Virtual STEM Labs: Engaging and inspiring Hispanic youth to pursue STEM degrees and careers

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Background/Motivation

Solving the world's most pressing and complex issues, including the recent pandemic, climate and environmental challenges, and sustainable economic development, is dependent on scientific innovation. This need is reflected in Science, Technology, Engineering and Mathematics (STEM) occupation growth which has increased 79% since 1990 and is projected to grow by 10.8 percent by 2031 [1]. To meet these labor market demands, the United States has consistently invested over $500 million dollars in STEM education specifically since 2019 with an emphasis on programs that increase participation of minoritized and underrepresented groups [2]. The emphasis on promoting a more equitable, diverse, and inclusive STEM industry is demonstrated through the recent "You Belong in STEM" National Coordinating Conference hosted by the U.S. Department of Education. The conference garnered support from over 90 organizations including affinity organizations that support and promote the participation of minoritized groups in STEM education and industry [3].

Research highlights the impact of early STEM experiences on building a STEM identity for the pursuit of STEM education and career pathways [4]. Research consistently finds that a child's STEM identity is developed as early as elementary school [5]. Introducing STEM concepts at a young age is essential to not only academic competency but also comfortability, self-efficacy, and awareness [6]. Early exposure to different STEM career paths increases the chance of a student choosing STEM as their career destination. More specifically, Dou et al. found that informal STEM experiences including "science consumption" through STEM activities at home and conversations with family and friends about science "were predictive of STEM identity in college" [7]. Further, research shows that social capital is key to broadening participation in STEM; Saw suggests that a student's social capital is "derived from families, peers, teachers, and professional networks" and supports their academic performance in STEM subjects as well as their career trajectory in STEM pathways [8]. Convincingly, informal experiences outside of the classroom have proven to be significantly associated with STEM education and career outcomes. As a result, policies and programs that support informal out-of-classroom "science consumption" can help fill gaps in social capital for minoritized students in STEM.

The Hispanic/Latinx population in the United States is a key demographic for meeting the STEM labor market demands now and in the future. Hispanic people are the fastest growing ethnic demographic in the United States both in population and participation in the labor force [9]. But, according to a recent Pew Center research report, the disparity of Hispanic representation in STEM industry is not narrowing [10].

The Society for Hispanic Professional Engineers (SHPE) is committed to the You Belong in STEM campaign ran by the U.S. Department of Education and is taking a novel approach to increasing Hispanic students' identity in STEM with the goal of increased participation in STEM career pathways. SHPE has developed a program, called Virtual Stem Labs (VSL), that increases

students' social capital in STEM by increasing "science consumption" through at-home activities that involve the whole household. This programmatic offering increases access and awareness to STEM for primarily first-generation Hispanic students who are less likely to have inherited a social network of STEM professionals compared to their white counterparts. This paper outlines the program's objectives, implementation, and results for the first two years of its operations. These findings aim to highlight the impact and growth of this program to date, make data-driven recommendations for programmatic improvement, and provide best practices which can be applied to similar programming for Hispanic and other minoritized groups in STEM and education more broadly.

Program Description and Objectives

SHPE's Virtual Stem Labs (VSL) are grounded in the belief that all Hispanic pre-college students can excel in STEM if they are provided access to the tools and resources that support their progress toward a STEM degree regardless of where they are in their academic journey. VSL is a pre-college program that brings STEM concepts to hundreds of Hispanic and Latinx K-12 students with a variety of opportunities and experiences that spark excitement for STEM. This program meets students where they are – both developmentally and geographically. VSL brings hands-on STEM experiences to a student's home, their school, their community, and their computer. The goal is that students truly have access to informal after-school STEM experiences and explore them without any limits.

VSL's have three core objectives:

1. increasing awareness of STEM fields and careers;
2. increasing participants' beliefs about their ability to succeed in STEM; and
3. increasing participants' sense of STEM identity.

These objectives are derived from Dou and Clan's expanded model for constructing STEM identity [11]. VSLs are usually offered twice a month at different times aligned with U.S. time zones to increase access to students all across the United States. These labs are typically sponsored by a corporate industry partner and last two hours. Participants have the opportunity to hear from engineering students and professionals, complete a STEM hands-on activity using a pre-packed science kit, and present their work to others in attendance. The following sections provide additional information on how the program leadership team establishes partnerships, conducts outreach, and implements the program.

Establishing Partnerships

SHPE's Virtual STEM Labs are a collaboration between SHPE, industry partners, school district partners, and the supplier of STEM activities. Industry partners sponsor one or multiple virtual STEM labs per fiscal year depending on their grant contribution. Typically, this funding aligns with the company's philanthropic mission or community outreach goals, and also provides a mechanism for employee volunteerism. Industry partners are highlighted throughout the event and are often guest speakers. They have the option to invite engineers and other STEM professionals to interact with the students, serve as panelists for the Q&A session, and model the STEM activity alongside the students. Everyone supporting the event goes through intensive

volunteer training where they learn their roles and responsibilities, receive access to the kit guides, and learn the science behind the STEM kit. This allows volunteers to better instruct the student participants. The industry involvement in the program is important for providing students with role models with similar backgrounds and life experiences as them; research has shown that this is critical in supporting and building STEM identity for a minoritized group, especially Latinas [12]. In this way, the partnership supports the three program objectives by presenting different STEM fields and career options to students, illustrating to students that people like them can have a successful trajectory in their STEM path, and seeing themselves represented within the STEM field.

Additionally, industry partners have the opportunity to identify local schools or organizations that they would like to invite for participation in the VSL. Often, industry partners already have working relationships with multiple communities and the local schools within those communities. In this way, the program reaches communities where trust has already been established, and the accessibility of the VSL program increases the industry partner's reach and impact. In order to support students with the highest demonstrated need and the target program demographic, title I schools with high Hispanic student populations that are traditionally underserved are prioritized.

Registration Process and Participant Selection

The virtual offerings are provided once a month at two different times to expand the program's reach across different time zones. The event is marketed in SHPE's newsletter, SHPE Nation, through a dedicated email blast, and to schools SHPE has formed a relationship with. Parents and caregivers are invited to register their student(s) for participation through an online registration form (JotForm) for each VSL. The registration form has been developed in English and Spanish to support registration for Spanish-speaking parents and caregivers. Caregiver and student demographic information is collected in order to be able to speak on communities served and impact. Caregiver information collected includes name, address, email, phone number, education, demographics, and eligibility for free/reduced lunch. Student information collected includes name, address, birthdate, grade, and school information. Participants are selected on a first come, first serve basis until the maximum capacity of kits available is reached which depends on sponsorship and kit cost, but usually around 120-160 kits per VSL. Upon registration parents/students are notified via email. Figure 1 shows an example of the program's advertisement in SHPE Nation Newsletter.

Family Communication

Families are sent two email reminders with the updated program URL; event start times and the PDFs of the guides they will assemble. All communication is provided in Spanish and English to ensure accessibility for our Spanish-speaking caregivers.

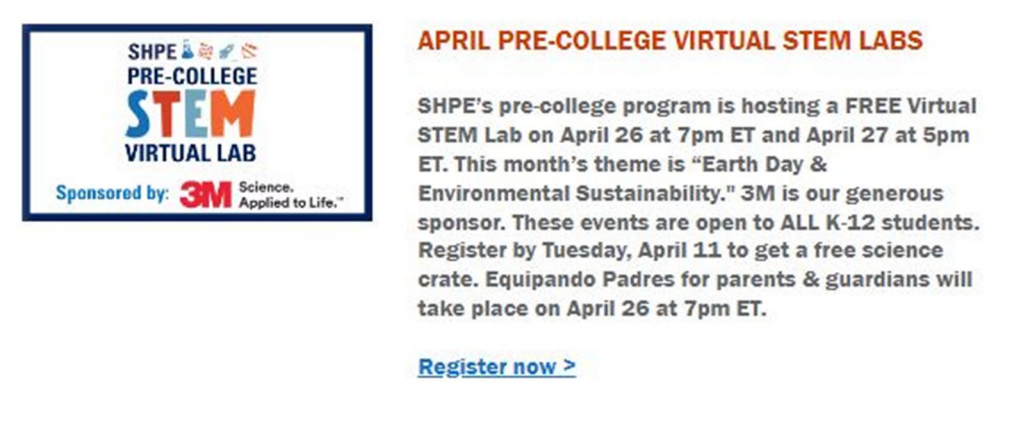


Fig. 1 SHPE's VSL Advertisement in SHPE Nation

Operation of a Virtual STEM Lab

All VSLs have a consistent flow and monthly theme and are administered by facilitators. Facilitators are SHPE students and professionals as well as sponsor volunteers. The agenda format includes:

1. Welcome from SHPE
   Students are welcomed to the event, SHPE staff introduce themselves, and attendance is taken by facilitators.

2. Community Agreements
   Standards are set in conjunction with the students about behavior and communication expectations. Some examples include listening to others and waiting for their turn to speak, being respectful, and engaging with questions and the activity.

3. Event Host Explains Agenda
   The event host, usually either an industry sponsor representative, or an individual versed on the monthly theme explains the agenda for the VSL and goes over the activities the students will work on and connects them with the lab's theme. The event host also provides information about themself, their education, and their STEM journey.

4. Guest Speaker
   The guest speaker, also usually either an industry sponsor representative, or an individual versed on the monthly theme, takes the "virtual" stage and discusses their STEM journey or a topic applicable to the monthly theme. At this point, the 5-12 students stay for a Q&A session with the guest speaker and a panel of students and professionals, while the K-4 students go to their breakout room to start working on the activity.

5. Breakout Rooms
   Students are divided according to their grade level (K-4, 5-8, 9-12). There are two facilitators in each room that walk them through the hands-on STEM project which commonly includes KiwiCo Science Crates.

6. Evaluation
   Students are given a survey through Kahoot to evaluate program effectiveness in reaching its goals. More information on program evaluation is given later in the paper.

7. Show and Tell
   Students are given an opportunity to take the "virtual" stage to share their projects and what they learned.

8. Closing
   The activity is closed with closing remarks from the host which includes thanking facilitators, volunteers, industry sponsors, sharing our social media platforms, and future VSLs dates and opportunities to engage.

Fig. 2. Example of kits used for the April 2023 VSL.
(Left: Environmental Science: Oil Cleanup, middle: Drip Irrigation, right: Electrochemistry lab.)

Project Examples and Themes

The KiwiCo project kits are carefully selected to align with the monthly theme of the VSL. For example, the April 2023 VSL's theme was "Earth Day and Environmental Sustainability". As part of this theme, K-4th grade students worked on an oil cleanup project, where students simulated an oil spill and rescued affected wildlife. The 5th-8th grade students worked on a drip irrigation project that taught them about one of the most environmentally sustainable irrigation methods, and the 9th-12th grade group constructed a saltwater-powered clock and learned about sustainable energy production. Table 1 shows the different themes and projects that have been covered since December 2022.

TABLE I

VSL'S THEMES AND PROJECTS

Month	Theme	Kits Used
December 2022	N/A	K-4: Solar System 5-8: Water Fountain 9-12: Electric Pencil Sharpener
January 2023	You Can Be Both! Exploring STEM & The Arts (Kits highlighted both science and art.)	K-4: Chomping Mechanical Dinosaur 5-8: Light- Up Wire Art 9-12: Ukulele
February 2023	Celebrating Black History Month (Kits highlighted notable African American figures/inventors.)	K-4: Marine Biology Starter 5-8: Civil Engineering Starter 9-12: Hand pump
March 2023	Celebrating Women's History Month (Kits highlighted notable female scientists.)	K-4: Fun with Flight 5-8: Snake Robot 9-12: Laser Speaker
April 2023	Earth Day & Environmental Sustainability (Kits highlighted environmental themes.)	K-4: Environmental Science: Oil Cleanup 5-8: Drip Irrigation 9-12: Electrochemistry Lab

Host & Facilitators Responsibilities

SHPE's VSL program employs students and professional leaders to serve as support staff. Research shows that Hispanic students often need to take on separate jobs, which are not STEM-related, to make ends meet while they are studying [13]. Therefore, these facilitator jobs provide them with an opportunity to earn extra income while studying, build their resume, and reinforce their STEM identity. Facilitators are compensated $200 for their time spent preparing and assisting with each VSL.

Facilitators are primarily undergraduate, graduate, or PhD students with 62% of facilitators being undergraduate students, 19% being graduate students,14% pursuing their PhD, and 5% being professionals. The represented majors include Civil Engineering, Molecular, Cell, and Developmental Biology, Mechanical Engineering, Chemical Engineering, Industrial Engineering, Biomedical Engineering, Computer Science, Computer Engineering, Electrical Engineering, Computational Science, Aerospace Engineering, Microbiology, Higher Education, and Nursing.

Facilitators were trained to support the learning of K-12 students, with STEM content creator Jay Flores providing the training. Training covered topics and skills such as how to discuss

engineering with young students, effectively leading hands-on STEM activities, guiding students through the engineering process, and providing a safe space and enriching virtual learning environment. The training was recorded so that facilitators can refresh their knowledge and to train new facilitators when needed.

Facilitators are assigned to various roles for each VSL, which include:

- **Event Host**
  Welcomes students as they enter the event, interacts with students, and provides leadership throughout the event.

- **Keynote Speaker**
  Notable individual that provides students with information on their STEM journey.

- **Q&A Panelists**
  Participate in a Q&A session focused on the VSL theme.

- **Q&A Panelist Leader**
  Host of the Q&A session.

- **Activity Lead**
  Main facilitator in charge of STEM activity in their designated breakout room. The activity lead is the primary speaker that discusses the steps of the STEM kit guide and partners with the activity demonstrator to show students how to build the kit and respond to questions.

- **Activity Demonstrator**
  Presents the STEM kit guide on screen and assists the lead in explaining each step in the construction of the kit. The activity demonstrator also interacts with students through the chat and assists with any questions.

- **Attendance Tracker**
  Records student attendance.

- **Student Interaction & Support**
  - **Mute & Name Support**
    Maintains the waiting room, ensures students are muted throughout the event, contacts students to change their display name to established naming convention.
  - **Chat Support & Porrista (cheerleader)**
    These are the event cheerleaders who praise students in the chat, leave encouraging comments, reassure students, and respond to student questions/comments.
  - **Screen Monitor**
    Ensure that no students or parents are exhibiting behavior that goes against SHPE's behavior policy.

Program Evaluation

To monitor the program's progress and effectiveness, we collect the following data after each VSL:

- The total number of students registered
- The total number of students who attended
- Registration and attendance by grade level

The results from September 2021 to January 2023 on all these measures are presented in the next section.

For the April 2023 VSL, we conducted a pilot test of a 6-question survey using Kahoot, a game-based learning platform. The survey was designed to be quick and engaging while measuring at least one of our three program goals. Each question utilized a 4-point scale ranging from "Strongly Disagree" to "Strongly Agree". Table 2 presents the questions corresponding to each program goal. The results of the pilot test are presented in the following section.

TABLE II

SHPE'S VSL PROGRAM OBJECTIVES AND SURVEY QUESTIONS

Program Objective	Questions
1. Increasing awareness of STEM fields and careers	Because of this STEM lab, I know about different kinds of STEM jobs.
2. Increasing participants' beliefs about their ability to succeed in STEM	Because of this STEM lab, I am better at building things. This STEM lab has taught me skills that will help me do better in my science classes at school.
3. Increasing participants' sense of STEM identity	Because of this STEM lab, I know I can be a scientist or engineer one day. This STEM lab has provided me with the knowledge necessary to understand science concepts. This STEM lab has helped me see that I am a science person.

Results

VSL events have been conducted on a regular basis since September 2021. SHPE was able to implement the program through sponsorship of six industry partners including Meta, Honeywell, Dow, Bechtel, Toyota Research Institute, and 3M.

During these 21 events, a total of 2,608 pre-college students participated. Figure 3 shows the number of students registered and the number of students that attended each one of the VSLs for the period between September 2021 to January 2023.

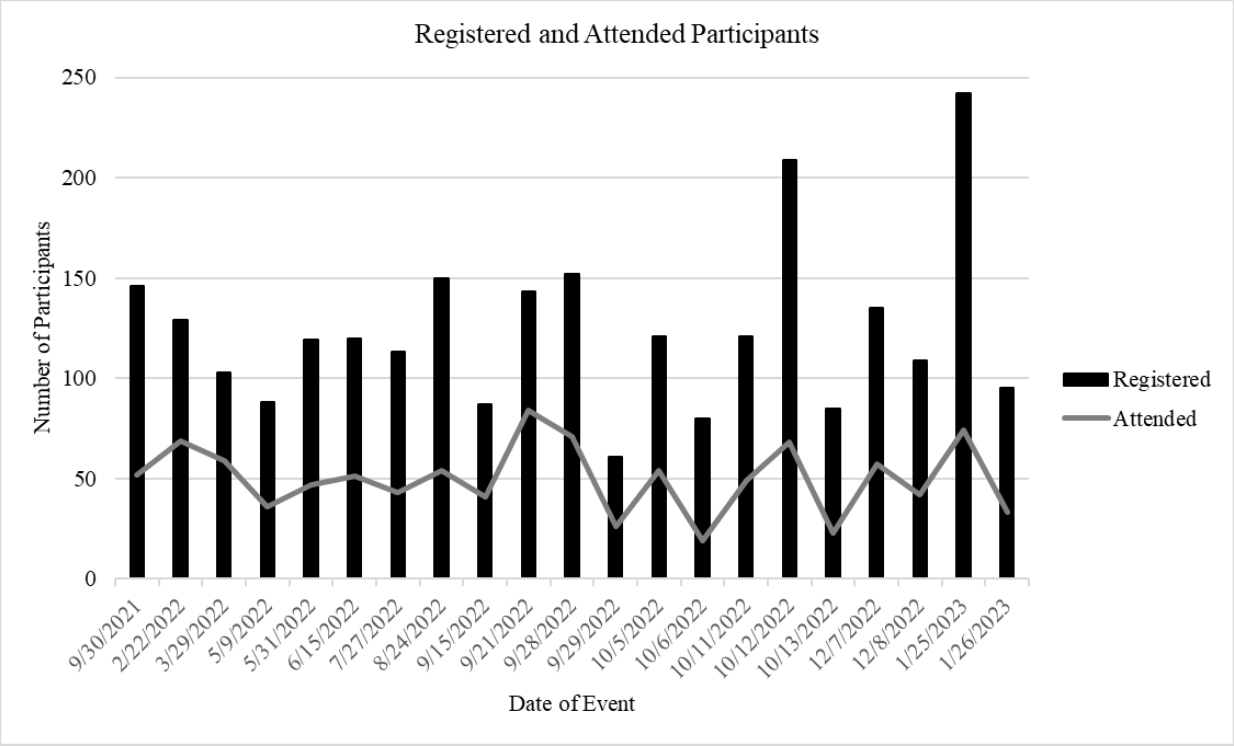


Fig. 3: Number of Participants that Registered and Attended, Per Event

Unfortunately, participation is capped so not all were able to participate in the complete VSL program. However, all the registered students were provided with a STEM kit to participate on their own at home. Due to the increased demand over the 120-150 kit range limit, program leadership is currently exploring ways to be able to serve more pre-college students given the resources at hand.

Figure 4, below, shows VSL registrants between September 2021 and January 2023 by grade level. As noted in the graph, the majority of registrants (55%) were students in elementary school. Most students are registered by their mothers (71%); and, on average, 30% of those registered are first-generation-to-college students.

VSL attendance between September 2021 and January 2023 is shown below in Figure 5 by grade level. On average, the program has a 40% attendance rate. This is an area of opportunity for program improvement. The challenge is that many register to get the free STEM kit and do not attend and participate in the VSL. Attendance by grade level is very similar to the graph of those registered by grade level. As noted in the graph, the majority of participants who attended (58%) were students in elementary school. There were also students in attendance that did not register, during the period from September 2021 to January 2023; this includes a total of 95 “tag along” participants. No further descriptions can be given of this group as they did not fill out a registration form.

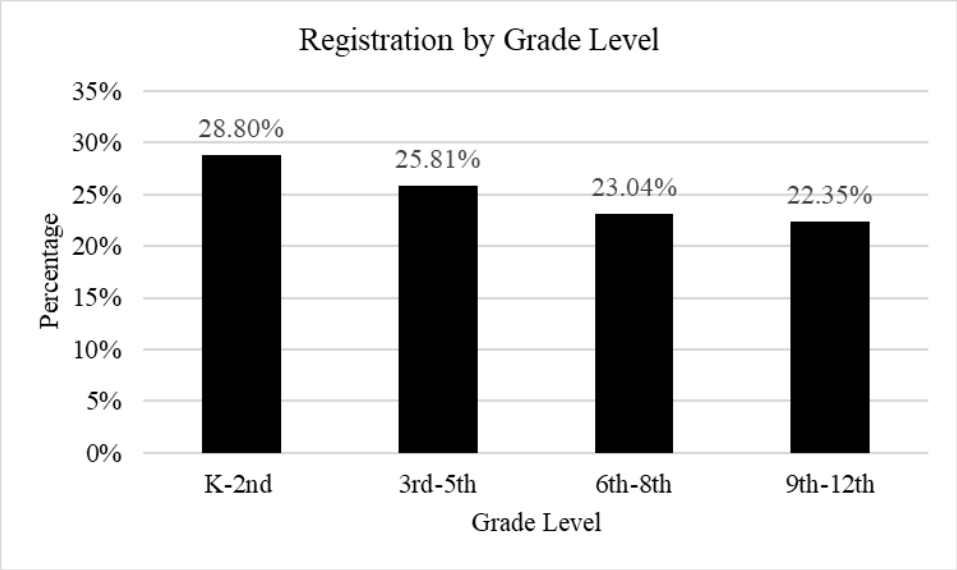


Fig. 4: Registration, by Grade Level

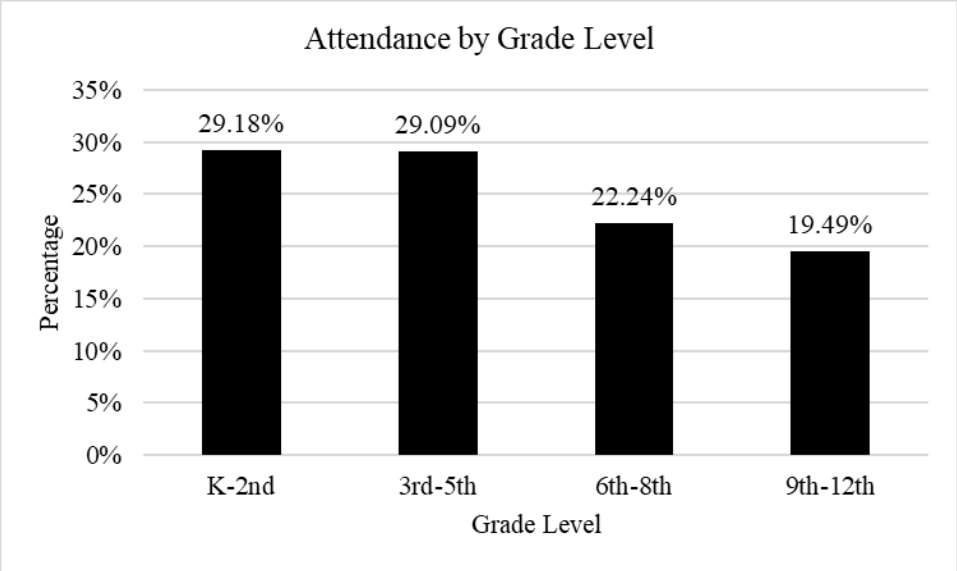


Fig. 5: Attendance, by Grade Level

The 21 VSLs included in this report had a total of approximately 407 volunteer hours, and the total number of volunteers is approximately 139. This estimate is not a unique count of volunteers, as many of them have participated in more than one VSL. The program team is currently working on methods to better keep track of volunteers and volunteer hours.

In the VSL registration form, parents are asked for their students' name and birthday. This is done so that participants can be tracked on their future education trajectory using the StudentTracker database. The report from StudentTracker provides the following information:

- If the student is attending or attended college. College they are attending/attended and the state of that college. The information also identifies if the institution is a 2-year or 4-year institution and whether is public or private.
- Enrollment start and end date as well as current student enrollment status.
- Student's class level.
- Student's enrollment major and how many times, if any, they have changed majors.
- If the student has graduated, and what degree was conferred.

From those that attended/registered for VSL events for the period of September 2021 to January 2023, data was verified for 51 students that were in high school and are presumed to have graduated. The program leadership is interested in learning if these students went to college, and if they did, if they chose a STEM major. From those submitted, detailed data for 12 students was received back from StudentTracker. The other 39 had no data which might be a result of having a wrong birthday, a wrong name, or the student might have their records blocked. While this is too small of a sample size to make any generalizations, it is provided to show the varied information given for participants that have a record with Student Tracker. It has the potential to show programmatic impact and outcomes as participants graduate and go through their college journey.

Table III: StudentTracker Data

Student	Grade Level	2-year	4-year	Major
1	Senior		x	
2	Senior	x		
3	Senior	x		
4	Senior		x	Civil Engineering BS UG
5	Junior		x	Math & Engineering
6	Junior		x	Engineering Technology
7	Junior		x	
8	Junior	x		
9	Junior	x		
10	Sophomore	x		
11	Sophomore	x		
12	Freshman	x		

Of the records submitted, ten were seniors, and an assumption is made that six had graduated because they attended a VSL before May 15, 2022, and likely graduated in May 2022. Of the two senior records that were found, one went to a 4-year college with its major reported as "Freshman Connection", and the other one also went to a 4-year college with a major in "Civil Engineering BS". The other two enrolled in a 2-year institution with no major listed, likely a dual enrollment or college credit courses while still in high school.

For juniors, 18 participants were submitted, data was received for 5. Three out of the five enrolled in a 4-year institution, one with a major reported in "Math, Engineering, and Science",

the other in “Engineering Technology”, and the third one with no major reported. The other two appeared to be enrolled in a 2-year institution with no major listed.

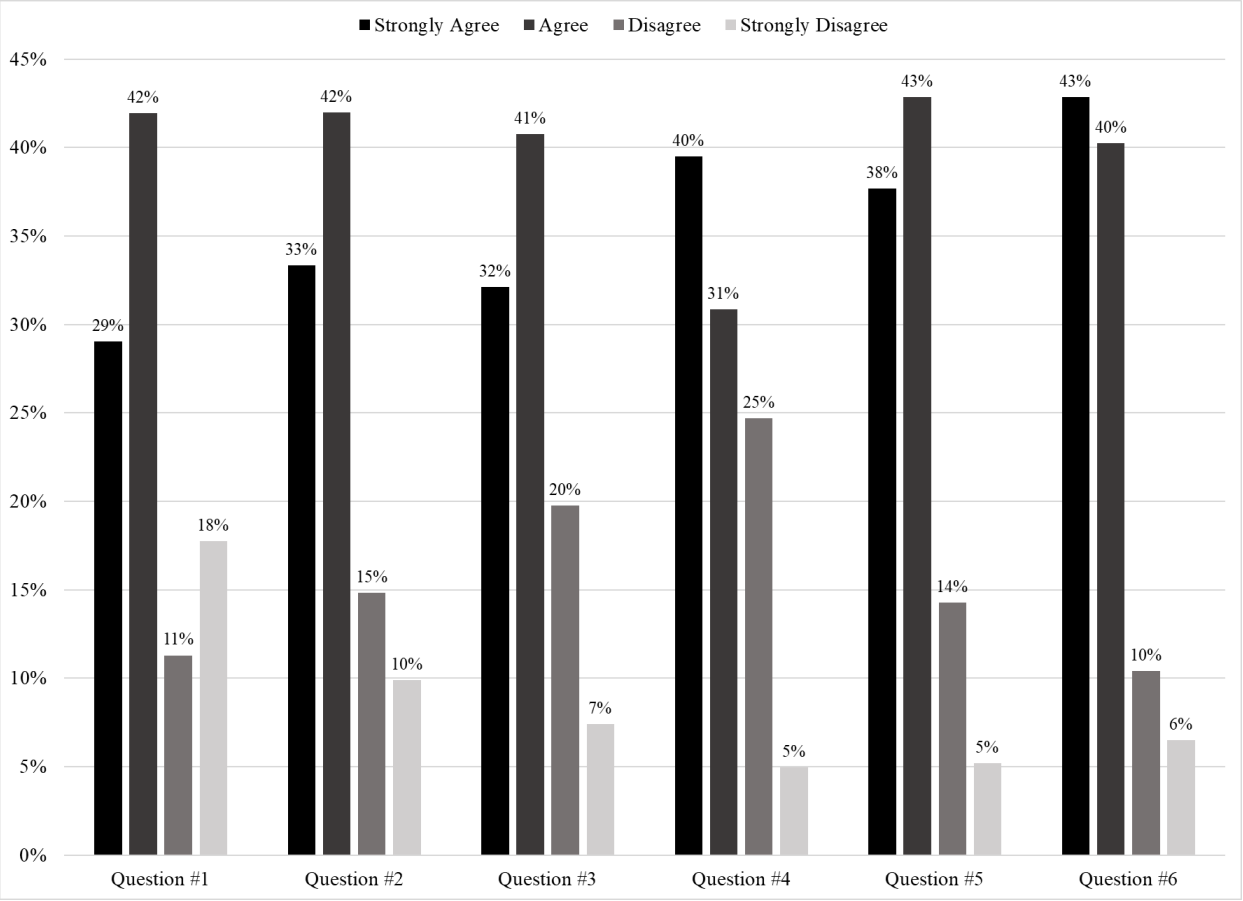
For sophomores, 13 participants were submitted, and data was received for two; both enrolled in a two-year institution with no major listed. Finally, for freshman, 10 participants were submitted, and data was received for one participant who is enrolled in a two-year institution with no major listed.

Based on this very small sample size, of those for whom we got our records back, 58% are currently enrolled in a 2-year institution while 42% are enrolled in a 4-year institution. From those, 25% chose a degree in STEM.

The goal for continued data collection is to better be able to understand and formally communicate the program’s impact. This includes measuring trends of how many pre-college participants enrolled in college, how many of them chose a STEM major, and how many persisted and graduated. This would tie back to the three program goals: increasing awareness of STEM fields and careers; increasing participants’ beliefs about their ability to succeed in STEM; and increasing participants’ sense of STEM identity. As a result, a formal program evaluation can be conducted to either continue investment in this programming, expand it, or divert based on the findings.

No data is given in this paper for the VSLs conducted for the period of February 2023 to April 2023 as data is still being processed and will be published at a future time, however we had the opportunity of pilot testing an impact survey during April 2023 and preliminary results are shown below in Figure 6.

As stated earlier in the paper, the survey was administered using Kahoot and consisted of 6 questions that were tied to the program goals. Figure 6 shows the preliminary survey results, which indicate that overall, most participants either strongly agree or agree with the statements. From those that answered the survey, 43% were female and 57% were male. In terms of grade level, 45%, 33%, and 22% were K-4, 5-8, and 9-12 respectively.



- Question #1: Because of this STEM lab, I know about different kinds of STEM jobs.
- Question #2: Because of this STEM lab, I am better at building things.
- Question #3: This STEM lab has taught me skills that will help me do better in my science classes at school.
- Question #4: Because of this STEM lab, I know I can be a scientist or engineer one day.
- Question #5: This STEM lab has provided me with the knowledge necessary to understand science concepts.
- Question #6: This STEM lab has helped me see that I am a science person.

Fig. 6: Program Impact Survey Results for April 2023

Future Direction

The future of VSL includes a plan to continue with once-a-month offerings with two distinct time options. In addition, program leadership is investing time in the evaluation of different opportunities to increase the program's reach with the goal of better serving the Hispanic community, and more specifically, Hispanic pre-college students with low socioeconomic status (SES).

The program team is currently developing VSLs designed for schools, with a very similar format but targeting classrooms instead of individuals. The activity would still be virtual but would have the opportunity to broadcast to multiple classrooms and schools with just one event. School site selection is currently underway using information from the Department of Education. The goal is to find schools with a high population Hispanic and with a high percent of students with low SES using free or reduced lunch qualification as an indicator.

Training for volunteers and facilitators is also underway. This training will consist of a series of short videos developed by STEM content creator, Jay Flores. Jay Flores was selected, because he is a social media influencer with experience in K-12 programming, so he brings a unique perspective on how to better reach and communicate with kids in a motivational manner. The training will go over important topics like how to create a welcoming and fun introductory period while students are logging in or arriving to an event, how to maintain progress of project and help students falling behind, how to manage student questions, and how to engage students with a language they can understand. The possibility of making this training a certification is also being considered so that our volunteers and facilitators can use it to build up their resume. The nascent findings provided in this report support the existing research that shows that pre-college students are key in closing the gap of Hispanic representation in STEM careers. The VSL team is excited to continue growing this program and be able to continue to change the lives of many, with the help of partners, sponsors, and supporters.

Acknowledgements

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