

Exploring Student Perceptions of Diversified Teaching Methods: A Case Study of the UCSD IEM OPALS Program

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ABSTRACT: This article explores the perceptions of diversified teaching strategies used in the Institute of Engineering in Medicine's (IEM) Outreach Program Advancing Learning in STEM (OPALS) program at the University of California, San Diego. The study investigated how various teaching methods impacted the OPALS interns' learning outcomes. The program activities included (a) traditional lectures, (b) invited speaker talks, (c) site visits to laboratories, institutes, and companies, (d) peer-learning through small group discussions and projects, (e) team-building activities, and (f) active learning through hands-on laboratory work. A mixed-method survey was administered to 43 OPALS participants after the completion of the program. The survey included both multiple-choice and short-answer questions to gather quantitative and qualitative information from the interns regarding their experiences with varied instructional methods. Descriptive statistics were used to evaluate self-reported learning outcomes, knowledge acquisition, skill development, program participation, and engagement. It was found that the majority of survey participants reported positive experiences regarding the diversified teaching methods, thus shedding light on their effectiveness within the context of the OPALS program.

INTRODUCTION

Background. OPALS (Outreach Program Advancing Learning in STEM) is a college preparatory program aimed at providing high school students with hands-on experience in biomedical and engineering research (OPALS, n.d.). Launched in 2015 as a part of the UCSD Biophotonics Lab, OPALS has allowed for the development of a deep connection between students and the world of STEM research and has steadily expanded its reach and impact. Former OPALS interns have matriculated to renowned academic institutions, including University of California, Los Angeles (UCLA); University of California San Diego (UCSD), Stanford University; Columbia University; University of California, Berkeley; and Johns Hopkins University. They also have won awards, such as from the Biomedical Engineering Society (BMES).

By integrating a variety of teaching approaches, the diversified teaching model implemented in OPALS takes advantage of experiential learning, the process by which students learn through experience. Experiential learning itself manifests in multiple ways (e.g., hands-on experience, internships, lab work, etc.), and has been implemented in

several fields, such as engineering education (Jamison et al., 2022). A crucial aspect of experiential learning is the emphasis on learning as a process as opposed to the traditional classroom's focus on valuing learning as a means to an outcome (Kolb, 1984). Previous research has identified a need for more comprehensive research aimed at assessing the value and impact of experiential learning within STEM fields (Staehle et al., 2023).

OPALS Program Description. Below we describe the OPALS program and the 2023 Cohort, with whom this study was conducted.

Program Application Process. In order to participate in OPALS, prospective interns complete an application through the OPALS website. The application package includes a letter of recommendation and a virtual interview component.

Program Evolution. Virtual learning approaches have been shown to improve accessibility (Dreesen et al., 2020). Thus,

in response to challenges posed by the COVID-19 pandemic, OPALS transitioned from an in-person to a virtual format in the summer of 2020, providing invaluable learning experiences to 40 high school students during a time of physical and mental upheaval. Building on this success, the OPALS program persisted in 2021, delivering a comprehensive online curriculum including Zoom sessions, virtual lab visits, and campus tours. In recognition of its enduring commitment to excellence, the program was officially renamed OPALS in 2022. This rebranding coincided with the introduction of a six-week dual-format approach: an in-person option for local San Diego interns, and a concurrent remote offering for out-of-state students, who primarily participate via Zoom and are invited to participate in person for hands-on laboratory work, if desired.

2023 Cohort Overview. The 2023 cohort marked a significant milestone for OPALS, demonstrating the program's potential to attract and engage a diverse spectrum of aspiring scientists and researchers; of the 113 interns, over half identified as female. Additionally, this cohort included three out-of-state participants, 20 individuals from counties outside of San Diego, and one international participant, highlighting the program's global appeal. A noteworthy aspect of the 2023 cohort was the allocation of 12 financial scholarships, which broadened accessibility and ensured that a diverse group of young minds could benefit from the program's enriching offerings.

Research Projects and Mentorship. The 2023 cohort was divided into groups of five students who were given the opportunity to engage in ongoing college-level research activities via 23 projects. These projects included research on heart diseases, glaucoma, neurodegenerative diseases, nano-scale edge detection, cell thickness calculation, and machine learning algorithms in cell segmentation and connection, among others. The interns also benefited from mentors—undergraduate students who were part of the OPALS staff and entrusted with the responsibility of overseeing 2-3 groups of interns. The mentors' primary role was to lead and supervise the interns, as well as acquaint them with the background and context of their projects. Near-peer tutors (akin to mentors in OPALS) have been shown to be effective as role models and in fostering academic development in Science, Technology, Engineering, and Math (STEM) education (Nelson et al., 2013).

Program Engagement. OPALS was not a selective program in 2023, as all students who submitted a complete application were accepted. Therefore, by extension, the applicants had varying expectations of the program due to their different levels of research experience. To best fit their needs, the interns were able to indicate their desired level of participa-

tion in the OPALS program using a color-coded framework during Week 2. Allowing students to have choices regarding instructional methods has been shown to improve learning outcomes (Billingsley et al., 2018). Interns were able to reach out to mentors for assistance in achieving their individual goals and had the flexibility to alter their color codes at any time.

Color Code Framework. The color codes were defined as follows:

1. Violet (~400 nm): Expresses a willingness to meet new people, learn from various labs, institutes, and center tours, take notes during common meetings, and actively participate in small group discussions.
2. Blue (~500 nm): In addition to the above, commits to completing at least one MATLAB onramp course, conducting research on the designated research areas prior to each lab, institute, center tour, and invited speaker lecture, preparing questions for the tours and lectures, and documenting key knowledge and keywords after the tours/lectures.
3. Orange (~600 nm): Builds upon the previous levels by completing at least two MATLAB onramp courses, developing proficiency in image processing related to the assigned project, and being able to present the project to group members within 3-5 minutes by the 5th week.
4. Red (~700 nm): Commits to the highest level by dedicating at least 60+ extra hours outside of the OPALS regular hours to image processing, result analysis, figure preparation in a publishable format, understanding how to draw conclusions, and actively engaging in progress discussions with scientists and postdocs.

These color code options were provided by OPALS and allowed students to select their preferred level of involvement, with guidance from their group mentors. After choosing a color to represent their desired engagement level, both virtual and in-person students were supervised by mentors who ensured their goals aligned with the chosen path and supported them throughout the process.

Diversified Teaching Methods. OPALS utilized a diversified teaching approach that included lectures, invited speakers, lab visits, small group discussions and projects, team-building activities, and hands-on lab work. Lectures were given either by guest speakers or mentors on a variety of topics related to the interns' projects. Invited speakers, who represented a range of backgrounds, spanning medical, business, and other academics in STEM fields, shared valuable insights into their careers and educational journeys. Both lectures and

invited speakers were generally conducted during ‘common group meetings’ in which all 113 interns met in a lecture hall. Interns were encouraged to take notes and discuss what they learned with their group members. Students can benefit immensely from role models, in the form of invited guest speakers and group mentors. These role models can serve as beacons of inspiration and help them envision their future careers and professional journeys (Schumann, 2018). These interns’ OPALS experiences will provide them with crucial aid at a point in their lives when they are deciding on universities and selecting their majors. Through guidance from influential role models, students are equipped with crucial insights as they approach pivotal decisions. The academic literature provides extensive documentation of a gender gap within the STEM field (Card & Payne, 2020). Having role models, especially for female students, has been shown to inspire them to become more entrepreneurial (Karimi et al., 2014), thus helping close the existing gender gap. Additionally, interns were taken to labs across the UCSD campus and beyond. In these lab visits, students gained perspective on the research process and the day-to-day activities of a research scientist. At the same time, students were able to engage with these researchers, thereby providing the OPALS interns with valuable information to formulate career pathways prior to entering university.

OPALS employed a project-based learning strategy, fostering team cooperation and learning through experience. In case examinations similar to the OPALS initiative, implementing project-based learning has generally garnered favorable feedback (Imaduddin et al., 2022). Additionally, project-based experiential learning, coupled with team coaching and collaboration, has been shown to have a positive impact in fields such as the health service delivery industry (Chelagat et al., 2020).

During ‘small group discussions’ OPALS interns worked on projects supported by a mentor to further their research. Additionally, students studied their project topic, read scientific journal articles tangential to their small group projects, conducted image and data analysis, and wrote scientific abstracts and posters. Group project work was generally done during small group discussions, lunch, or outside of OPALS hours. This use of peer and collaborative learning methods, especially in the context of small group activities, has been shown to help students achieve various learning goals (Boud et al., 1999). Peer and near-peer learning (Bulte et al., 2007) activities have been shown to enhance student engagement and positively impact learning gains.

Interns were also encouraged to complete self-paced online MATLAB courses to provide them with technical skills and improve their soft skills development. MATLAB, often utilized by researchers and engineers, is a platform developed by MathWorks that allows for matrix manipulation and data analysis. These courses, which are accessible through

MATLAB’s official website, span a wide range of content, including introductory courses as well as more advanced courses concerning the fundamentals of object-oriented programming within the MATLAB environment. By successfully completing these courses, interns were able to obtain certification through MATLAB, attesting to their mastery of the acquired knowledge and skills.

Interns were also able to build public speaking skills by presenting their projects at the end of the OPALS program. Improvement in public speaking skills can play a role in enhancing students’ sense of engineering, or STEM, identity (Linvill et al., 2019).

The interns engaged in team building through activities and outings in order to promote collaboration and teamwork. Team-building activities allowed for the fostering of psychological safety as the interns became more comfortable with each other. In similarity to previous findings (Gillies, 2004), OPALS interns were able to enjoy collaborative work dynamics. Fostering psychological safety and promoting cooperative learning within small groups has been shown to enhance innovation (Post, 2012). A sense of belonging and valuable peer support can also improve students’ overall well-being and mental health (McBeath et al., 2018). It is important to acknowledge that while a virtual intern option offers flexibility, it can hinder collaborative learning. In order to combat this, OPALS cultivates inclusion among its virtual interns through online team-building exercises via online games such as skribbl.io or Kahoot. Nurturing a sense of belonging among online learners can significantly improve their learning experiences (Peacock, 2020).

Interns also had the opportunity to engage in hands-on lab work related to their group projects. Applied experimental lab work that directly correlated to the interns’ group projects helped enrich their experience even further, allowing them to put theory into practice, an important facet of experiential learning. Hands-on lab work is an application of active learning, which has been found to be generally successful in the field of engineering education (Prince, 2004). Furthermore, the efficacy of hands-on engagement in STEM programs has been validated in programs similar to OPALS (Carlson & Sullivan, 1999). While OPALS prides itself on having a flexible and non-structured learning environment, a general weekly schedule outline is shown in Table 1.

Table 1. General weekly schedule for OPALS.

Time	Mondays/ Wednesdays	Tuesdays/ Thursdays	Friday
10:00am-12:00pm	Common Meetings	Small Group Discussions	Outings
12:00pm-1:00pm	Lunch	Lunch	Lunch
1:00pm-3:00pm	Research Lab Visits	Small Group Discussions	Outings

Research Objectives. As opposed to traditional learning environments, OPALS utilizes a holistic approach for the purpose of enhancing learning outcomes. OPALS implements a blended teaching philosophy that includes traditional lectures, invited speaker talks, laboratory visits, peer learning through small group discussions and projects, team-building activities to boost a sense of belonging and psychological safety, and active learning through hands-on lab work.

At the completion of the 6-week program, a survey was administered to obtain feedback from the 2023 OPALS interns. The survey collected data on the perceived impact of the instructional methods on the interns' knowledge acquisition, learning gains, skill development, and program participation and engagement. Additionally, it collected information on how well this teaching model aligned with the interns' personal learning style, in contrast to a traditional classroom setting. The purpose of this study was to examine the perception of this pedagogical approach in fostering comprehensive skill development, preparing students for conducting research at an undergraduate level, and overall improving learning outcomes through an analysis of survey responses and qualitative feedback.

METHODS

Research Context and Sample. The survey was designed to explore the interns' experiences with the diversified teaching methods. It was distributed via email to all 113 OPALS interns in the 2023 cohort and collected through Google Forms. A total of 43 interns (38%) responded to the survey, which was anonymous and voluntary. The survey was approved with an exempt determination by the Office of IRB Administration (OIA) at UC San Diego. It is important to note the potential impact on the findings of the self-selective responses to the survey.

Survey Design. The survey consisted of 12 questions, ranging from multiple-choice to short-answer form (see Appendix for complete survey). OPALS participants were asked to rate their overall experience with the diversified teaching methods on a Likert-type scale of 1 to 5, with 1 representing a "poor" experience and 5 a "very good" one. They also were asked to rank and evaluate specific teaching methods used in OPALS. Several questions invited detailed feedback on preferences and suggestions for improving the teaching strategies.

Survey Respondents. Of the OPALS participants who responded to the survey, 55.8% ($n = 24$) identified as female, 41.9% ($n = 18$) identified as male, and 2.3% ($n = 1$) selected Prefer Not to Answer. Participants were asked to select the race or ethnicity that best describes them; 81.4% ($n = 35$) selected Asian or Pacific Islander, 7% ($n = 3$) chose Two or

More ethnicities, 4.7% ($n = 2$) chose White, 2.3% ($n = 1$) chose Hispanic/Latino, and 4.7% ($n = 2$) chose Prefer Not to Answer. They also were asked the grade in which they were last enrolled; 39.5% ($n = 17$) were enrolled in the 12th grade, 39.5% ($n = 17$) in the 11th grade, 16.3% ($n = 7$) in the 10th grade, and 4.7% ($n = 2$) in the 9th grade.

RESULTS

Perception of Teaching Methods. The ratings interns gave to each teaching approach provided a nuanced perspective on how they evaluated their overall experience. In response to "How would you rate your overall experience with the various teaching methods utilized throughout the OPALS program?" (Question 4), the majority of interns indicated that they were pleased with the instructional approaches (see Table 2). A majority of survey respondents (81.4%; $n = 35$) assigned a "good" or "excellent" rating, indicating high levels of satisfaction with the diversified teaching methods. Note that only one respondent recorded a rating of "below average" for this question. This outlier may be attributed to the differences in specific group projects, team members, and group mentors, which yielded distinct learning experiences for each learner. Despite this variability, the overall finding demonstrates the adaptability of the diversified teaching model and its relevance for emulation by analogous initiatives.

Similar findings were seen in intern's responses to "How well did the diversified teaching strategies align with your personal learning style, as opposed to a traditional classroom?" (Question 5). As shown in Table 2, 83.7% ($n = 36$) of interns gave the strategies a "good" or "excellent" rating while 16.3% assigned the middle rating of "average."

Learning Outcomes and Skill Development. The survey asked the interns to rate the effectiveness of each teaching method for its effectiveness in three aspects of learning: knowledge acquisition, the creation of a collaborative and engaging learning environment among OPALS interns, and

Table 2. Interns' overall experience ratings for the diversified teaching methods on a 5-point Likert scale. The number in parentheses after each percentage is the number of students giving this rating.

Rating	How would you rate your overall experience with the various teaching methods utilized throughout the OPALS program?	How well did the diversified teaching strategies align with your personal learning style, as opposed to a traditional classroom?
1 (Poor)	0% (0)	0% (0)
2 (Below Average)	2.3% (1)	0% (0)
3 (Average)	16.3% (7)	16.3% (7)
4 (Good)	48.8% (21)	44.2% (19)
5 (Excellent)	32.6% (14)	39.5% (17)

Table 3. *Impact of diversified teaching methods as perceived by OPALS interns. The number in parentheses after each percentage is the number of students giving that response. *Skill development was defined as including soft skills such as teamwork, leadership, critical thinking and problem solving.*

Teaching Method	Which teaching method had the biggest impact on your knowledge acquisition?	Which teaching method allowed for a collaborative and engaging learning environment among OPALS interns best?	Which teaching method contributed the most to your skill development*?	Please rank each teaching method in terms of effectiveness for improving your learning outcomes. [First Choice]
Lectures	9.3% (4)	2.3% (1)	0% (0)	2.3% (1)
Invited Speakers	20.9% (9)	0% (0)	7.0% (3)	14.0% (6)
Lab Visits	7.0% (3)	7.0% (3)	4.7% (2)	9.3% (4)
Small Group Discussions	2.3% (1)	11.6% (5)	7.0% (3)	7.0% (3)
Group Projects	20.9% (9)	32.6% (14)	51.2% (22)	25.6% (11)
Team Building Activities	0% (0)	32.6% (14)	11.6% (5)	7.0% (3)
Hands-On Lab Work	39.5% (17)	14.0% (6)	18.6% (8)	34.9% (15)

the development of skills, including soft skills such as teamwork, leadership, critical thinking, and problem solving.

As shown in Table 3, a majority of interns attributed hands-on lab work and invited speakers with the most substantial knowledge acquisition. In response to “Which teaching method had the biggest impact on your knowledge acquisition?” (Question 6), 39.5% indicated hands-on lab work, with 20.9% indicating invited speakers, and an equal percentage indicating group projects. This data emphasizes the importance of experiential learning and exposure to accomplished professionals and academics in the knowledge acquisition process in STEM. Furthermore, Table 3 highlights that the students strongly preferred learning through their own experiences (through hands-on lab work or group projects) or through hearing about the experiences of others (through invited speakers).

In terms of building collaborative relationships, 32.6% of survey respondents cited group projects, and 32.6% cited team building activities as the most effective approach to promoting a collaborative and engaging learning environment in response to “Which teaching method allowed for a collaborative and engaging learning environment among OPALS interns best?” (Question 7). In contrast to small group discussions, fostering collaboration among team members appeared to be more effectively achieved through the implementation of group projects and team-building activities. This finding bears implications and provides insights into improving learning outcomes in OPALS and similar STEM training programs, highlighting the value of utilizing a range of educational strategies.

Finally, as shown in Table 3, the emphasis on group projects emerged as the most significant factor in nurturing essential soft skills such as teamwork, leadership, critical thinking, and problem solving. In response to “Which teaching method contributed the most to your skill development (including soft skills such as teamwork, leadership, critical thinking and problem solving)?” (Question 8), 51.2% of interns identified group projects as the learning method most contributing to their skill development. Moreover, the em-

phasis on active learning through collaborative group projects validates OPALS’ goal of developing holistic skill sets.

Students were asked to “Please rank each teaching method in terms of effectiveness for improving your learning outcomes.” (Question 9). Of the respondents, 34.9% chose hands-on lab work as their first choice, and 25.6% chose group projects (see Table 3).

Feedback and Recommendations from Interns. The survey collected qualitative data regarding interns’ most preferred and least preferred teaching methods with Question 10 requesting, “Please write a brief explanation for your first choice and your last choice. In other words, what was the reasoning behind your favorite and least favorite teaching method?” Their responses provided valuable insight into the OPALS participants’ perspectives and preferences regarding the diverse teaching strategies utilized in the program. Throughout all the feedback, interns overwhelmingly emphasized the effectiveness of active learning strategies over passive ones. The impact of interactive and experiential learning methods on knowledge acquisition, retention, and engagement was emphasized throughout the responses. Many interns expressed a preference for hands-on work, with one participant stating, “Hands-on lab work was interesting and was a new experience for me so I learned a lot.” This sentiment was echoed by several OPALS participants, underscoring the effectiveness of experiential learning or learning through experience.

A strong appreciation for group projects and small group meetings emerged as a common theme. These experiences were perceived to greatly impact the collaborative and engaging environment of OPALS, as well as credited with developing a sense of camaraderie among interns. As one intern wrote, “My first choice is group projects because they enabled me to not only write research papers, which was an excellent opportunity, but also conduct research (a potential career path for me) in a collaborative setting.” Through highlighting the benefits of collaborative efforts, interns pointed out the importance of interactions with peers. By working

together, interns were able to enhance their understanding of the group projects more effectively.

Along with positive feedback, interns offered suggestions for improving specific teaching approaches. The most common feedback was to make the lectures more interactive to allow for a more participatory experience, which supports other findings from the survey and is consistent with current ideas in cognitive learning theory. Furthermore, one of the major challenges of the more traditional lecture-based teaching strategy was the difficulty in maintaining interns' attention throughout the entire lecture. One intern wrote, "I prefer doing things hands on and experiencing it rather than listening to lectures and writing things down." In other words, a more 'passive' learning strategy, such as lectures, was not as engaging and effective as 'active' learning strategies such as small group discussions and group projects. A recurring sentiment among OPALS interns was the emphasis on how effective the diverse teaching methods were in fitting into the interns' varied learning styles. This suggests that experiential learning is important as it allows for a level of personalization and customization in order to optimize student engagement. The diverse teaching model presented by the OPALS program does more to cater to individual learning styles than a traditional classroom does.

Interns also valued the exposure to different career paths through the invited speakers, writing about their interest in the speakers' varied perspectives and experiences. One intern noted, "I loved learning about the various career paths that the various guest speakers had. It allowed me to have a more open minded view on my future career plans."

Notably, one intern wrote, "The team building activities were very fun but I did not find it memorable in the context of all the other teaching methods that OPALS offered." This feedback, along with others reflecting similar sentiments, highlights the fact that one teaching strategy is not able to accomplish everything. In other words, the diverse teaching model allows for many different nodes of learning to be achieved through the usage of both active and passive learning strategies, as well as allowing for both collaborative and individual learning. While team-building activities were seen as a fun activity that helped build camaraderie among interns, in terms of retaining knowledge, this learning method was not perceived as an effective strategy. Nevertheless, interns emphasized that the ability to build relationships with their team members allowed them to establish a supportive and influential learning environment that facilitated a sense of belonging and a culture of mutual assistance. It is important to recognize that student academic performance and the ability to acquire new skills are enhanced by learning environments that prioritize psychological safety, which increases a sense of belonging and boosts student engagement. Overall, the interns' feedback reinforced the importance of fostering experiential learning environments in STEM edu-

cation in order to effectively enhance knowledge acquisition and build engagement with the program.

Another survey question asked: "Are there any teaching methods that could be improved and/or modified to better facilitate a positive learning environment? If yes, please specify." (Question 11). Many participants responded "No" or "N/A", indicating high levels of satisfaction with the existing diverse teaching methods. However, others provided constructive feedback to further improve OPALS' ability to prepare students for undergraduate-level research. One common suggestion was the preference for a more balanced distribution of the teaching methods offered by the program. As one intern wrote, "I believe it would be better to have more group project/teamwork bonding time in replacement of lectures. The lectures were informative, but sometimes long." Thus, it is important for OPALS in the future to create a more strategic blend of learning methods to maintain student engagement and prevent monotony. This was reinforced by another intern, who noted that "The 2 hour lectures during the beginning of the day could maybe be modified." In other words, interns wanted less passive learning time (lectures, invited speakers) and more active learning time, as noted by this intern, who wrote, "More hands on lab and group activities will help opals." Interns also expressed a desire for more guidance regarding the group projects. One participant wrote, "I thought that there could be slightly more teaching coming from the actual group leaders, but overall I think that my group leader did a great job explaining to us the different processes for the projects."

Based on this feedback, OPALS can work on maintaining a more manageable schedule, with more time given to active learning strategies to avoid burnout and maximize student engagement. Some suggestions included increasing lab time, decreasing lecture durations, and introducing small breaks between lectures and lab visits to provide a mental reset. As noted earlier, despite the suggestions for improvements, many interns expressed overall satisfaction with the program. As noted by one participant, "I think all teaching methods were good!" Therefore, it can be concluded that the feedback demonstrated a collective desire among interns for a well-rounded learning experience through the incorporation of more hands-on lab work time and shorter lectures and invited speaker time. These insights will be extremely valuable in guiding OPALS to further enhance its learning environment in future iterations.

The final question of the survey asked "Is there any other feedback you would like to provide?" (Question 12). Due to its open-ended nature, the responses varied greatly. Numerous interns expressed positive sentiments and seemed very satisfied with the program. The overall tone of the responses was one of gratitude, with many thanking the program director and their group mentors in particular. For example, one intern wrote:

I thought this program was a fantastic way to spend my summer and I am grateful that I was given this opportunity to come and learn at UCSD. During OPALS, I was able to meet so many smart and kind individuals and expand my horizons.

Furthermore, many participants highlighted the positive aspects of OPALS, including the opportunity to explore various career paths and engage with guest speakers, as well as participate in unique lab visits. One intern noted:

The OPALS program was a great experience and I had a very great time with hands on learning and lab experiences. I got a lot out of this program. I was able to meet and network with so many smart and great people.

In this response, the ‘aspects’ refer to the diversified teaching methods, which proved to be very popular among OPALS interns. The interns expressed how the multifaceted nature of this OPALS differed from other similar STEM programs in its unique teaching style and flexibility, which allowed for a comprehensive learning experience. In conclusion, the qualitative feedback received from this survey expressed a strong sense of appreciation for the OPALS program’s diverse teaching strategies due to the positive impact on the interns’ learning experience.

DISCUSSION

The survey data provided valuable information regarding OPALS interns’ perceptions of the diversified teaching model. The majority of respondents reported positive experiences, suggesting that they were mostly satisfied with the range of pedagogical techniques instituted by the program. Hands-on lab work and group projects emerged as important learning tools, with OPALS interns attributing substantial knowledge acquisition to these learning methods. This aligns with the principles of experiential learning, due to the direct engagement and “learning-by-doing.”

Furthermore, the emphasis on group projects as a catalyst for soft skill development resonates with pedagogical theories that emphasize the importance of collaborative learning as it applies to real-world applications. Most importantly, these survey findings highlight the multifaceted nature of effective pedagogy. The combination of experiential and collaborative learning approaches emerges as a powerful way to enrich learning outcomes in STEM. Individual preferences vary, but overwhelmingly, OPALS interns valued the diversified teaching strategies over traditional learning strategies. In contrast to the passive reception of lectures in a traditional classroom setting, OPALS interns exhibited a notable inclination toward active engagement with hands-on lab work, collaborating with group members to solve problems, and

experiential learning.

The flexible structure of OPALS and the inclusion of group outings facilitated the prevention of monotony. Thus, this method has the potential for broader application within STEM education. While there is room for improvement, the diversified teaching methods provide tangible advantages to students, as demonstrated by their feedback. The survey data provide practical implications for improving the OPALS program. Based on this feedback, OPALS will likely continue to embrace a pedagogical model utilizing mixed instructional methods. The positive feedback about the role of team-building activities and outings will allow OPALS mentors to continue and even increase the amount of team-building activities in order to foster camaraderie among team members, as they played a key role in creating a positive collaborative learning environment.

The survey data show a positive reception by interns of the instructional approaches employed in the OPALS program, consistent with the literature. Considering that students favor a blended teaching strategy as opposed to conventional pedagogical approaches seen in traditional classroom settings, OPALS and similar programs are prompted to reflect on this finding and its implications. That is, what is it that students really want, and how do these learning methodologies align with positive learning outcomes? Going beyond, how can STEM initiatives stimulate students’ enthusiasm for learning and foster a love for research? Participant feedback allows OPALS to harness and improve synergies among the various teaching methods utilized throughout the program activities. As the practical application of diversified teaching methods within the OPALS program activities improves over time based on lessons learned and participant feedback, future studies and reports will become a valuable asset for OPALS as well as for similar STEM educational programs.

ASSOCIATED CONTENT

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

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

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ABBREVIATIONS

BME: Biomedical Engineering Society; IEM: Institute of Engineering in Medicine; OIA: Office of IRB Administration; OPALS: Outreach Program Advancing Learning in STEM; STEM: Science, Technology, Engineering, and Math; UCLA: University of California, Los Angeles; UCSD: University of California San Diego

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