esri AZ ArcGIS Online Competition. Figure 3 describes the timeline of project activities designed around the academic year.

To conduct outreach with URMs, we followed strategies for recruitment and retention of minority students found in Menfield et al. (2024) and Doyle (2019; Table 2).

Our model is based on the aims of youth engagement outlined by Gilliam et al. (2017; Table 3).

Assessment Method. To assess the effectiveness of the program, we designed a survey as a pre- and post-program evaluation tool. Survey questions used either a 5-point Likert scale or a binary yes/no response (see Table 4 for a complete list of assessment questions). The same survey was taken by students four times during the project.

The survey was meant to be taken by middle school and high school students before the program started (before they visited the university for the first time) and then every time after they visited the university campus. However, the students took the first survey in the afternoon after the kickoff event, due to the significant bureaucratic constraints involving the processes required for surveying students who are minors. The survey questions had to be vetted by multiple school administrators and parents, which required several months of time and special considerations for working with youth.

Survey questions inquired about the students' perception of competency around collaboration with others, and visualizing and analyzing data. We also asked about students' perception of themselves as a scientist or engineer. Both questions used binary yes/no response options. Self-perception is especially important among girls and racial minorities, who face both material and cultural barriers and have historically perceived themselves as less capable in these sub-

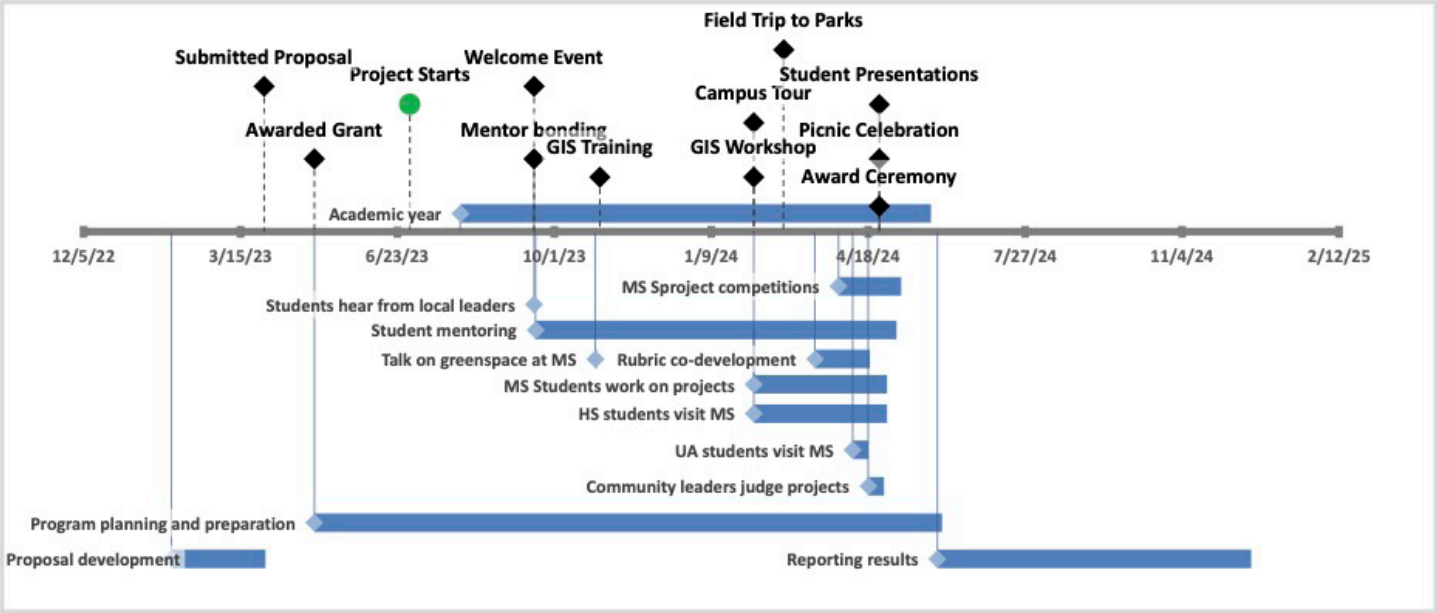

Figure 3. **Project timeline**. Even though most activities happened during the academic year (from August 2023 to June 2024), there was a lot of work before and after. Training occurred during the fall, and the students worked on their projects in the spring. (MS=Middle School, HS= High School, and UA=University of Arizona).

jects (Broyles, 2009). Other questions assessed the students' change in comfort around project activities: identifying challenges in their neighborhood, working with community leaders, and attending university. These response options ranged from 1 (novice) to 5 (superhero).

Open response questions supplemented the quantitative survey questions. Samples of these qualitative reflections, across the different groups, are provided in Table 5. Classroom teachers facilitated discussions and collected written feedback from middle school students throughout the project, some of which is included as evidence in the results section. They discussed successes and challenges and provided suggestions. High school students also participated in reflection exercises with community partners through mentorship trainings. During these exercises, they responded to prompts such as "What does it mean to be a mentor?" and "What is inspiring you in small or big ways?" They also created their own StoryMaps about their mentor journey, and an end-of-project video that answered the question, "How has your year as a STEM mentor impacted you and the Sunnyside community?" Reflections were also gathered from community members about their participation and important takeaways. All responses were collected in a shared folder and used to triangulate survey data.

Team members and university mentors also collected qualitative data after each of the campus visits, in which they reflected on how the event went, how it could have been improved, and what we learned. First modeled by a university faculty mentor, the undergraduates then took the lead on facilitating post-event debriefs. Notes from these were kept in a shared folder as a living archive of engagement reflections, used in the planning of future events. Our findings, while preliminary and not generalizable, are valuable to other researchers and practitioners considering similar programs. Our project focused on teaching, learning and project evaluation (rather than hypothesis-generating research) and was therefore not required to seek human subjects approval due to its evaluative nature.

RESULTS

This project engaged, supported, and prepared middle school students on multiple fronts using a youth model of STEM mentorship. The project's impacts emerged in three main ways for the middle school participants: the improvement of specific scientific skills (especially GIS), an emphasis on relationship-building and leadership skills, and changing attitudes toward college and potential futures in STEM. These outcomes support and enhance one another, as effective learning is often a social process and skill- and confidence-building tend to coincide.

Adding to the STEM Toolbox. The most material outcome of this project was the instruction of middle school students in GIS skills, and in turn, their enhanced confidence in this area. Students learned from multiple teachers, including their primary instructors, university and high school mentors, and community leaders who joined them at parks, events, and in the classroom. The student work extended beyond the boundaries of the project, as the top five projects from our competition were then entered in the state's Middle School StoryMap competition, earning awards and cash prizes. One of the 7th graders from the program won the competition and advanced to the national contest. At the time of writing,

Table 2. *Strategies used to recruit URM students to higher education and STEM majors.*

Recruitment Strategy	Implementation
Use alumni networks	We recruited high school students who were alumni of our partner middle school.
Partnership with local organization	We partnered with the local organization CommunityShare who has a history working with schools and conducting student-driven projects.
Targeted outreach efforts at K-12 schools with predominant minority students	We targeted Lauffeur Middle School located in a predominantly Hispanic low income neighborhood (Title 1 District).
Support students academically in STEM and socially	The youth mentoring model aimed to provide academic and social support.
Connect prospective students to diverse initiatives on campus	During a campus tour, we introduced middle and high school students to university centers that support minority students.
Connect recruitment efforts with STEM employment	We engaged community leaders that worked on STEM careers. They shared their stories with students and their data needs.
Create initiatives that align with minority identities, enhance understanding and strengthen their confidence	The student projects aimed to empower students with a better understanding of differences between parks. With data, students became confident in advocating for their community.
Increase URM mentors	Our team includes Hispanic and Pacific Islander-descent faculty, and females. About 50% of our university student mentors were bilingual and of Hispanic ethnicity.
Break barriers by bringing K-12 students to campus	We organized a total of four campus visits to increase familiarity with the university campus and the location of the main buildings and services.

Table 3. *Properties of the youth mentoring model (based on Gilliam et al., 2017).*

Aims of Youth Engagement	Operationalization
Social community and peer support	University students (undergraduate and graduate) met once a week to plan the engagement activities. Peer support was promoted through paired activities and continuous reflection. Students were paired based on different levels of competency.
Collaboration and teamwork	Engagement activities were broken down in parts. Each part was led by a different team of students based on their interests, skills, and capabilities.
Real-world relevance and investigative learning	Middle school students were tasked with comparing a park quality or feature between two different parks. One of the parks is in their neighborhood, which provides real-world relevance.
Mentoring and exposure to STEM professionals	STEM professionals (who we called "community leaders") played a key role in this program. Students met them at the beginning of the project and listened to their career stories. Community leaders were the judges of the student poster competition and handed out the awards.
Hands-on activities to foster transferable skill building	During fieldtrips, students collected data on parks that they reported for their final projects in the form of a student poster, a StoryMap and a video presentation.
Interface with technology	Hands-on activities were designed to build capacity around spatial analysis and the use of geographic information systems (GIS). The poster used Survey123 to illustrate project findings.

several other students are revising their projects for the Maps and Apps Contest for the upcoming state GIS Symposium.

Participation in these types of competitions with peers was enabled by the advanced skills students gained through this project. This helped improve their confidence in STEM. For example, Figure 4 shows changes in students' feelings of competency in several science skills—collaboration, data visualization, and data analysis—over the course of the project.

Building Relationships and Leadership Skills. Students and mentors also received useful training and experience in a wider range of skills applicable to the workplace and beyond. University mentors completed university-based, multimedia training such as "Working with Youth" and "Mentor Universe" modules, through which they brainstormed their own "mentorship universe map," where they considered their values as a mentor and mentee and the various supports they already have in place. University students were also led by a faculty mentor using career conversations, which gave them a chance to list their own strengths and SMART changes and define next steps. These are the same professional development activities practiced by university staff and faculty.

The goal here was not just to train students and mentors to be technically competent in data collection and analysis, but also to empower them with data to advocate for their community, communicate their own needs and concerns, and be effective leaders. This included discussion of social science issues like equity and justice, which many students were able to recognize as pertinent to their own experiences. In many of their final projects, the middle school students specifically highlighted the discrepancies between the amenities in a park near their school and one in a wealthier neighborhood in North Tucson.

Toward the end of the project, students were asked what they would like to see changed in their own neighborhoods. Their responses frequently captured the interconnected na-

Table 4. *Assessment questions from program evaluation tool.*

Question/Statement	Potential Response
I have completed a science, engineering, or STEM project with… High school student mentors before University of Arizona mentors before	Yes/no
I am good at… Collecting data Making observations Research Recording information/ note-taking Analyzing data Visualizing data Collaborating with others on a project Solving problems	Yes/no
I am excited and engaged in school	Yes/no
I see the value of a university education	Yes/no
I know I can make the world a better place through science and engineering	Yes/no
I feel… Like I can improve my neighborhood/community Like a scientist/engineer Like a leader Like what I learn in this experience will help me in my future career and education Connected to people in my community who can help me achieve my future goals Like people in Tucson care about me	Yes/no
Do you think visiting the university and working with community leaders will help you to succeed in research competitions such as SARSEF and Future City?	Yes/no
Do you feel like you have a "voice" and are listened to when speaking about challenges in your neighborhood?	Yes/no
Do you feel like you can make a change in your neighborhood?	Yes/no
How comfortable are you in… Visiting the University of Arizona campus? Working with community leaders? Identifying challenges in your neighborhood? Speaking about challenges in your neighborhood? Being a citizen scientist and collecting data? Thinking about attending a university? Using a smartphone to collect pictures/images? Using software or an app to create maps?	1 (Novice) to 5 (Superhero)

ture of social and environmental problems. For example, one 8th grader responded, "I would make more outdoor activities for people to use and to get other people out of their houses to get air, exercise, and have more quality time with family and friends." Another student similarly called for "a community pool and more parks because [in] my neighborhood, no one really goes outside and socializes that much." Other recommendations included providing financial aid to struggling families, reducing crime through opportunities for productive activities, installing bike paths to reduce traffic, cleaning parks and other green spaces, and fixing up dilapidated houses, potholes, and other infrastructural issues. These responses illustrate students' increased comfort, over the course of the project, with identifying challenges in their own neighborhoods (Figure 5). While many did not yet view themselves as "superheroes," there was a notable increase from beginner status to more moderate levels of expertise, as the project progressed.

Similar results emerged regarding students' comfort working with community leaders, where moderate increases were seen from the beginning to the end of the project (Figure 6). Taken together, these findings illustrate the ways in which close relationships with community leaders coincided with students' confidence in their own active leadership.

High school mentors had the opportunity to go beyond their student roles and provide instruction and support to middle schoolers. In one training where they reflected on the meaning of mentorship, they demonstrated a nuanced understanding of their roles. "You have to understand and identify someone's strengths so they can build confidence," described one, "meaning they will be less likely to give up on the goals they have set." Another similarly explained how "a mentor should build on the student's knowledge rather than telling the student what to do." Another summarized their experience in the project: "The biggest takeaway I have had is that there is also still much to be learned, especially as a mentor, and often we can learn from the mentees."

Community partners also reported positive impacts of the collaborative project. As one explained, "I learned that I can make a difference. The program works because the community comes together to guide and prepare the students for the competition. It makes us all a part of the learning." One of the benefits of a youth mentor approach is that the learning is not top-down. Middle school, high school, and university students, instructors, and community partners embark on a collaborative learning experience that is as much about community, equity, and justice as it is about STEM.

Thinking About College and Futures in STEM. Finally, this project aimed to foster positive attitudes toward college and STEM. This appears to have been effective among the middle school students, as by the end of the project, more than 80% (compared to 68% pre-project) ranked their comfort in thinking about attending a university in the top two levels of agreement, on a scale from 1 to 5 (Figure 7).

We sought to increase students' comfort with and interest in college through repeated interactions with the campus and university life, and especially through a one-day event with campus tours and Q&A sessions with our college mentors. The project also had a notable impact on students' perceptions of themselves in relation to STEM (Figure 8).

By exposing them to and training them in GIS, StoryMap creation, and other scientific skills, the middle school students increased their perception of themselves as scientists and engineers. Combined with their increased confidence as leaders in their community, this project provided a valuable pathway for students to understand their own expertise and apply it in real-world scenarios.

Reflections from High School and University Mentors. This project posited that there would be significant benefits, not just to the middle school students, but to their mentors as

Table 5. *Sample reflections of middle school, high school, and university students, and community partners, throughout the year.*

September Reflections
Middle school students
Successes I experienced during the field trip: *"I learned some new things and new ways of looking at things"* *"I got comfortable with the U of A mentors and I was able to speak to them without being that nervous."* *"I learned a lot about our community leaders and had a lot of fun doing the activities as well."*
February Reflections
High school students
What is inspiring you in small or big ways? *"I am inspired to see my peers who work hard and seeing everyone as we apply to pre-college programs!"* *"What is inspiring me is how I can see how I affect the students I mentor. I'm seeing a positive impact that I'm making on them and they are making on me."*
April Reflections (end-of-program)
High-school students/mentors
"Seeing the impact I've had has given me a new perspective of what community and togetherness really means" *"Being a high school STEM mentor has really shown me how to be a good leader and role model to middle-school students who are already very bright and creative and show talents of a future engineer."* *"One thing I am proud of is my ability to help students who want to solve a problem by using my knowledge and experience as a tool."*
University students/mentors
"My favorite memory from this experience was watching how fast the middle-school students grasped all the concepts from things like equity to all the technology stuff we did, like making maps and collecting data. And something I take with me from this experience is learning how to work with all different age groups […] *and how we can all teach each other."* *"It was really cool to see how enthusiastic* [the students] *were about this project and to learn about GIS."* "[The students' Future City projects] *were so cool, and I was just so impressed because that's never something that I would have had the chance to do when I was in middle school.*
Community partners
"I am more convinced than ever that the solutions we need to the big problems we have created are somewhere in the minds of these future scientists and engineers." *"I learned that I can make a difference. The program works because the community comes together to guide and prepare the students for the competition. It makes us all a part of the learning.* *"These Lauffer Future City students are capable of exploring complex ideas and strategies for putting together futuristic models of our world."*

well. High school mentors took the same evaluation surveys as middle school students, and over the course of the year, they showed marked improvements in several indicators. With 1 representing "novice" and 5 "superhero," they advanced their average comfort level (from pre-survey to end-of-project survey) in: working with community leaders (3.9 to 4.2), identifying challenges in their neighborhood (3.8 to 4.4), speaking about challenges in their neighborhoods (3.6 to 4.4), and using software or an app to create maps (3.4 to 3.9).

Undergraduate and graduate mentors had the opportunity to plan and implement four large-scale campus events. They also organized post-event reflection activities for themselves and faculty. These reflections were structured as "Diamonds" (what worked well), "Delta" (what could change), and "Proposals" (practical ideas for improvement), as applied to each activity in the event schedule. This activity allowed students to improve each event that followed, and provided insight into the experience of undergraduate and graduate mentors in this project.

After the first campus visit, university mentors were excited about the significant community-building that took place. Overall, they reflected that the event felt positive and well-organized, and that students actively participated. They enjoyed the interactive and small-group activities. Several reported seeing middle school students helping one another, and that students told them at the end of the day how much they had enjoyed themselves. Some of the opportunities for growth were organizational (e.g., scheduling in less speaking and more activity, engaging more parent chaperones, and building in flexibility to adapt to unexpected changes). In contrast, others reflected on skills they wanted to improve, such as facilitation, public speaking, or time management.

For the next event, where students participated in data collection activities, mentors again reflected on the positive atmosphere and their significant preparation leading up to the event. They had also improved on some of the "deltas" from the previous event, as mentors reported feeling more

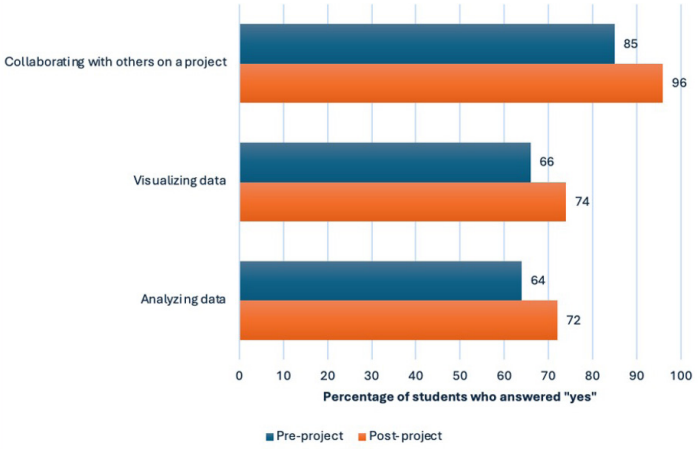

Figure 4. Differences in middle school student responses to three questions, beginning **"I am good at…"** Students were asked to respond whether or not they agreed with the statement (yes or no).

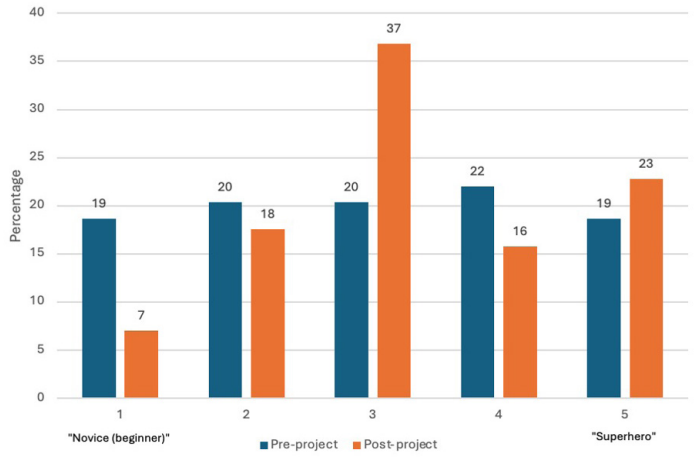

Figure 5. "How comfortable are you in identifying challenges in your neighborhood?" Differences in middle school student responses prior to the start of the project and following project completion, on a scale from 1 (novice/beginner) to 5 (superhero).

comfortable leading their groups, and they were better able to handle it when the bus arrived late that morning. Outside of the classroom, mentors were able to build more personal relationships with students, as well as instruct them in GIS skills using Survey123 data collection software on their mobile devices.

The third event was the campus tour and FAQ session. Mentors expressed pride in how well-prepared they were for this extensive activity. Several had expressed nervousness about leading students and parents around campus and speaking publicly, and so their success felt particularly rewarding. This day was an opportunity for undergraduate and graduate mentors to share more of their personal stories, backgrounds and college experiences; the middle school students were curious and asked thoughtful, engaged questions. One of the big successes acknowledged by mentors during this event was the more effective engagement of the high school students, who both learned from the college mentors and supported the middle school students—a benefit of this type of near-peer mentorship model.

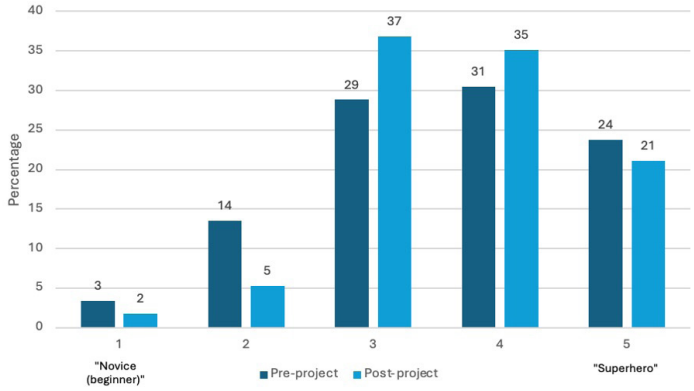

Figure 6. "How comfortable are you in working with community leaders?" Differences in middle school student responses prior to the start of the project and following project completion, on a scale from 1 (novice/beginner) to 5 (superhero).

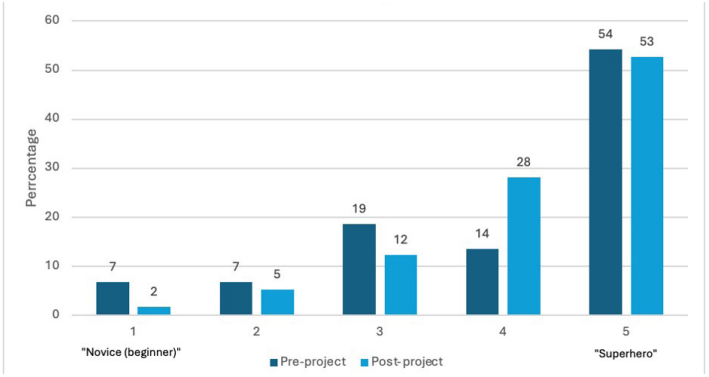

Figure 7. "How comfortable are you in thinking about attending a university?" Differences in middle school student responses prior to the start of the project and following project completion, on scale from 1 (novice/beginner) to 5 (superhero).

Following the final event, university students reported feeling more confident leading the closing ceremony and feeling social cohesion among team members. They enjoyed looking at the student posters and showing the videos of the top students presenting their StoryMaps as part of the competition. The picnic lunch at a local park after the closing ceremony gave space for students to mingle, socialize, and build connections without a set agenda.

DISCUSSION

In this paper, we report our experience and evaluation of a pilot engagement program that aimed to increase the likelihood of URM students pursuing higher education and a STEM major. The pilot program consisted of a youth mentoring program designed to engage middle and high school students through active interaction with university students at different educational levels. Through pre- and post-project surveys and periodic group reflections, we assessed the effectiveness of our engagement model.

While survey responses provided some insight into the impacts of the pilot program, they are best understood along-

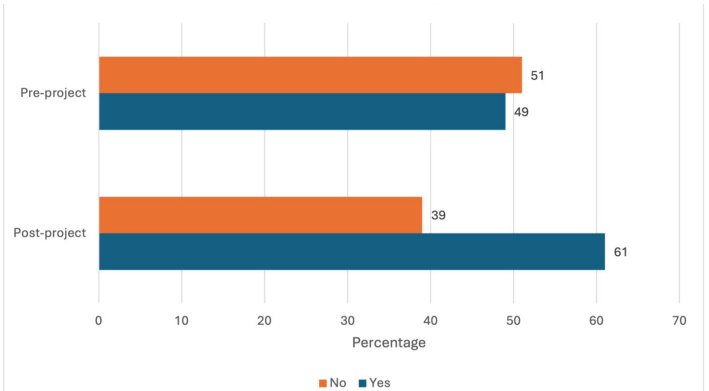

Figure 8. "I feel like a scientist/engineer." Differences in middle school student responses prior to the start of the project and following project completion.

side the other more descriptive and qualitative results from the group reflections. Many of the questions were broad, and students' feelings may change from day to day; some of this variation may have little to do with the pilot program. For example, students might report feeling more confident in science skills in the spring for various reasons, including being older and having another year of science education under their belt. Although there were several examples of improvements in the data (as discussed above), there were also cases in which students' attitudes did not change. As such, these should be understood as part of a larger approach to hands-on science education and experiential descriptions of the program.

Ultimately, the project resulted in four successful on-campus events, more robust relationships between students, mentors, and community members, and effective instruction in STEM concepts. While improving STEM skills was an important aim of this project, students' self-evaluation of those skills was just as important. In other words, their confidence in skills like working with others, and collecting, analyzing, and visualizing data could encourage future engagement with STEM education and, potentially, STEM careers. Others have noted that disengagement with STEM comes early (Moreno et al., 2016), so fostering feelings of competence during middle school can potentially bolster students' confidence in STEM for years to come. This is perhaps best illustrated by changes in students' reactions to the statement, "I feel like a scientist/engineer." Over the course of the project—where they were engaged in science activities, presented their results to community leaders, and were regularly treated like scientists, in the classroom and beyond, by their teachers and others—students' agreement with this statement increased by twelve points. Adopting a scientific identity may provide confidence as they encounter more challenging STEM subjects and skills.

Projects such as this one also may improve students' attitudes toward college. In the baseline survey, slightly more than half of students described themselves as "superheroes" when considering their future college plans. This number did not change much over the course of program activities and the academic year. However, there was improvement among those students who initially ranked themselves lower on the five-point scale. Declines among the lowest two responses (1 and 2) translated into a notable 14-point increase among those who ranked themselves at 4. This is suggestive of reaching some of the students who were most hesitant about college when entering the program.

There were similar results regarding students' comfort in working with community leaders. Again, there was a relatively stable baseline of students who expressed extreme comfort ("superhero") at both the start and end of the project. However, there was also movement from the lowest levels (especially 2) to higher levels (3 and 4) over the course of the project. This is an important indicator, as building such relationships can enhance students' feelings of empowerment and encourage community-building activities within and beyond their schools.

In their final projects, the middle school students reflected on many of the differences they saw between the park in their neighborhood and its counterpart in a wealthier neighborhood. They noted the ways that inequities materialize, such as through broken or outdated play equipment or poorly maintained restrooms and trash facilities. Recognizing and documenting such inequities is important, but not enough. By sharing these findings with community leaders, students were able to better situate themselves as leaders and advocates for their community through the data-driven evidence in their narratives.

Beyond the anticipated outcomes of the project, there were other positive results as well. For example, as mentioned, many middle school students chose to continue working on their projects after the final event and submitted their revised projects to the ArcGIS Online Competition for middle and high schools and the Arizona State GIS Symposium. An indication of the enthusiasm for integrated STEM is that there were more than 100 applications to the integrated STEM class that includes ArcGIS projects for fall 2024. One of the middle school student projects was even selected as the Arizona Middle School StoryMap winner and advanced to the national competition. In this way, students were able to continue to build valuable STEM networks, improve their STEM skills, and share their stories beyond the scope of our one-year project.

In evaluating this project, we found that it supported valuable outcomes for underserved students, including increased confidence, skill-building in STEM subjects, and relationships with peers, mentors, and community leaders. However, a project like this also comes with its share of challenges. Working with minors poses special considerations and some bureaucratic delays. For us, it took a long time to finalize survey questions due to the multiple layers of approvals needed from school administrators and parents. Each event also required a certain number of chaperones and certified adults to accompany students. We tended to have a low number of parents able to participate in field trip activities, probably exacerbated by the fact that lower-income families tend to have less schedule flexibility due to work and other obligations. This aligns with previous studies documenting lower parent involvement in poor neighborhoods with minority students (Christianakis, 2011; Threlfall et al., 2013). Nevertheless, university policy is stringent in having minors accompanied by certified adults at all times, particularly during restroom breaks. This regulation required us to carefully plan activities around "bio breaks" to ensure a chaperone was always available for restroom visits.

Another challenge was the time it took to build trust and

co-create a plan among university faculty, NGO partners, and middle school educators. We suggest allowing sufficient time for trust-building in engagement efforts and the participatory design of the program and budget. University faculty and middle school educators have different external pressures, outcome expectations, incentive structures, and schedules. Shive (1997) states that collaboration

> *between colleges and universities and K-12 schools has frequently resembled an enemy attempting to occupy someone else's country. Public schools traditionally represent a foreign country to many university professors; and, likewise, the university is traditionally a place of second-class citizenship for public school teachers.*

Our study found similar issues related to a real and perceived power imbalance between community partners and the university. For example, the university controls the budget administration of internal grants like this one, and stringent policies restrict funding use. This dictates who gets to participate and how, and who decides what the money is used for. Effective collaboration between the two institutions would address the power imbalance that leads one group to dictate the rules; this means rethinking patterns of organization, cultural priorities, norms, and roles (Shive, 1997). Separate budget accounts for each institution could help address power imbalances and reconcile differences in culture and norms.

There also can be issues engaging with undocumented or unhoused students since a social security number and address are required on tax forms in order to receive a stipend. This issue can prevent these students from participating in projects like the one reported here and is an important challenge for outreach efforts in disadvantaged neighborhoods, as has been previously documented (Lad and Braganza, 2013). In addition to the stress and the multiple challenges that undocumented families face in the US, undocumented students find difficulty navigating the educational system and accessing many services, which constitutes a human and civil rights issue (Lad and Braganza, 2013).

Additionally, we found that this type of project is very difficult to sustain in the long term by individual faculty members. While this project was recognized as an outreach effort, it did not replace any of our duties related to research, teaching, or service, as expected in our annual reviews. Because the project activities represented a significant workload added to our regular responsibilities, it is not feasible to continue doing this work in the future. This finding aligns with previous studies documenting that there tends to be a lack of university incentives to propose and implement outreach programs that require an additional workload for faculty, especially URMs, who work on these projects without formalized incentives or reward structures (Garcia, 2023).

Still, there were many benefits from this relationship-building experience. In implementing this year-long project, we helped a significant cohort of Sunnyside students grow. They were not only trained in spatial analysis but were also exposed to young role models pursuing higher education. They also had multiple ice-breaking opportunities to develop relationships among themselves and other older students. In addition, our team was able to develop valuable partnerships with a wide range of school and community leaders. This type of network can facilitate future activities. It also helps to ensure that activities are locally relevant and can help improve trust and public buy-in. All too often, seemingly "community-based" projects are implemented by outside actors without meaningful relationships with local people. By investing in people—students, teachers, and local leaders in sustainability—we have laid the groundwork for future engagement activities. Over the long term, there is also potential for alumni of this project to serve as future mentors, thus reinforcing the mutual benefits available to students, mentors, and the community at large. Already, we saw the benefits of including high school mentors who had attended the same middle school as the younger students, as it provided a strong foundation upon which to build relationships and confidence in their own abilities in STEM. Over time, this foundation can continue to grow to support a larger, more robust network of scientists and leaders.

We recommend the institutionalization of STEM mentoring programs by university schools or colleges. It is necessary to have an allocated funding source for these types of initiatives and to involve non-URM faculty members in participation through rotation schemes. It is also important to ensure the recognition of this work as part of the faculty members' service or advising responsibilities, relieving them from other duties. Incentives and awards for all participants are also helpful in ensuring the sustainability of mentoring programs, as these can increase faculty support. In addition, to achieve faculty buy-in, the program needs to be co-created by the faculty body in a participatory way. Support from other university offices is needed. For example, the admissions office at the university can co-sponsor projects like this one as part of their recruitment efforts, support campus visits with tours of the facilities, and introduce campus resources to minority students. The institutionalization of mentoring minority K-12 students is an endeavor that should be prioritized in minority-serving institutions (Castro Samayoa and Gasman, 2019). There also needs to be established institutional structures that survive leadership changes and turnover of faculty and students, which can undermine the long-term survival of such programs, despite their benefits.

Similarly, we recommend that schools and districts consider instituting policies and practices that enable K-12 edu-

cators to have the planning time, flexible schedules and seat time, and financial and material resources to undertake projects that meaningfully engage their students in the broader community. We also recommend that teacher preparation programs and K-12 professional development offerings prioritize preparing teachers to design relevant, real-world learning experiences with students and community partners. Overall, it is critical to rethink institutional patterns to integrate all educational levels, from K-12 to graduate school, which can promote intergenerational mentoring and foster pathways for minorities to pursue higher education and a STEM major.

CONCLUSION

In this paper, we report the evaluation of a pilot program that aimed to increase the enrollment of minority students in STEM majors at a higher education institution. The pilot program consisted of a youth mentoring program that brought together middle and high school students, university students, postdocs, and faculty to work on enhancing spatial analysis skills. Through four campus visits, minority students were also exposed to the university campus, breaking barriers to enrollment. During these visits, students learned about the multiple resources available to assist their education.

Student-driven mentoring activities included training on GIS, Survey123, and StoryMap. By using these software platforms, students were able to map attributes in two parks—one located in their neighborhood and the other in a wealthy neighborhood—and make comparisons. Their results were presented to community leaders and were displayed in multiple forms for a student competition.

Results suggest that, through these activities, we increased the likelihood of students pursuing a STEM education while helping build relationships and strengthening community networks. We acknowledge multiple limitations to scaling up programs like this one, including the bureaucratic hurdles of working with minors and the lack of incentives for faculty to work on these projects. Ultimately, this pilot program should be considered only a small part of a more extensive intervention needed to engage with minority students. Above all, there remains an ongoing need to address legacies of disinvestment and injustice that have put minority populations at a disadvantage, not only in STEM education but in multiple facets of human life. Finally, for the long-term sustainability of programs like this one, we recommend institutionalizing mentoring minority K-12 students in universities, particularly those designated as minority-serving institutions, and integrating all educational levels, from K-12 to graduate school, to foster mentoring and increase higher education and STEM majors in minority groups.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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ABBREVIATIONS

AIR: Arizona Institute of Resilience; DEI: Diversity, Equity, and Inclusion; ESRI: Environmental Systems Research Institute; GIS: Geographic Information Systems and Science; HIS: Hispanic-Serving Institution; NGO: Non-governmental Organization; NIH: National Institutes of Health; NSF: National Science Foundation; SARSEF: Southern Arizona Research, Science, and Engineering Foundation; STEM: Science, Technology, Engineering, and Math; URM: Underrepresented Minority Groups

REFERENCES

Anderson, E., and Kim, D. (2006). *Increasing the success of minority students in science and technology.* American Council on Education. https://www.acenet.edu/Documents/Increasing-the-Success-of-Minority-Students-in-Science-and-Technology-2006.pdf

Arcidiacono, P., Aucejo, E. M., and Hotz, V. J. (2016). University differences in the graduation of minorities in STEM fields: Evidence from California. *American Economic Review*, 106(3), 525–562. https://doi.org/10.1257/aer.20130626

Benish, S. (2018). Meeting STEM workforce demands by diversifying STEM. *Journal of Science Policy and Governance*, 13(1).

Bowman, N. A. (2013). How much diversity is enough? The curvilinear relationship between college diversity interactions and first-year student outcomes. *Research in Higher Education*, 54, 874-894.

Bowman, N. A., and Park, J .J. (2014). Interracial contact on college campuses: Comparing and contrasting predictors of cross-racial interaction and interracial friendship. *The Journal of Higher Education*, 85(5), 660-690.

Broyles, P. (2017). The gender pay gap of STEM professions in the United States. *International Journal of Sociology and Social Policy*, 29(5/6), 214-226.

Burt, B. A., Stone, B. D., Motshubi, R., and Baber, L. D. (2023). STEM validation among underrepresented students: Leveraging insights from a STEM diversity program to broaden participation. *Journal of Diversity in Higher Education*, 16(1), 53-65.

Castro Samayoa, A. and Gasman, M. (Eds.) (2019). A primer on minority serving institutions. Routledge.

Chittum, J. R., Jones, B.D., Akalin, S., and Schram, A.B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education*, 4(11). https://doi.org/10.1186/s40594-017-0065-4

Christianakis, M. (2011). Parents as "help labor": Inner-city teachers' narratives of parent involvement. *Teacher Education Quarterly*, 38(4). 157-178.

Culpepper, D., Reed, A. M., Enekwe, B., Carter-Veale, W., LaCourse, W. R., McDermott, P., and Cresiski, R. H. (2021). A new effort to diversify faculty: Postdoc-to-tenure track conversion models. *Frontiers in Psychology*, 12, 733995. https://doi.org/10.3389/fpsyg.2021.733995

Doerschuk, P., Behrim, C., Daniel, J., Kruger, J., Mann, J., and Martin, C. (2016). Closing the gaps and filling the STEM pipeline: A multidisciplinary approach. *Journal of Science Education and Technology*, 25(4), 682-695. doi:10.1007/s10956-016-9622-8.

Even, W. E., Yamashita, T., and Cummins, P. A. (2023). The STEM wage premium across the OECD. *New Horizons in Adult Education and Human Resource Development*, 35(1), 5-19.

Fakayode, S. O., Jennings Davis, J., Yu, L., Meikle, P. A., Darbeau, R., and Hale, G. (2019). Transforming STEM departments for inclusion: Creative innovation, challenges, adaptation, and sustainability at the University of Arkansas – Fort Smith. In Z. S. Wilson-Kennedy, G. S. Byrd, E. Kennedy, and H. T. Frierson (Eds.) *Broadening participation in STEM: Effective methods, practices, and programs*, (pp. 73-105). Emerald. https://doi.org/10.1108/S1479-364420190000022004

Franz-Odendaal, T. A., Blotnicky, K., French, F., and Joy, P. (2016). Experiences and perceptions of STEM subjects, careers, and engagement in STEM activities among middle school students in the Maritime Provinces. *Canadian Journal of Science, Mathematics and Technology Education*, 16(2), 153–168. https://doi.org/10.1080/14926156.2016.1166291

Garcia, G. (2023). *Transforming Hispanic-Serving Institutions for equity and justice*. John Hopkins University Press. https://doi.org/10.56021/9781421445915

Gerlak, A. K., and Zuniga-Teran, A. A. (2020). Addressing injustice in green infrastructure through socio-ecological practice: What is the role of university-community partnerships? *Socio-Ecological Practice Research*, 2(2), 149-159. https://doi.org/10.1007/s42532-020-00052-5

Gilliam, M., Jagoda, P., Fabiyi, C., Lyman, P., Wilson, C., Hill, B., and Bouris, A. (2017). Alternate reality games as an informal learning tool for generating STEM engagement among underrepresented youth: A qualitative evaluation of the source. *Journal of Science Education and Technology,* 26(3), 295-308. https://doi.org/10.1007/s10956-016-9679-4

Hegarty, M. (2014). Spatial thinking in undergraduate science education. *Spatial Cognition and Computation*, 14(2), 142-167. https://doi.org/10.1080/13875868.2014.889696

Hur, H., Maurer, J. A., and Hawley, J. (2019). The role of education, occupational match on job satisfaction in the behavioral and social science workforce. *Human Resource Development Quarterly*, 30(3), 407-435. https://doi.org/10.1002/hrdq.21343

Kinsler, J., and Pavan, R. (2015). The specificity of general human capital: Evidence from college major choice. *Journal of Labor Economics,* 33(4), 933–972. https://doi.org/10.1086/681206

Lad, K., and Braganza, D. (2013). Increasing knowledge related to the experiences of undocumented immigrants in public schools. *Educational Leadership and Administration: Teaching and Program Development*, 24, 1-15.

Lee, J., and Bednarz, R. (2009). Effect of GIS learning on spatial thinking. *Journal of Geography in Higher Education*, 33(2), 183-198. https://doi.org/10.1080/03098260802276714

Lee, H. B., Hu, X., Flores, L. Y., and Navarro, R. L. (2024). The role of contextual variables and structural diversity on college students' engineering self-efficacy. *Behavioral Sciences,* 14(7), 564. https://doi.org/10.3390/bs14070564

Lohman, D. F. (1994). Spatial ability. In R. J. Sternberg (Ed.), *Encyclopedia of intelligence*, (Vol. 2, pp. 1000-1007). Macmillan.

McGee, E.O., and Robinson, W.H. (Eds). (2019). Diversifying STEM: *Multidisciplinary perspectives on race and gender*. Rutgers University Press.

Menfield, C., Estorcien, V., Ndongo, J.-C., Quispe, M.-P., and McDonald, B.D. (2024). Retention and recruitment of minority students and faculty in public affairs and administration programs. *Journal of Public Affairs Education*, 3(1), 97-117. https://doi.org/10.1080/15236803.2023.2251338

Miller, K., Sonnert, G., and Sadler. P. (2018). The influence of students' participation in STEM competitions on their interest in STEM careers. *International Journal of Science Education, Part B: Communication and Public Engagement*, 8(2) 95-114. https://doi.org/10.1080/21548455.2017.1397298

Moreno, N. P., Tharp, B. Z., Vogt, G., Newell, A. D., and Burnett, C. A. (2016). Preparing students for middle school through after-school STEM activities. *Journal of Science Education and Technology*, 25(6), 889-897. https://doi.org/10.1007/s10956-016-9643-3

Nelson, K., Sabel, J., Forbes, C., Grandgenett, N., Tapprich, W., and Cutucache, C. (2017). How do STEM mentors reflect upon their mentoring experiences in an outreach program engaging K-8 youth? *International Journal of STEM Education*, 4(3). https://doi.org/10.1186/s40594-017-0057-4

Santos, L. R., Silva, M. M., Martins, C. A., Oliveira, N. M. F., Piani, R. C., Bezerra, J. M., and Teles, L. K. (2019). Lessons learned on conducting a STEM education program. *Proceedings of the 13th International Technology, Education and Development Conference*, 9031-9040. https://doi.org/10.21125/inted.2019.2244

Seymour, E., and Hunter, A.-B. (Eds.). (2019). *Talking about leaving revisited—Persistence, relocation and loss in undergraduate STEM education*. Springer Nature.

Shive, G. (1997). Collaboration between K-12 schools and universities. In N. E. Hoffman, W. M. Reed and G. S. Rosenbluth (Eds.), *Lessons from Restructuring Experiences: Stories of Change in Professional Development Schools*, (pp. 33-49). State University of New York Press.

Sidanius, J., Levin, S., Van Laar, C., and Sears, D .O. (2008). *The diversity challenge: Social identity and intergroup relations on the college campus*. Russell Sage Foundation.

Smith-Doerr, L., Alegria, S. N., and Sacco, T. (2017). How diversity matters in the US science and engineering workforce: A critical review considering integration in teams, fields, and organizational contexts. *Engaging Science, Technology, and Society*, 3, 139-153. https://doi.org/10.17351/ests2017.142

Subburaj, A. S., Lockwood-Cooke, P. R., Hunt, E. M., and Subbaraj, V. H. (2020). Initiatives to financially, academically, and socially support underrepresented minorities in STEM disciplines. *ASEE Annual Conference and Exposition Conference Proceedings*. https://doi.org/10.18260/1-2--34830

Sunnyside Unified School District. (2022). *Profile of a graduate*. https://susd12.org/22/district/

Threlfall, J., Seay, K. D., Kohl, P. L. (2013). The parenting role of African American fathers in the context of urban poverty. *Journal of Child Poverty*, 19(1), 45-61. https://doi.org/10.1080/10796126.2013.764846

Udall Foundation. (n.d.). Steward E. Udall Parks in Focus® Program. https://www.udall.gov/ourprograms/parksinfocus/parksinfocus.aspx

Uttal, D., and Cohen, C. A. (2012). Spatial thinking and STEM education: When, why, and how? In B. Ross (Ed.), *Psychology of learning and motivation* (Vol. 57, pp. 147-178). Academic Press. https://doi.org/10.1016/B978-0-12-394293-7.00004-2Get rights and content

Varnado, J. W. (2021). Encouraging underrepresented minority student participation in the STEM pipeline through authentic STEM learning experiences. [Doctoral dissertation, University of Houston]. https://uh-ir.tdl.org/server/api/core/bitstreams/d409324d-48f1-40f6-8e58-01542dabf51f/content

Wai, J., Lubinski, D., Penbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, 101(4), 817-835. https://doi.org/10.1037/a0016127

Wilson-Kennedy, Z., Byrd, G. S., Kennedy, E., and Frierson, H. T. (Eds). (2019). *Broadening participation in STEM: Effective methods, practices, and programs*. Emerald. https://doi.org/10.1108/S1479-3644201922