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Assessing the Impact of Inclusive STEM Outreach with Near-Peer Mentorship in a Middle School Mobile Bioengineering Program (Evaluation)

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Abstract

Persistent disparities in the quality and accessibility of kindergarten through 12th grade (K-12) science, technology, engineering, and mathematics (STEM) education remain a challenge, particularly for interdisciplinary fields, such as bioengineering, that require integration across multiple domains. Bioengineering is frequently perceived as inaccessible due to its experimental costs and technical complexity. Furthermore, K-12 educators often face barriers to implementing such topics, including limited budgets, insufficient training, and systemic constraints. Nevertheless, bioengineering's subject matter can be meaningfully embedded within existing middle and high school science courses, offering a pathway to broaden exposure without requiring new standalone programs.

Outreach initiatives extend a promising structure to address the gaps in training, while also providing STEM role models for students from underserved communities who may lack access. An effective approach within these initiatives is near-peer mentorship, in which mentors and mentees are separated by only a few years of training. This dynamic has demonstrated benefits for both groups, especially in the context of K-12 and undergraduate students. K-12 mentees gain relatable guidance and support, while undergraduate mentors develop stronger communication skills and increased confidence in their disciplinary knowledge through teaching experience.

The Mobile Bioengineering Lab was developed by the Biomedical Engineering Journal Club at the University of Illinois Urbana-Champaign to provide hands-on, experiential learning in life sciences and bioengineering for local students with limited exposure to STEM. Following a successful pilot implementation in 2024-2025, the outreach initiative was expanded in collaboration with an 8th-grade biology classroom in Fall 2025. Through a series of biweekly workshops, structured to closely align with their school curriculum, students engaged with bioengineering topics and techniques including DNA extraction, gel electrophoresis, chromatography, regenerative medicine, biomechanics and prosthetics, and fluorescence microscopy. Undergraduate volunteers delivered brief introductory presentations and then guided students through each experiment during classroom visits.

This study evaluates the impact of the Mobile Bioengineering Lab on middle school students' confidence and interest in STEM, comprehension of bioengineering concepts, and perceptions of STEM degrees and careers through near-peer mentorship. We also examine the development of university students' mentoring and science communication skills, as well as their emerging identities as bioengineers. Finally, we share resources and strategies to support educators in integrating bioengineering into middle school curricula, with the goal of offering a scalable outreach model applicable across school districts, regions, and diverse student populations.

Introduction

Bioengineering in K-12 Education

Public kindergarten through 12th grade (K-12) science, technology, engineering, and mathematics (STEM) education standards in the United States are primarily determined by state. However, 44 states and the District of Columbia adopted K-12 life-science curricula and recommendations set by the Next Generation Science Standards (NGSS) in 2013 [1]. These guidelines emphasize evidence-based instruction and the integration of science and engineering practices across grade levels. Even so, decisions about implementing the framework are largely left to the states, districts, and schools, leading to a nationwide disparity in the quantity and quality of STEM education each student receives.

This imbalance is particularly noticeable for interdisciplinary fields that require the integration of various domains. Prior research employing the NGSS framework shows that K-12 STEM educators often struggle with implementing this suggested curriculum [2]. This could be attributed to restrictive classroom budgets, lack of teacher training, and the overall struggle of the public educational system to support diverse educational needs and ambitions [3]. As a result, multidisciplinary fields, such as bioengineering, face even greater barriers to K-12 inclusion [1].

Bioengineering applies engineering and design principles within biological contexts, making it a practical venue to incorporate engineering into K-12 biology curricula rather than requiring new independent courses [4]. However, engineering concepts may seem abstract for students who struggle to relate the content to real-world applications [5]. Here, Kolb's Experiential Learning Theory provides a useful pedagogical framework for engineering education [6]. In the theory's four-stage cycle, students are first exposed to hands-on problem-solving before reflecting, conceptualizing, and iterating to address challenges. Experiential learning can be especially effective in bioengineering education, which is intrinsically hands-on through engineering design, experimentation, reflective quantitative and qualitative analysis, and iteration [7, 8].

Role of Outreach & Mentorship in K-12 Education

While experiential learning provides a compelling framework for the classroom, a question still remains: where will this bioengineering expertise originate? Most K-12 teachers understandably lack training in the field, and budget constraints make hiring dedicated engineering instructors impractical [9]. Experienced bioengineering students and professionals have long designed outreach initiatives and accessible resources to attempt to fill this gap [10, 11].

Outreach initiatives can play a significant role in supporting students through their learning experiences, especially for those from underserved communities who may lack access to role models in STEM [11]. While many outreach programs utilize traditional mentorship models that rely on professional scientists or university faculty's guidance, the age gap and perceived professional distance can make these mentors seem less approachable or relatable to K-12 students [12]. Near-peer STEM mentorship, where individuals in the dynamic are separated by only a few years of experience rather than entire career stages, have been shown to reduce self-doubt and increase a sense of belonging, even more so for underrepresented groups [13].

This outreach arrangement and mentorship relationship also becomes mutually beneficial. Undergraduate STEM students who participate in outreach and teaching activities show improved communication skills and increased confidence in their disciplinary knowledge [14].

Mobile Bioengineering Lab's Groundwork

The Mobile Bioengineering Lab (MBL), an experiential outreach initiative developed at the University of Illinois Urbana-Champaign (UIUC) by the Biomedical Engineering Journal Club (BMEJC), provides hands-on bioengineering workshops to students with limited STEM exposure [15]. The pilot MBL program established a biweekly collaboration between an 8th-grade biology classroom at a bilingual (Spanish and English) school and the BMEJC during the 2024-2025 academic year [16]. Middle school students were selected as the target MBL audience, as NGSS-mandated science courses (employed in Illinois) at this formative stage can establish a foundation in STEM leading to high school coursework and future careers [17].

To execute the pilot program, undergraduate volunteers from the BMEJC developed, presented, and led students through hands-on experiments relevant to the students' curriculum. For example, in coordination with the classroom teacher, a DNA extraction lab followed a genetics unit. The workshop series elevated students' STEM confidence and interest and improved understanding of bioengineering concepts while documenting possible classroom bioengineering integration strategies [15]. In the 2025-2026 academic year, the MBL expanded to an additional 8th-grade classroom in the same district, introducing four improved and three newly developed workshops over one semester. Methods to recruit undergraduate volunteers and conduct workshops are previously described [15].

Objectives

In this Evaluation, we aim to assess the expanded Mobile Bioengineering Lab's impact on:

1. middle school students' confidence and interest in STEM, comprehension of bioengineering concepts, and perceptions of college and STEM careers via near-peer mentorship;
2. the development of university students' skills as mentors and science communicators, and identity as bioengineers; and
3. additional strategies for effectively integrating bioengineering into middle-school curricula.

Methods

8th-Grade Student Population

In the 2025-2026 Illinois Report Card, the K-8 school's student population was 57.9% Black, 27% Hispanic, 6.8% White, 3.6% Asian, and 4.6% that identified with 2 or more of the aforementioned races. 47.4% of the population identified as male and 52.5 % identified as female. Additionally, over 78.6% of students come from a low income background. Moreover, the students' science proficiency rate (Illinois State Assessment) of 6.8%, was significantly lower than that of the district (32.6%) and state (43%) [18]. In the Fall 2025 8th-grade biology classroom, there were a total of 33 students across 3 class periods.

Volunteer Population & Material Preparation

As the MBL operates under the BMEJC, all undergraduate students at the university were eligible to volunteer. Recruitment occurred during university-sanctioned student engagement events and other promotional marketing, such as dispersing fliers in life science or engineering buildings and delivering promotional presentations to bioengineering classes.

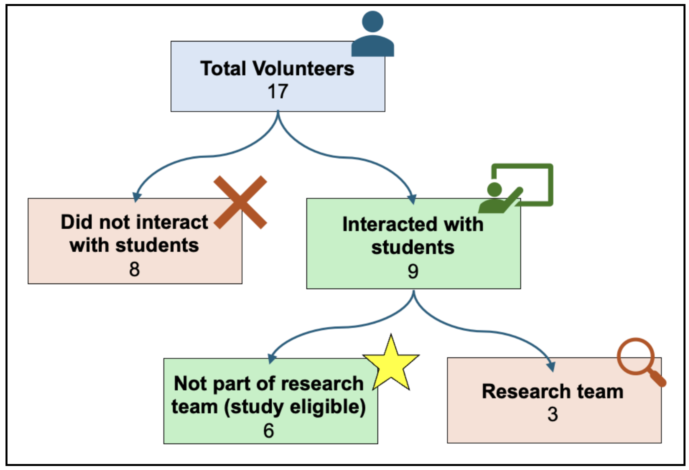


Figure 1. Volunteer Participants' Eligibility in the Current Study.

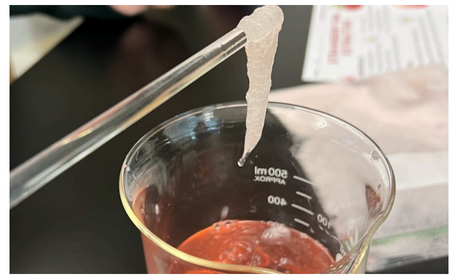
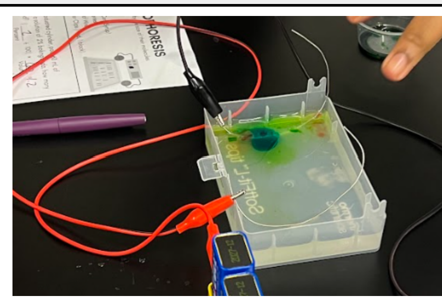
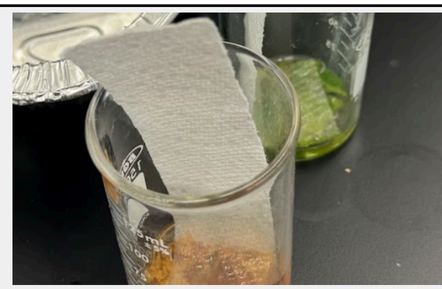
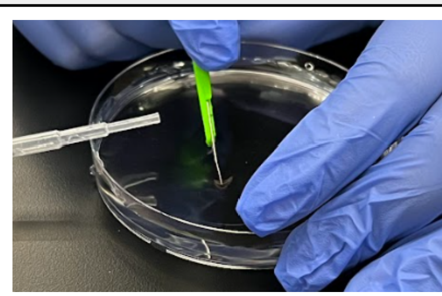
Volunteers had multiple options to engage with the MBL: (1) supporting workshop development and material preparation at the university campus (as described in **Table 1**), and/or (2) traveling to the classroom to facilitate workshops for 8th-grade students. Six of the 17 volunteers met the eligibility criteria for this study, as they had direct interactions with the 8th-grade students and were not a part of the undergraduate research team (**Fig. 1**).

Program Evaluation

The MBL was evaluated through a mixed-methods approach across three data collection instruments:

1. Post-Workshop Exit Slips: To capture immediate feedback on workshop deliverables, the 8th-graders completed paper exit slips assessing their thoughts on the session content and delivery at the conclusion of each experiment (**Fig. A1**).
2. Student Post-Survey: Upon completion of the workshop series, the 8th-graders completed a retrospective quantitative and qualitative post-survey in Qualtrics, available in both English and Spanish (**Table A1**). The survey employed:
    a. Validated instrumentation to assess STEM identity, via Vincent-Ruz and Schunn's STEM Identity Measure for 7th and 9th-graders [19].
    b. Validated instrumentation to assess change in STEM fascination, via Chung's Measuring Activation instrument for 10-14 year old respondents [20].
    c. Questions assessing the impact of university mentors on students' experiences and their perceptions of STEM and bioengineering.
3. Volunteer Post-Survey: Upon completion of the workshop series, volunteers completed a retrospective post-survey in Qualtrics (**Table A2**) assessing their:
    a. Motivation for volunteering.
    b. Self-reported science communication efficacy adapted for the MBL, via Robertson Evia's Self-Efficacy for Public Engagement with Science Scale [21].
    c. Science identity adapted for bioengineering, via Estrada's Science Identity measure for university students [22].

Table 1. Biweekly STEM Workshop Descriptions Performed in Fall 2025. * indicates a previously developed workshop that was improved for this collaboration [15]. ** indicates a new workshop developed for this semester. Photos are shown for corresponding workshops.

Workshop	Description	Photos
What is Bioengineering? + Strawberry DNA Extraction *	Provide an introduction to the field of bioengineering. Educate students about DNA and its importance in organisms. *Core Techniques & Concepts* ● Mechanical Lysis (mashing) ● Chemical Lysis (buffer) ● Filtration (cheese cloth) ● Extraction (DNA)	
Edible DNA Model *	Explain the structure of DNA and its components in an interactive and engaging manner. *Core Techniques & Concepts* ● DNA Sequencing ● Complementary Base Pairing ● Spatial Recognition	
Gel Electrophoresis *	Teach students about DNA separation and commonly used techniques in biological research. *Core Techniques & Concepts* ● Solution Preparation ● Concentration Calculations ● Pipetting ● Analytical Separation (mystery dye)	
Leaf Chromatography **	Explore the role of pigments in photosynthesis and plant coloration. *Core Techniques & Concepts* ● Mechanical Homogeneization (mortar and pestle) ● Solvent Extraction ● Capillary Action	
Regenerative Medicine *	Educate students about model organisms (such as planaria) used in regenerative medicine research while performing a dissection. *Core Techniques & Concepts* ● Model Organisms ● Microdissection & Safety ● Longitudinal Observational Study	

Biomechanics & Prosthetics **	Explore the role of pigments in photosynthesis and plant coloration. *Core Techniques & Concepts* ● Human Centered-Design ● Trade-off Analysis ● Prototyping & Iterating	
Fluorescence Microscopy **	Explore the principles of fluorescence and its application in microscopy techniques. *Core Techniques & Concepts* ● Fluorescence ● Serial Dilutions ● Comparative Observations	

Following best practices to reduce stereotype threat, demographic questions were placed at the end of both surveys [23]. Participation in the study was voluntary (and did not affect workshop participation), with parental consent and student assent obtained before data collection. This study was approved by the Institutional Review Board at the University of Illinois Urbana-Champaign (Project IRB25-1225). Evaluation of the program was determined to be non-human subject research (Project IRB26-0182).

Data Analysis

Exit slips and survey responses were transcribed into Microsoft Excel before being de-identified for analysis. Likert-scale responses were assigned ordinal numerical values (1-3, 1-4, 1-5, or 1-6 as appropriate), where lower values indicated disagreement with the prompt (e.g., 1 equates to “Strongly Disagree”). In instances where participants provided multiple selections on exit slips (e.g., both “Somewhat Agree” (4) and “Strongly Agree” (5) were selected), responses were coded as the mean of the values. Missing data points were preserved as blank entries.

Validated survey instrumentation to evaluate self-reported STEM or bioengineering identity [19, 22], student science fascination [20], and volunteer science communication [21] were adapted for this study when applicable, as previously described, and scored according to the recommended scoring rubrics and psychometric guidelines. All instruments were evaluated using Cronbach’s alpha (α) to assess the internal consistency with this study’s population ($N = 27$), where $\alpha = 0.7$ indicated sufficient reliability [24]. Chung’s STEM fascination scale yielded αs of 0.81 (95% CI [0.68, 0.90]) and 0.83 (95% CI [0.71, 0.91]) for pre- and post-program assessments, respectively. Vincent-Ruz and Schunn’s STEM Identity Measure demonstrated an α of 0.78 (95% CI [0.61, 0.89]); while this meets the reliability threshold, the wider confidence interval reflects the study's small sample size. Cronbach’s α was not computed for instrumentation in the volunteer survey due to the limited sample size ($N = 4$).

Student career aspirations were sorted thematically according to the Holland codes [25]. Student career aspirations were categorized into sets of up to three letters in the RIASEC model (Realistic, Investigative, Artistic, Social, Enterprising, Conventional). For example, “doctor” was sorted as ISR (Investigative, Social, and Realistic). Open-ended volunteer responses regarding participation motivations were analyzed through collaborative manual coding of thematic categories.

Demographic characteristics were compiled and presented using Overleaf. Data was analyzed and visualizations were generated using GraphPad Prism (version 10.6.1) and Python (version 3.14.2) utilizing the Plotly library (version 6.5.2). To compare retrospective pre- and post-program scores for STEM fascination and volunteer bioengineering identity, a paired Wilcoxon signed-rank test was employed. This nonparametric approach was selected because of the ordinal nature of the survey data inherent with Likert data. Statistical significance was defined as $p < 0.05$.

Results & Discussion

Participating Student Demographics
27 of the 31 students participated in the retrospective post-survey. Student demographic characteristics such as gender identity, race, languages spoken at home, and parent's highest education level are summarized in **Table 2**. When asked about future career aspirations, examples of diverse responses included engineer, fashion designer, investigative journalist, online streamer, and doctor; 8 of the 27 students were unsure at this time (**Table B1**).

Table 2. Enrolled Student Demographics. Results represent 27 of the 33 students in the class who completed the post-survey. Career aspirations are categorized using the RIASEC model.

Characteristic	n	%	Characteristic	n	%
Gender Identity			**Career Aspirations (RIASEC)[a]**		
Female	9	33.3	Realistic (R)	10	37.0
Male	15	55.6	Investigative (I)	9	33.3
Non-binary / Third Gender	1	3.7	Artistic (A)	4	14.8
Other	2	7.4	Social (S)	8	29.6
			Enterprising (E)	9	33.3
Racial and Ethnic Identity[a]			Conventional (C)	9	33.3
Black / African-American	16	59.3			
Hispanic / Latino	8	29.6	**Parent's Highest Education**		
White / Caucasian	4	14.8	Did Not Complete HS	1	3.7
Asian	3	11.1	Associate's Degree	1	3.7
Native American / Alaska Native	2	7.4	Some College	4	14.8
Middle Eastern / North African	1	3.7	Bachelor's Degree	3	11.1
Other	6	22.2	Master's Degree	2	7.4
			Doctoral Degree	2	7.4
Languages Spoken At Home[a]			Unsure / I don't know	14	51.9
English	22	81.5			
Spanish	7	25.9			
French	3	11.1			
Lingala	1	3.7			
Dutch	1	3.7			
Vietnamese	1	3.7			
German	1	3.7			

[a]Multiple responses allowed; percentages may exceed 100%.

Workshop Evaluation & Experimental Confidence

Upon the completion of each experiment, students responded to the following prompts on exit slips (**Fig. 2, Fig. A1**). The answers followed a Likert scale with response options of Strongly Disagree (1), Somewhat Disagree (2), Neutral (3), Somewhat Agree (4), and Strongly Agree (5).

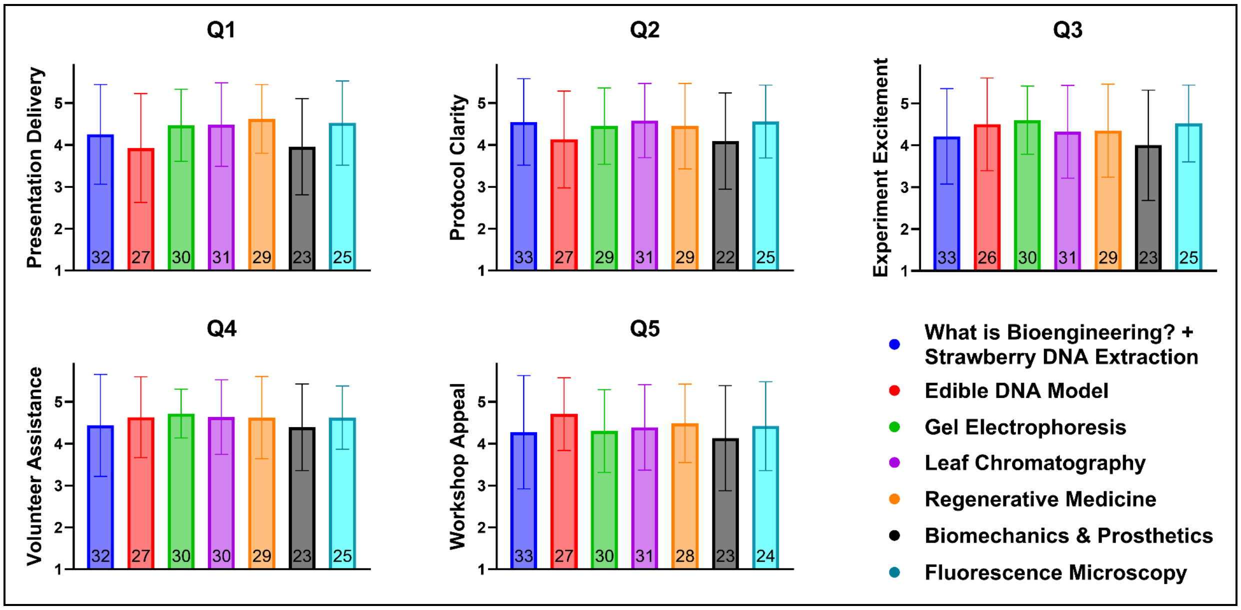


Figure 2. Student Exit Slip Responses (Q1-5) Across Workshops. Workshops are ordered chronologically. Likert scale responses are shown as mean values with standard deviations, from 1.0 ("Strongly Disagree") to 5.0 ("Strongly Agree") for the given question. Sample sizes (N ≤ 33) are annotated at the bottom of each bar and vary by experiment due to absences or submission errors.

Q1. The presentation was easy to understand. Students rated the Regenerative Medicine presentation as the easiest to understand (average of 4.62), while the Edible DNA Model and Biomechanics & Prosthetics workshops' presentations received the lowest ratings (3.93 and 3.96, respectively; **Fig. 2, Q1)**. Across all workshops, students gave an average score of 4.32 for presentation comprehensibility.

Q2. The protocol was easy to follow. The Leaf Chromatography and Fluorescence Microscopy protocols were rated as the easiest to follow (averages of 4.58 and 4.56, respectively), whereas the Biomechanics & Prosthetic's protocol was the most difficult to follow (4.09) **(Fig. 2, Q2)**. Across all workshops, students gave an average score of 4.40 for ease of following the protocols.

Q3. This experiment was exciting. Overall, students had indicated great excitement for all workshops with averages for all workshops in a range from 4.00 to 4.60. The students found the Gel Electrophoresis workshop the most exciting and found the Biomechanics & Prosthetics workshop the least exciting (4.0). Across all workshops, students gave an average score of 4.36 for how exciting they found the experiments. (**Fig. 2, Q3**).

Q4. College volunteers were helpful and answered questions. Students rated the college volunteers' assistance and knowledge as highly satisfactory during all workshops (averages of 4.98; **Fig. 2, Q4**). The lowest average was a strong value of 4.39 (in between "Agree" and "Strongly Agree") for the Biomechanics & Prosthetics workshop, indicating that the college volunteers were helpful and answered questions adequately for all workshops. Post-workshop retrospective surveys also pointed strongly to the impact of mentorship, as the students unanimously strongly agreed to the prompt that "the college volunteers made me feel welcomed, respected, and included."

Q5. I think other kids would like this workshop. Participants gave the highest ratings to the Edible DNA Model workshop (average of 4.70). Conversely, the Biomechanics & Prosthetics workshop was the least recommended (4.13) **(Fig. 2, Q5)**. Overall, students believed that the workshops would be enjoyable to others, with an average rating of 4.38.

In averaging the responses of Questions 1-5, the students' most highly rated experiments were Fluorescence Microscopy and Gel Electrophoresis (average values of 4.48 for both), while their least favorite was the Biomechanics & Prosthetics workshop (4.07). This may be explained by this workshop's minimal instruction beyond provided examples and the lack of familiarity in engineering design approach. These results align with observations of student excitement and confidence, as later described. Students also provided qualitative feedback for each workshop (**Table 3**). Overall, these results suggest that while there is opportunity to improve the protocol, presentations, and volunteer training, all averages were sufficiently high to indicate good success of the program. It is also important to note that due to the varying sample size throughout the workshops, these results may not be representative of the entire class.

Table 3. Representative Qualitative Student Feedback for Each Workshop.

	7a. What was the most challenging part?	**7b. What was the best part?**
What is Bioengineering? + Strawberry DNA Extraction	"Mashing the strawberries" "Getting the exact number on the beaker" "[Pouring] the rubbing alcohol" "Seeing the DNA"	"Seeing the DNA float to the top" "Smashing the strawberry"
Edible DNA Model	"Matching the strands" "[Putting] the toothpick in"	"Eating it" "Building it"
Gel Electrophoresis	"Preparing the buffer" "The 2nd step was hard to understand" "Putting in the food dye"	"Putting the dye in" "Everything. The colors were the best."
Leaf Chromatography	"... crushing the leaves"	"Waiting for the color to come up" "Grinding the leaves" "[Using] hot water"
Regenerative Medicine & Planaria	"Cutting them, it was kinda gross" "Keeping them [Planaria] still"	"Cutting them, it was also interesting" "Watching them move around"
Biomechanics & Prosthetics	"Cutting cardboard" "Putting the yarn [through]"	"Finishing cutting" "Playing with it" "Making the hand"
Fluorescence Microscopy	"Writing [with solution]" "Mixing [the solution]"	"Using the UV light" "Seeing the green glow"

Impact on Students' STEM Confidence & Interest

Student confidence was measured in two ways. First, exit slips (**Fig. A1**) included one question per workshop:

Q6. <u>I'm confident in performing experiments</u>. Students reported being the most confident in performing experiments after the Gel electrophoresis workshop (average score of 4.37), but the Edible DNA workshop yielded the highest percentage of "Strongly Agree" responses (73.1%). Participants were least confident after the first workshop, the Strawberry DNA Extraction workshop (average score of 3.79), with only 51.5% strongly agreeing. **(Fig. 3)**. Across all workshops, students gave an average confidence rating of 4.13. Beyond providing the immediate post-workshop confidence ratings, this question also permitted longitudinal tracking of students' confidence in performing experiments over the workshop series (**Fig. 3**). Across five of the seven workshops, average confidence ratings were greater than to a 4.0, with students reporting overall maximum confidence ratings with the Gel Electrophoresis workshop, followed by the Leaf Chromatography (4.33) and the Fluorescence Microscopy workshop (4.25) which all directly connected to topics they had recently covered in class. The Strawberry DNA workshop has the lowest confidence rating with 12.1% strongly disagreeing and 9.1% somewhat disagreeing potentially due to it being the first workshop and students were getting used to understanding and following the protocol. The Biomechanics workshop (3.91) had the second lowest rating, likely because it was the most challenging, offering greater freedom with fewer examples or instructions. Overall, students had a net increase in experimental confidence throughout the series.

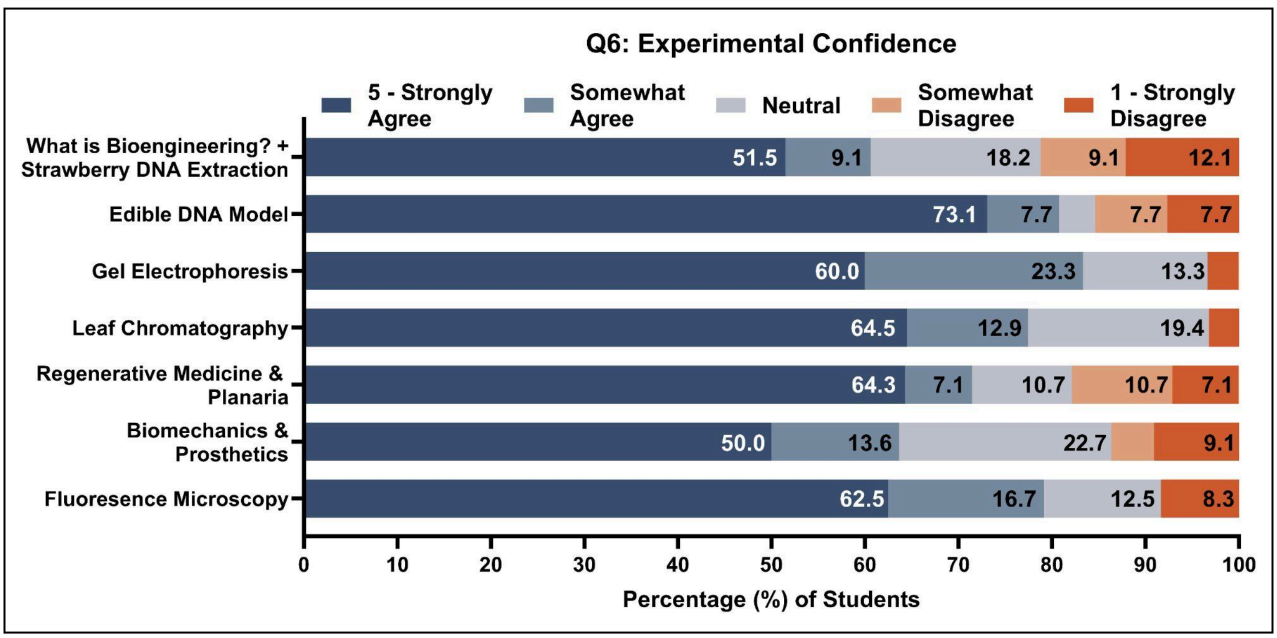


Figure 3. Students' Confidence in Performing Experiments Throughout the Workshop Series (Q6). A stacked bar plot shows the distribution of student confidence across the series. Workshops were conducted sequentially from "What is Bioengineering?" (first) to "Fluorescence Microscopy" (last). Percentages are mapped to a Likert scale from 1.0 ("Strongly Disagree," burnt orange) to 5.0 ("Strongly Agree," navy blue). Sample sizes (N ≤ 33) are denoted on the far left of each bar, varying by experiment due to absences or submission errors.

Secondly, in the post-program survey (**Table A1**), students retrospectively evaluated their knowledge and confidence about bioengineering and science as a result of the MBL series provided the following questions (**Fig. 4A**). They rated three paired statements on a 5-point Likert scale:

1. <u>Before/after this program, I knew/know what bioengineers do.</u> On average, students' reported knowledge of the bioengineering field increased from a mean score of 2.6 to 3.8. This shift is further illustrated in the distribution of responses shown. The percentage of students who 'Strongly Agreed' they understood the field increased nearly eightfold (3.8% to 29.66%), while those who 'Strongly Disagreed' dropped from 18.5% to 7.4%.
2. <u>Before/after this program, I was/am confident in communicating science and biology ideas to others.</u> Students' confidence in applying their learning and communicating science and biology concepts,which increased from 3.3 to 3.7. The percentage of students in strong agreement increased from 22.2% to 33.3% (a 50% increase) and in somewhat agreement rose from 14.8% to 22.2%.
3. <u>Before/after this program, I was/am confident in performing hands-on science experiments in a team.</u> Students were asked to rate their performance in completing experiments within a team, as they had worked in groups of 2-3 for all workshops except the Edible DNA Model. They reported an increase from 3.5 before the program to 4.0 after the program, with those who 'Strongly Agreed' increasing from 22.2% to 48.1%.

Additionally, students retrospectively evaluated their fascination with STEM on a 4-point scale (**Fig. 4B**) [20], which averaged to 2.67 prior to the MBL (**Fig. 4B**). Following the MBL program, average STEM fascination scores increased to 2.89. Students also responded to questions to quantify their STEM identity after the workshop series on a 4-point scale [19]. The average post-workshop score was 2.2, which directly aligned with the instrument's established baseline of

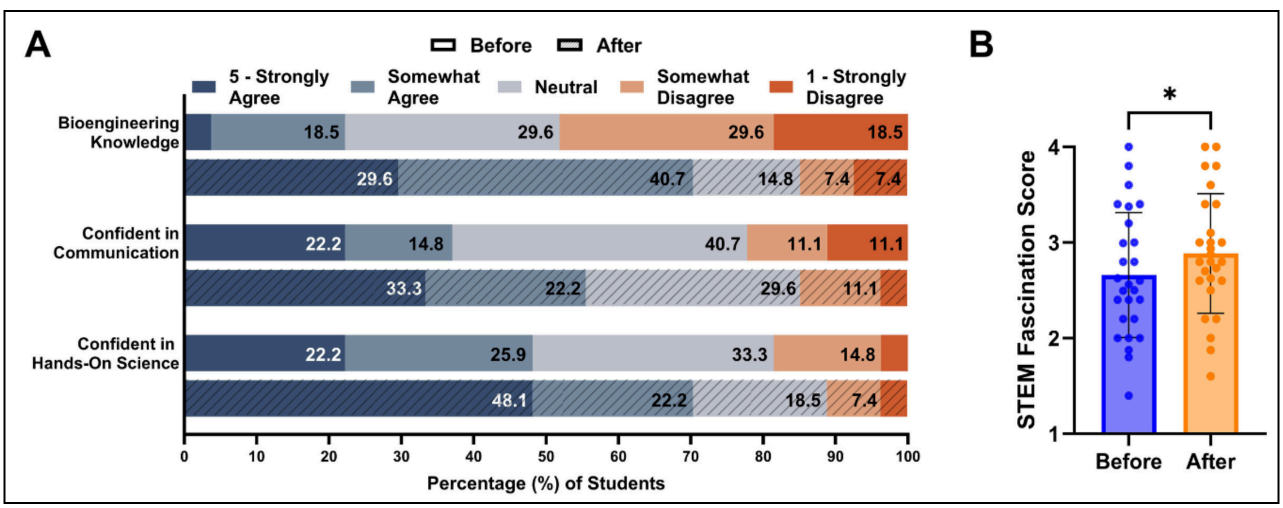


Figure 4. Retrospective Evaluation of Science Knowledge and Confidence and STEM Fascination Score. (A) Stacked bar plot (N = 27) showing the distribution of student responses regarding bioengineering knowledge and confidence before (*solid*) and after (*striped*) the workshop series; percentages are mapped to a Likert scale from 1.0 ("Strongly Disagree," burnt orange) to 5.0 ("Strongly Agree," navy blue). **(B)** Average STEM fascination scores before (blue) and after (orange) MBL participation. Dots represent individual responses. Significance was determined using a paired Wilcoxon signed-rank test (*$p < 0.05$).

2.2. This suggests that the participants achieved a level of STEM identity consistent with typical results for this age group and demographic in larger validation studies.

Next, we investigated students' interest in continuing to pursue STEM-relevant aspirations due to the MBL, including activities such as participating in another program like the MBL, taking a STEM class in high school, and pursuing a career or hobby in STEM (**Fig. 5**). The sentiment towards participating in another STEM program was fairly positive (average of 3.42), and the interest in High School STEM classes averaged 3.04. The sentiment to pursue a STEM hobby or career was also positive (3.18). In the short term, most students were open and interested in further engaging with STEM, and some could see themselves pursuing STEM as a career.

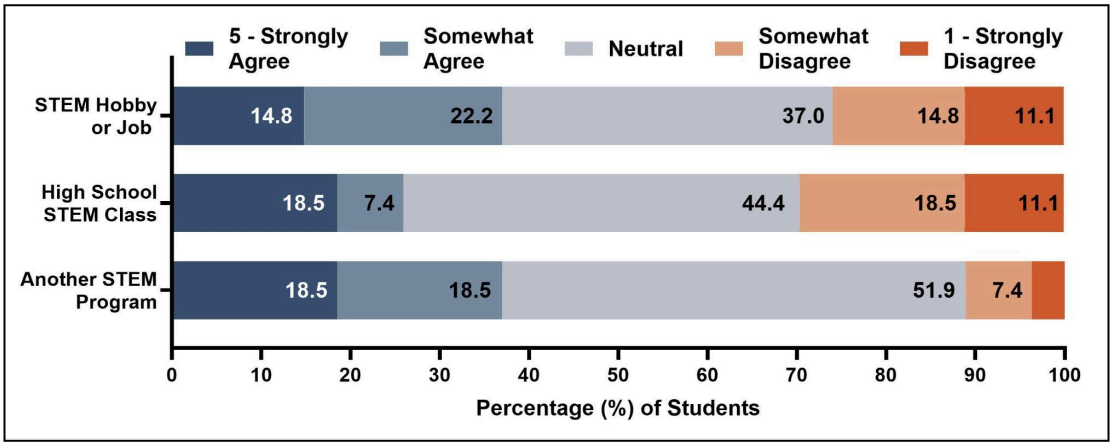


Figure 5. Influences of MBL Participation on Future STEM Engagement. Stacked bar plot (N = 27) showing the distribution of student responses. Percentages are mapped to a Likert scale from 1.0 ("Strongly Disagree," burnt orange) to 5.0 ("Strongly Agree," navy blue).

Role of Volunteering & Near-Peer Mentorship on Student Experience

Students were asked to extrapolate on their experiences with the college volunteers to understand the impact of near-peer mentorship (**Fig. 6**).

1. <u>Talking with college volunteers helped me better understand what scientists and engineers do</u>. Students felt that they gained a good understanding on what scientists and engineers do, with the average score being 3.79. Of the following questions, this question received the most agreement from respondents (37.0% strongly agreed and 18.5% somewhat agreed).
2. <u>Seeing college volunteers made me feel like I could be a scientist or engineer too.</u> Students resonated with the college volunteers and somewhat agreed to now potentially pursuing a similar career, with the average score being 3.32. Only 7.4 percent of the students strongly disagreed with this statement.
3. <u>I would like more opportunities to talk with college students in the future.</u> The students on average want more opportunities to talk with college students with the average score being 3.54. Most students strongly agree (29.6%) and somewhat agree (14.8%) with this statement.

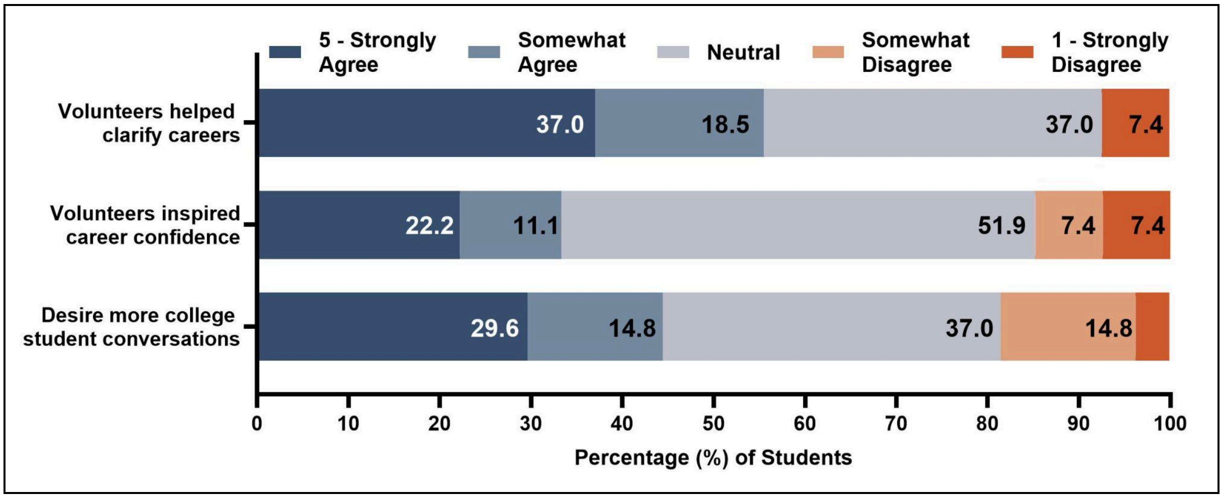


Figure 6. Student Reflections on Volunteer Interactions & Impact. Stacked bar plot (N = 27) showing the distribution of student responses. Percentages are mapped to a Likert scale from 1.0 ("Strongly Disagree," burnt orange) to 5.0 ("Strongly Agree," navy blue).

In a free-response prompt, students described what they liked about working with college volunteers. They mentioned the volunteers' demeanor ("They are kind and welcoming") and the roles the volunteers played during their experiments ("[Helping me] seeing how things work and making them [experiments]" and "I liked how helpful they were and they were good at answering questions we had").

Lastly, we inquired if the MBL assisted in their understanding of the material taught by their classroom teacher in one sentence. Students stated "Yes," because "[the MBL] helped me learn some stuff I didn't know" , "... sometimes we would do experiments that matched what we were learning in class".

Participating Volunteer Demographics & Prior Educational Experience

17 undergraduate students (including the three undergraduate authors of this Evaluation) across a variety of years and life science-related majors volunteered to assist in this program. Volunteers spoke an array of languages at an intermediate or greater level, with most being at least bilingual. Nine of the students delivered the workshops to the students in the Mobile Bioengineering Lab, while others assisted with preparation of materials. Of the six eligible non-author participants, four completed the entire survey (N = 4). The three authors completed the demographic questions and the inquiry regarding motivation for volunteering to further represent the volunteer population (N = 7 for these sections; **Table 4**) but were excluded from the program evaluation survey sections.

Table 4. Enrolled Volunteer Demographics (N = 7).

Characteristic	n	%	Characteristic	n	%
Gender Identity			**Major[a]**		
Female	5	71.4	Bioengineering	5	71.4
Male	2	28.6	Chemistry	1	14.3
			Biochemistry	1	14.3
Race and Ethnic Identity[a]			Health Science	1	14.3
Asian	5	71.4			
White	3	42.9	**Prior Educational Outreach Experience**		
Black/African American	1	14.3			
			Yes	4	57.1
Languages Spoken[a]			No	3	42.9
English	7	100.0			
Hindi	2	28.6	**Parent's Highest Education**		
Spanish	2	28.6	High School/GED	1	14.3
Japanese	1	14.3	Bachelor's Degree	3	42.9
Kashmiri	1	14.3	Master's Degree	2	28.6
Mandarin	1	14.3	Doctoral Degree	1	14.3
Marathi	1	14.3			
Romanian	1	14.3	**Highest Level of Education Hope to Acquire**		
Vietnamese	1	14.3			
Yoruba	1	14.3	Master's Degree	2	28.6
			M.D.	4	57.1
Year			Ph.D.	1	14.3
Freshman	2	28.6			
Sophomore	3	42.9			
Junior	1	14.3			
Senior	1	14.3			

[a]Multiple responses allowed; percentages may exceed 100%.

Volunteer Motivation, Self-Efficacy, and Bioengineering Identity

Volunteers were asked to briefly describe their motivations for volunteering (**Fig. 7**). Volunteers responses were categorized into six themes:

1. Community Impact: Driven by a commitment to give back to the local community.
2. STEM Exposure: Interested in providing K-12 students another opportunity to interface with STEM.
3. Professional/Personal Growth: Used the MBL framework for personal fulfilment and/or to improve their technical and communication skills.
4. K-12 Enjoyment: Expressed an aptitude for mentorship and dedication in working with students.
5. Personal Connection: Motivated by lived experiences or professional backgrounds that align with the MBL's goals.
6. Curiosity: Characterized by a desire to learn more about experiential learning, performing experiments, and trying a new experience in volunteering.

Verbatim responses with coding are available in **Table C1**. Many volunteers were primarily interested in the social responsibility and impact of outreach, as well as the mutually beneficial roles and the opportunity to develop a near-peer mentorship dynamic. Community impact had

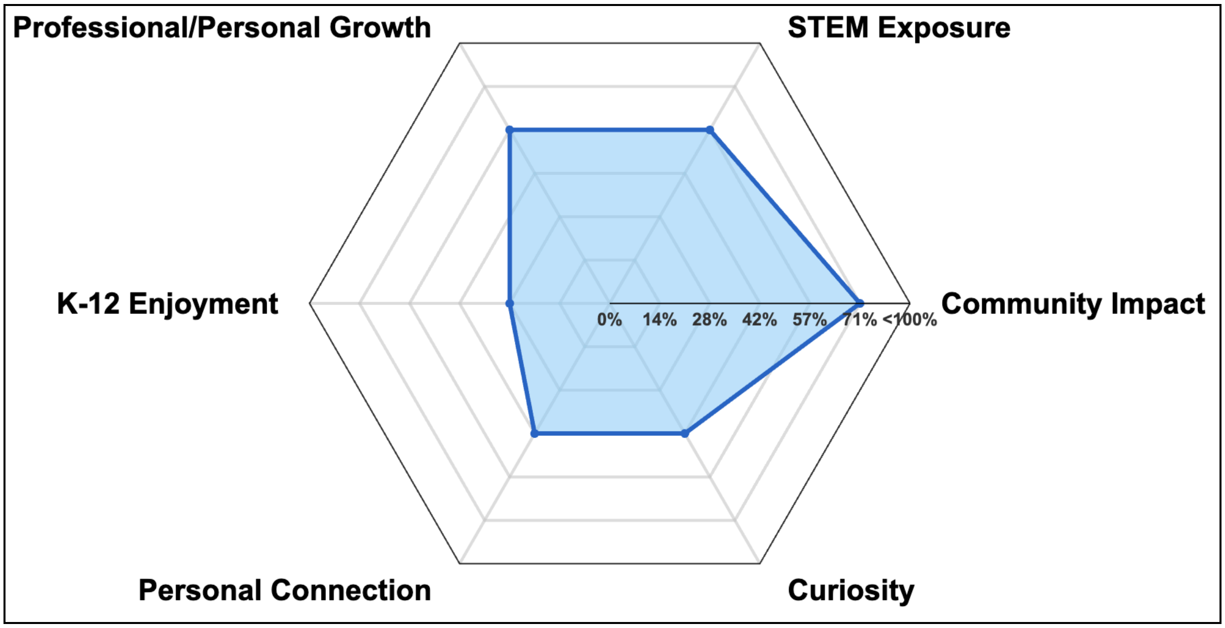


Figure 7. Volunteer Motivation for Participating in the MBL. Each axis represents a motivational category, with percentages indicating the proportion of volunteers (N = 7) mentioning that category.

the largest influence, with 71% (or 5/7) of volunteers citing it as a motivation. This was closely followed by STEM exposure and professional/personal growth (57% or 4/7), then curiosity and personal connection (43% or 3/7), and, finally, K-12 enjoyment (28% or 2/7).

We next employed a validated self-efficacy scale for public engagement with science [21], defined as the belief in one's ability to deliver technical and scientific content to an audience. The group of volunteers were assessed using a 6-point scale (1 = Strongly Disagree, Moderately Disagree, Mildly Disagree, Mildly Agree, Moderately Agree, and 6 = Strongly Agree). The volunteers achieved a mean score of 4.83, slightly above the instrument's validation study of 4.64. Individual scores varied from 3.85 to 6.0, with the lower end of the range being higher than the average (2.46) presented in the validation study. This is a promising indication that most of the volunteers felt moderately confident in their ability to facilitate effective dialogue and manage challenges of delivering scientific content.

Lastly, we measured Bioengineering Identity to assess the extent to which volunteers integrated their role as a 'bioengineer' into self-concept [22]. The volunteers' average scores increased from a baseline of 3.05 before the program (i.e., neutral feeling toward their identity, which was lower than the 3.78 score of the participants in the validation study) to 3.84 after the program (higher than the validation study's score (**Fig. 8**). Although the increase was not statistically significant, volunteers moved from a neutral baseline to an average score of 3.84, surpassing the validation benchmark. This shift suggests the program fostered a stronger bioengineering identity, which is linked as a predictor of career persistence.

Study Limitations
Due to the limited sample size of participants able to be assessed, this study may not accurately represent the student population that completed the program. This is especially true for volunteers, where there were 4 responses of the 6 eligible. Cronbach's alpha was used to corroborate with the validated instrumentation provided in our sample to confirm the validity of the study's responses [26]. Although a standard approach, it assumes the data to be continuous, which is untrue for ordinal Likert data. However, research shows that for scales with 5 or more categories the gap between ordinal and linear methods shrinks [27]. As this study predominantly employed 5 and 6-point likert scales, in conjunction with the limited sample size, Cronbach's alpha was suitable to use as a conservative estimate to validate our findings. Further research with larger sample sizes may require ordinal reliability coefficients, such as polychoric alpha [19].

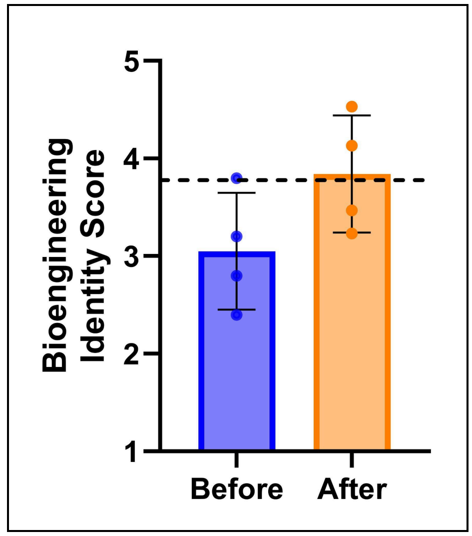


Figure 8. Average Retrospective Bioengineering Identity (N = 4). Average STEM fascination scores before (blue) and after (orange) MBL participation. Dots represent individual responses. The black dashed line indicates the average score from the validated instrument's study. Significance was determined using a paired Wilcoxon signed-rank test (*$p < 0.05$).

Furthermore, the student science fascination instrument [20] suggests an analysis using the Rasch measurement model, which we were unable to effectively perform due to the smaller sample size. An average of the questions to form the construct was taken, as it was the suggested alternative in the validated instrument. This approach assumes equal intervals between response categories, however the Likert-scale responses are ordinal, which is a limitation of the assumption. Exit slip data sample size varied across the experiments which could have affected the consistency and comparability of results. Volunteer sample size was relatively small, limiting statistical power and limiting generalizability of results for this group. Other limitations include students absences and incomplete responses on some of the exit slips, which introduced inconsistencies in the data.

Lastly, the study used retrospective questions, which can introduce response bias. When participants answer questions about their current state in comparison to the past, a participant may feel inclined to have implicit bias that something must have changed [28].

Conclusion

In this evaluation, we have presented the impact of the expanded Mobile Bioengineering Lab program on both middle school students and their undergraduate near-peer mentors. Our results demonstrate that a cohesive, biweekly, experiential learning-based outreach program can successfully engage students in STEM, as evidenced by increased fascination, interest, and confidence. Moreover, we observed that the MBL program was effective in strengthening bioengineering identity in the university volunteers.

Lessons Learned in Workshop Preparation & Delivery

During a subset of experiments, students faced obvious challenges, described below. Improved versions of these workshops will be made available on the Mobile Bioengineering Lab website [29].

- Edible DNA Model: Students struggled with understanding base pairing at first; preliminary practice would be strongly beneficial.
- Gel Electrophoresis: Students had difficulty with pipetting technique, often breaking through the agarose gel. Although practice was implemented, assisting students and providing a clear example would be beneficial. Furthermore, students struggled in understanding calculations required to make the buffer solution. A scaffolding approach was provided in the protocol to assist in their preparation.
- Leaf Chromatography: Students grappled with the presentation; specifically, they struggled to articulate the procedural execution and quantitative analysis of chromatography techniques within a laboratory context.
- Biomechanics & Prosthetics: This workshop produced divergent outcomes. Some students demonstrated exceptional engagement with the design process, returning during lunch and after school to refine their cardboard arm prototypes. Others encountered difficulties due to insufficient time allocation and limited shared resources, particularly scissors. Ensure there is appropriate time allocated for your students in this workshop, especially if students will both design and build in one session.

Suggested Strategies for Bioengineering Curriculum Integration

1. Curriculum Alignment: Aligning workshops with active classroom units (e.g., Strawberry DNA Extraction during a genetics unit) further reinforces theoretical knowledge through hands-on application (experiential learning). Previous studies have shown that more opportunities to interface with a concept, the greater the learning outcome [30].
2. Protocol Interactivity: In the pilot phase of the MBL [15], protocols had minimal interactivity (e.g., lack of space for students to write their observations, no reflection questions), which limited students' capacity to engage with the scientific inquiry necessary to understand the objectives of the experiment. This observation suggested that a lack of structured engagement led to a focus on procedural completion rather than conceptual understanding. In the current study, we redesigned the protocols to include features such as scaffolding and space for calculations, areas to write observations, and critical thinking prompts. This intervention resulted in students more deeply analyzing procedural steps prior to execution and spending more time documenting and interpreting their results.
3. Resource Management: Some activities, such as Biomechanics & Prosthetics, require strategic resource management and flexible time allocation. We identified procedural bottlenecks (e.g., scissors, cutting cardboard) that hindered student progress. Therefore, budget pending, future iterations should employ a greater item-to-student ratio and permit extended or flexible durations to accommodate various speeds of student prototyping.
4. Near-Peer Mentorship: In the pilot phase of the Mobile Bioengineering Lab [15], the effect of near-peer mentorship was not evaluated on student engagement, understanding,

and workshop performance. However, in this study, the analysis of near-peer mentorship exhibited how the assistance and presence of college undergraduates increased student comprehension and enjoyment. Furthermore, the assistance of volunteers streamlined workshop preparation and clean-up.

The Mobile Bioengineering Lab: Looking Forward

In the future, we aim to increase sustainability and the scale of outreach. One priority is to strengthen and evaluate the collaboration between the MBL and other organizations that provide similar hands-on STEM-related learning opportunities to K-12 students. Such collaborations can increase the workforce behind the outreach, introduce new resources, and further broaden the reach of the MBL by leveraging existing community partnerships. Future studies will investigate student STEM identity with a closer lens retrospectively, as this study evaluated STEM identity only after the program. Alongside this goal, we aim to quantitatively evaluate the retention of bioengineering concepts with game-ified questionnaires, testing cumulative content.

Further expansion of the MBL program includes creating clear, explicit and free teacher guides to accompany the protocols and presentations [29]. Additionally, toolkits will be created for undergraduate students to create their own chapter of the Mobile Bioengineering Lab or to successfully deliver similar workshops. Providing these resources will support the expansion of the MBL beyond this study and community, and enable others to adapt the materials to their educational settings and student needs within NGSS and other standards.

Collectively, these future directions will position MBL as a flexible and scalable outreach model that can be applied to students of many different backgrounds, beyond a single institution or geographic location.

Acknowledgements

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References

[1] “Transforming Science Assessment: Challenges and Recommendations for States | Next Generation Science Standards,” *www.nextgenscience.org*. [Online]. Available: https://www.nextgenscience.org/transforming-science-assessment-challenges-and-recommendations-states

[2] T. R. Kelley and J. G. Knowles, “A conceptual framework for integrated STEM education,” *International Journal of STEM Education*, vol. 3, no. 1, pp. 1–11, Jul. 2016, doi: 10.1186/s40594-016-0046-z.

[3] J. A. Ejiwale, “Barriers To Successful Implementation of STEM Education,” *Journal of Education and Learning (EduLearn)*, vol. 7, no. 2, p. 63, May 2013, doi: 10.11591/edulearn.v7i2.220.

[4] S. Purzer and J. P. Quintana-Cifuentes, “Integrating engineering in K-12 science education: spelling out the pedagogical, epistemological, and methodological arguments,” *Disciplinary and Interdisciplinary Science Education Research*, vol. 1, no. 1, Nov. 2019, doi: 10.1186/s43031-019-0010-0.

[5] G. H. Roehrig, E. A. Dare, J. A. Ellis, and E. Ring-Whalen, “Beyond the basics: a detailed conceptual framework of integrated STEM,” *Disciplinary and Interdisciplinary Science Education Research,* vol. 3, no. 1, Dec. 2021, doi: 10.1186/s43031-021-00041-y.

[6] D. A. Kolb, "Experiential learning as an educational technique or type of learning," in *Experiential Learning: Experience as the Source of Learning and Development*, vol. 1, intro., p. xviii. Englewood Cliffs, NJ: Prentice Hall, 1984.

[7] J. Jaworski and M. Cho, “Implementation of an Experiential Service-Learning Course in Biomedical Engineering Design for Undergraduate Students,” *Biomedical Engineering Education*, vol. 3, no. 2, pp. 243–251, Jan. 2023, doi: 10.1007/s43683-022-00103-1.

[8] L. Montesinos, D. E. Salinas-Navarro, and A. Santos-Diaz, “Transdisciplinary experiential learning in biomedical engineering education for healthcare systems improvement,” *BMC Medical Education*, vol. 23, no. 1, Apr. 2023, doi: 10.1186/s12909-023-04171-x.

[9] D. Williams and L. Coles, “Evidence‐based practice in teaching: an information perspective,” *Journal of Documentation*, vol. 63, no. 6, pp. 812–835, Oct. 2007, doi: 10.1108/00220410710836376.

[10] H. M. Golecki, N. Y. Chung, T. Tran, and P. Liang, “Improving outreach interactivity in the virtual environment—evaluation of a computer vision-controlled soft robotic hand to broaden participation,” *ASEE Annual Conference and Exposition, Conference Proceedings*, Jun. 2024, doi: 10.18260/1-2--47592.

[11] R. J. Kaggwa *et al.,* "STEM Outreach to Underresourced Schools: A Model for Inclusive Student Engagement," *Journal of STEM Outreach*, vol. 6, no. 1, pp. 1-16, Feb. 15, 2023. doi: 10.15695/jstem/v6i1.04.

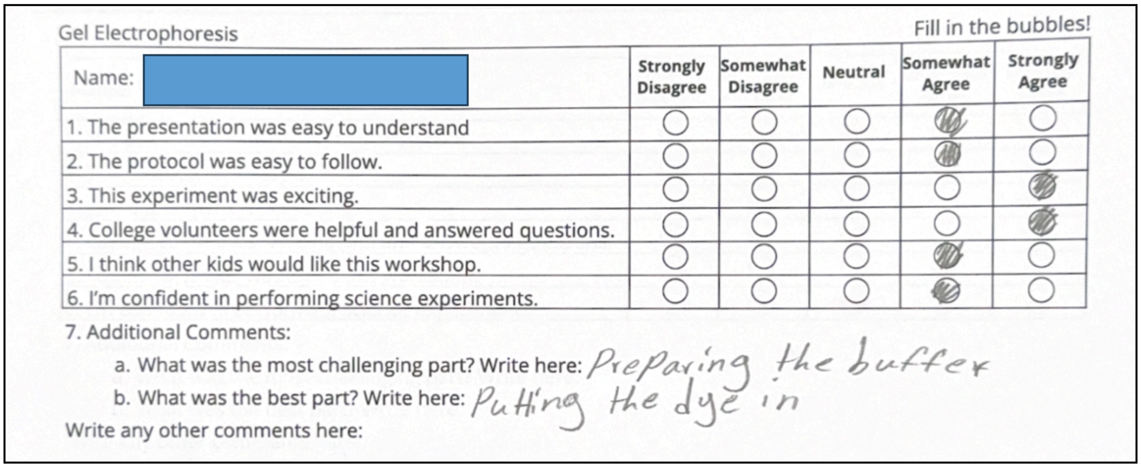
[12] A. L. Beauchamp *et al.*, "Effects of Research and Mentoring on Underrepresented Youths’ STEM Persistence Into College," *Journal of Experiential Education*, vol. 45, no. 3, pp. 316-336, 2022. doi: 10.1177/10538259211050098.

[13] G. Trujillo *et al.*, “Near-peer STEM Mentoring Offers Unexpected Benefits for Mentors from Traditionally Underrepresented Backgrounds,” *Perspectives on undergraduate research and mentoring : PURM*, vol. 4, no. 1, Nov. 2015, [Online]. Available: https://pmc.ncbi.nlm.nih.gov/articles/PMC5034940/

[14] M. K. Anderson *et al.*, "The Benefits of a Near-Peer Mentoring Experience on STEM Persistence in Education and Careers: A 2004-2015 Study," *The Journal of STEM Outreach*, vol. 1, no. 1, Feb. 2019, doi: 10.15695/jstem/v2i1.01.
[15] K. Zobus and C. Cvetkovic, "Mobile Bioengineering Lab: A Hands-On Workshop Series to Bring Experiments to 8th Grade Science Classes," *ASEE Annual Conference and Exposition, Conference Proceedings*, Jun. 2025, doi: 10.18260/1-2--56972.
[16] Biomedical Engineering Journal Club, "Biomedical Engineering Journal Club at UIUC." [Online]. Available: https://bmejc.super.site/
[17] M. Almeda and R. Baker, "Predicting Student Participation in STEM Careers: The Role of Affect and Engagement during Middle School." [Online]. Available: https://learninganalytics.upenn.edu/ryanbaker/JEDMpaper_istem_v19rsb.pdf
[18] Illinois State Board of Education, "Illinois Report Card." [Online]. Available: https://www.illinoisreportcard.com/
[19] P. Vincent-Ruz and C. D. Schunn, "The nature of science identity and its role as the driver of student choices," *International Journal of STEM Education*, vol. 5, no. 48, pp. 1–12, Nov. 2018, doi: 10.1186/s40594-018-0140-5.
[20] J. Chung, M. A. Cannady, C. Schunn, R. Dorph, and M. Bathgate, *Measures Technical Brief: Fascination in Science*. Pittsburgh, PA: Activation Lab, 2016. [Online]. Available: https://activationlab.org/wp-content/uploads/2018/03/Fascination-Report-3.2-20160331.pdf
[21] J. Robertson Evia, K. Peterman, E. Cloyd, and J. Besley, "Validating a scale that measures scientists' self-efficacy for public engagement with science," *International Journal of Science Education*, Part B, vol. 8, no. 1, pp. 40–52, 2017, doi: 10.1080/21548455.2017.1377852.
[22] M. Estrada, A. Woodcock, P. R. Hernandez, and P. W. Schultz, "Toward a model of social influence that explains minority student integration into the scientific community," *Journal of Educational Psychology*, vol. 103, no. 1, pp. 206–222, 2011, doi: 10.1037/a0020743.
[23] J. L. Hughes, A. A. Camden, and T. Yangchen, "Rethinking and updating demographic questions: Guidance to improve descriptions of research samples," *Psi Chi Journal of Psychological Research*, vol. 21, no. 3, pp. 138–151, 2016, doi: 10.24839/2164-8204.jn21.3.138.
[24] K. S. Taber, "The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education," *Research in Science Education*, vol. 48, no. 6, pp. 1273–1296, Jun. 2018. doi: 10.1007/s11165-016-9602-2.
[25] J. L. Holland, "A theory of vocational choice," *Journal of Counseling Psychology*, vol. 6, no. 1, pp. 35–45, 1959, doi: 10.1037/h0040767.
[26] D. G. Bonett, "Sample size requirements for testing and estimating coefficient alpha," *Journal of Educational and Behavioral Statistics*, vol. 27, no. 4, pp. 335–340, 2002, doi: 10.3102/10769986027004335.
[27] M. Rhemtulla, P. É. Brosseau-Liard, and V. Savalei, "When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions.," *Psychological Methods*, vol. 17, no. 3, pp. 354–373, Sep. 2012, doi: 10.1037/a0029315.

[28] J. Young and L. Kallemeyn, "Testing the Retrospective Pretest with High School Youth in Out-of-School Time Programs," *Journal of Youth Development*, vol. 14, no. 1, pp. 216–229, Mar. 2019, doi: 10.5195/jyd.2019.635.
[29] University of Illinois Urbana-Champaign, "Mobile Bioengineering Lab." [Online]. Available: https://publish.illinois.edu/mobile-bioe-lab/
[30] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proceedings of the National Academy of Sciences*, vol. 111, no. 23, pp. 8410–8415, May 2014, doi: 10.1073/pnas.1319030111.

Appendix A: Survey Instrumentation


Gel Electrophoresis

Fill in the bubbles!

Name: [redacted]	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1. The presentation was easy to understand	○	○	○	●	○
2. The protocol was easy to follow.	○	○	○	●	○
3. This experiment was exciting.	○	○	○	○	●
4. College volunteers were helpful and answered questions.	○	○	○	○	●
5. I think other kids would like this workshop.	○	○	○	●	○
6. I'm confident in performing science experiments.	○	○	○	●	○

7. Additional Comments:

a. What was the most challenging part? Write here: Preparing the buffer

b. What was the best part? Write here: Putting the dye in

Write any other comments here:

Figure A1. Representative Exit Slip of the Gel Electrophoresis Workshop.

Table A1. Student Survey Questionnaire.

Instrumentation	Question	Answer Options
N/A	1. Before this program… 1.1. I knew what bioengineers do 1.2. I was confident in communicating science and biology ideas to others 1.3. I was confident in performing hands-on science experiments in a team 2. After this program… 2.1. I know what bioengineers do 2.2. I am confident in communicating science and biology ideas to others 2.3. I am confident in performing hands-on science experiments in a team	Strongly Disagree, Slightly Disagree, Neutral, Slightly Agree, Strongly Agree
STEM Identity [19]	3. For each statement, choose the label that matches how you feel. 3.1. I am a science person 3.2. My family thinks of me as a "science person" 3.3. My friends think of me as a "science person" 3.4. My teachers/instructors think of me as a "science person"	YES!, Yes, No, NO!
STEM Fascination [20]	4. Before this program, I wondered about how nature works 5. After this program, I wondered about how nature works	Never, Once a month, Once a week, Everyday
	6. Before this program, when I worked on science I 7. After this program, when I worked on science I	Hated it, Didn't like it, Liked it, Loved it
	8. Before this program, I find science 9. After this program, in general, I find science	Very Boring, Boring, Interesting, Very Interesting

<table>
<tr><td></td><td>10. For each statement, choose the label that matches how you felt before the program.
10.1. After a science activity is over, I look for more information about it.
10.2. I need to know how objects work.
10.3. I want to read everything I can find about science.
10.4. I want to know everything about science.
10.5. I want to know how to do everything that scientists do.
11. For each statement, choose the label that matches how you felt after the program.
11.1. After a science activity is over, I look for more information about it.
11.2. I need to know how objects work.
11.3. I want to read everything I can find about science.
11.4. I want to know everything about science.
11.5. I want to know how to do everything that scientists do.</td><td>YES!,
Yes,
No,
NO!</td></tr>
<tr><td rowspan="4">N/A</td><td>12. For each statement, choose the label that matches how you feel.
12.1. I am interested in participating in another STEM program like this program.
12.2. I am more likely to take a STEM class in high school because of this program.
12.3. I am more likely to pursue my interests (hobby or a job) in STEM because of this program.</td><td>Strongly Disagree,
Slightly Disagree,
Neutral,
Slightly Agree,
Strongly Agree</td></tr>
<tr><td>13. Choose the answer that best matches how you feel about each sentence
13.1. The college volunteers made me feel welcomed, respected, and included.
13.2. Talking with college volunteers helped me better understand what scientists and engineers do.
13.3. Seeing college volunteers made me feel like I could be a scientist or engineer too.
13.4. I would like more opportunities to talk with college students in the future.</td><td>Strongly Disagree,
Slightly Disagree,
Neutral,
Slightly Agree,
Strongly Agree</td></tr>
<tr><td>14. What did you like about working with the college volunteers?
15. Did this program help you understand the science taught by [Redacted Teacher Name]? Explain your answer in 1 sentence.
16. What do you want to be when you grow up?</td><td></td></tr>
<tr><td>17. How old are you?
18. Do you identify as Hispanic and/or Latino?
19. What race do you identify with? Select all that apply. - Selected Choice
20. What race do you identify with? Select all that apply
21. What do you identify as?
22. What languages do you speak at home? Select all that apply
23. What is the highest level of education your parents have?</td><td></td></tr>
</table>

Table A2. Volunteer Survey Questionnaire

Instrumentation	Question	Answer Options
N/A	1. Why did you decide to volunteer with the MBL?	
Self-Efficacy Scale for Public Engagement with Science [21]	2. For each statement, choose the label that matches how you feel. MBL represents the Mobile Bioengineering Lab. 2.1. I am able to create activities and demonstrations that participants find engaging. 2.2. I have a hard time finding MBL topics that people connect with. 2.3. I find it difficult to leave time for people to share their perspectives during MBL activities. 2.4. I have a hard time finding the right words to convey my message during MBL activities 2.5. I am good at thinking together with MBL attendees about science topics. 2.6. I am good at knowing when to inform and when to listen during my MBL activities. 2.7. I am able to figure out how to improve MBL activities based on the kinds of questions the students ask. 2.8. I am able to engage in critical discussion about science topics with non-scientists. 2.9. I am able to moderate discussions with participants, even when they include a wide range of perspectives. 2.10. I am good at reading the audience during MBL activities, and making adjustments as needed. 2.11. I am good at finding ways to approach difficult topics. 2.12. I have a hard time answering questions from non-scientists in ways they understand. 2.13. I am able to moderate discussions that allow attendees to engage with me and with each other.	Strongly disagree, Moderately Disagree, Mildly Disagree, Mildly Agree, Moderately Agree, Strongly Agree
Bioengineering Identity [22]	3. Before volunteering in the MBL 3.1. I had a strong sense of belonging to the community of bioengineers. 3.2. I derived a great personal satisfaction from working on a team that is doing important bioengineering research/work. 3.3. I had come to think of myself as a 'bioengineer.' 3.4. I felt like I belonged in the field of bioengineering. 3.5. The daily work of a bioengineer appealed to me. 4. After volunteering in the MBL 4.1. I have a strong sense of belonging to the community of bioengineers. 4.2. I derive a great personal satisfaction from working on a team that is doing important bioengineering research/work. 4.3. I had come to think of myself as a 'bioengineer.' 4.4. I feel like I belong in the field of bioengineering. 4.5. The daily work of a bioengineer is appealing to me.	Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Strongly Agree
	5. For each statement, choose the label that matches how you feel 5.1. The program leaders communicated expectations to me clearly, with frequent and clear updates. 5.2. I felt comfortable reaching out to leaders with questions or	Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree,

<table>
<tr><td></td><td>concerns.
5.3. I felt adequately prepared for my volunteer role after the preparation sessions.
5.4. The training materials (e.g., handouts, slides, practice sessions) were helpful.
5.5. Overall, I would recommend volunteering in this program to others.</td><td>Strongly Agree</td></tr>
<tr><td rowspan="2">N/A</td><td>6. Do you have experience participating in or leading another educational outreach program (not as an attendee)? If so, please briefly state (1) which organization, (2) what you did, and (3) how many years/months you were involved.</td><td></td></tr>
<tr><td>7. If you said yes to the previous question, for each statement, choose the label that matches how you feel. Otherwise, select N/A (not applicable).
7.1. Being in that K-12 program had a positive impact on my interests and/or development.
7.2. Being in that K-12 program made me more inclined to participate in the MBL.
7.3. Being in that K-12 program made me feel more confident in my role as a volunteer in the MBL.</td><td>N/A
Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Strongly Agree</td></tr>
<tr><td>N/A</td><td>8. First and Last Name
9. Undergraduate Major(s)
10. What year are you in university?
11. What do you identify as?
12. Do you identify as Hispanic/Latino?
13. What race/ethnicity do you identify with? Select all that apply.
14. What is the highest level of education your parents have?
15. What is the highest level of education you hope to acquire?
16. Which languages do you speak, and at what proficiency?</td><td></td></tr>
</table>

Appendix B: Qualitative Student Survey Responses

Table B1. Representative Qualitative Student Survey Responses.

Question	Representative Responses
14. What did you like about working with the college volunteers?	"It was fun and interesting"
	"I liked how helpful they were and they were good at answering questions we had."
	"They helped me."
	"Seeing how things work and making them [perform experiments]"
	"They are kind and welcoming"
15. Did this program help you understand the science taught by [teacher's name]? Explain your answer in 1 sentence.	"Yea because we did more hands on things"
	"Yes, because sometimes we would do experiments that matched what we were learning in class."
	"Yes because I learn as I make them [perform experiments]"
	"Yes it did they helped me learn some stuff I didn't know"
16. What do you want to be when you grow up?	"An engineer"
	"Basketball player"
	"Computer science..."
	"Paleontologist"
	"A therapist"
	"A real estate agent"
	"Detective, journalist, or person investigator, or something in the medical field (Maybe)"
	"A fashion designer"
	"Streamer"

Appendix C: Qualitative Volunteer Survey Responses

Table C1. Motivation for Volunteering Responses.

Response	Categories
"I decided to volunteer with the Mobile Bioengineering Lab to give students experience with STEM concepts in a fun manner."	STEM Exposure, K-12 Enjoyment
"I decided to volunteer because I love working with kids and have prior experience in it, and I believe that having good hands-on science experiments for middle school kids is so important. Additionally, giving students their first exposure to a program like this is a very rewarding experience for me."	STEM Exposure, K-12 Enjoyment, Personal Connection
"It seemed like a good opportunity to both step outside of my comfort zone and give back to the community by volunteering."	Community Impact, Professional/Personal Growth
"I decided to volunteer because I had minimal opportunities to participate in STEM beyond basic coursework when I was in K-12. I also felt that the CU community, especially schools under greater socioeconomic stress, had less educational opportunities and resources in comparison to other communities that had strong educational institutions."	Community Impact, Personal Connection
"I wanted to see what we would do in the school we went to, and also, I've never volunteered before, so I thought it was a great chance to get into it."	Professional/Personal Growth, Curiosity
"I decided to volunteer with the Mobile Bioengineering Lab because I wanted to do something with my time that would benefit the local community while also improving my own communication skills. I've always been drawn to outreach in educational settings and the labs seemed engaging and well organized, so the MBL seemed like it would be a good fit. I've had a great time working with the students and other volunteers this past semester, and I look forward to returning next year!"	Community Impact, Professional/Personal Growth. Curiosity
"I found the program as a whole interesting and wanted to try teaching. I also felt like the impact on local communities, especially children who are not as exposed to STEM was something I resonated with. The hands-on learning and specifically bioengineering topics were also exciting for me as I myself had never done some of these experiments before."	Community Impact, Professional/Personal Growth, Personal Connection, Curiosity