Exploring Faculty Engagement in a Pre-College Engineering Outreach Program: Motivation, Facilitating Factors, and Barriers (Fundamental)

Hyena Cho, University of Illinois at Urbana - Champaign

Hyena Cho is a Ph.D. student in the Department of Education Policy, Organization and Leadership at the University of Illinois at Urbana-Champaign, specializing in Human Resource Development. She holds a B.A. and M.A. in Education from Yonsei University in Seoul, South Korea. Her research focuses on learning and development in engineering education contexts, using quantitative and qualitative methods to examine workplace and organizational learning that supports safe, inclusive, and learning-friendly environments. She is particularly interested in STEM and medical education, with an emphasis on student and faculty learning, creativity, and professional identity formation.

Yang Victoria Shao, University of Illinois at Urbana - Champaign

Yang V. Shao is a Teaching Associate Professor in electrical and computer engineering department at University of Illinois Urbana-Champaign (UIUC). She earned her Ph.D. degrees in electrical engineering from Chinese Academy of Sciences, China. She has worked with University of New Mexico before joining UIUC where she developed some graduate courses on Electromagnetics. Dr. Shao has research interests in curriculum development, assessment, student retention and student success in engineering, developing innovative ways of merging engineering fundamentals and research applications.

Prof. Yuting W. Chen, University of Illinois Urbana - Champaign

Dr. Yuting W. Chen is a Teaching Associate Professor in the Department of Electrical and Computer Engineering at the University of Illinois Urbana-Champaign, where she also leads the Women in Engineering program as the Director. She earned her B.S. in Electrical Engineering from the University of Illinois Urbana-Champaign in 2007 and her M.S. and Ph.D. in Electrical Engineering from Rensselaer Polytechnic Institute in 2009 and 2011, respectively. Her current interests include recruitment and retention of under-represented students in STEM, professional development for graduate students, service-learning, and curriculum innovation in electrical and computer engineering.

Exploring Faculty Engagement in a Pre-College Engineering Outreach Program: Motivation, Facilitators, and Barriers (Fundamental)

Abstract

Pre-college engineering outreach programs play an important role in broadening participation in STEM. Engineering faculty are key stakeholders in outreach programs, even though in many cases undergraduate or graduate engineering students participate more actively. Greater faculty involvement could improve outreach quality and sustainability, but faculty engagement is often limited by time constraints and competing academic responsibilities. This study examines how engineering faculty members describe their motivations for participating in a pre-college engineering summer camp and how they perceive factors that facilitate or hinder their engagement. A basic qualitative research design was employed for analyzing semi-structured interviews with five engineering faculty members who served as instructors in a week-long summer camp for middle school students.

Findings show that faculty engagement was constructed by motivations operating across multiple levels, including personal interest in working with youth, alignment with academic roles and disciplinary expertise, departmental goals related to community engagement, and broader educational purposes associated with outreach teaching. Faculty engagement changed during the camp through interactions with students, undergraduate lab assistants (LAs), and the instructional context. Student enthusiasm and peer support facilitated engagement, while challenges related to teaching middle school students, classroom management, limited coordination with LAs, and logistic constraints hindered it. Additionally, instructional autonomy functioned as both a facilitator and a barrier, fostering creativity while also increasing uncertainty, particularly at the outset.

This study conceptualized faculty engagement as a dynamic, multi-level meaning-making process. The findings suggest that sustainable faculty participation in pre-college engineering outreach requires an organizational support environment that complements individual motivation and autonomy at work.

Keywords. Faculty engagement, pre-college engineering outreach, STEM outreach, and basic qualitative research

Introduction

Pre-college engineering outreach has increasingly become a crucial mechanism for broadening participation in STEM and enabling historically underserved youth to access engineering pathways [1] - [3]. As universities continue efforts to strengthen the engineering talent pipeline and reduce structural barriers to participation, outreach programs led by engineering programs have received growing attention in both practice and research. Yet, the majority of engineering outreach studies have focused on student-side outcomes - such as interest in STEM, career intentions, or self-efficacy - or on program structures and curricular design [3]. Faculty, however, are not peripheral agents. They are the ones who enact outreach in real instructional settings, translate disciplinary knowledge into accessible forms, and shape students' lived experiences of engineering. Understanding why engineering faculty invest their time and effort in pre-college outreach, and under what conditions such efforts are sustained or constrained, is essential for enhancing program quality and long-term sustainability.

Prior research on faculty outreach engagement and motivation has produced multidimensional perspectives incorporating individual and environmental influences [4] - [7]. However, these frameworks have largely been derived from faculty in social sciences, education, and other community-oriented fields, with limited attention to the disciplinary norms and academic climate specific to engineering. Moreover, existing models tend to collapse relationship-based motivations, departmental culture, and disciplinary commitments into broad environmental categories, obscuring the nuanced interactions among personal identity, interpersonal relationships, departmental obligations, and engineering-specific values related to broadening participation [8]. As a result, there remains a limited in-depth understanding of how engineering faculty themselves make meaning of their outreach experiences through a multi-level motivational lens.

To address this gap, this study examines how engineering faculty who served as instructors in a week-long pre-college summer camp describe their motivations, identify factors that facilitate or constrain their engagement, and make meaning of their outreach experiences. This qualitative study is guided by the following research questions:

1. How do engineering faculty describe their motivations for engaging in this pre-college outreach summer camp as instructors?
2. What factors do faculty perceive as facilitating or hindering their engagement in outreach participation?

Background

Pre-college engineering outreach

University-led outreach has historically served as a means of advancing the public mission of higher education [9]. In engineering education, STEM outreach programs began to receive significant institutional attention in the 1990s. The 1986 Neal Report emphasized the need for increased faculty engagement and curricular reform in STEM education [10]. Over the past several decades, the National Science Foundation has developed a range of outreach programs that support K-12 STEM education, university-school partnerships, and efforts to broaden

participation in science and engineering [11]. Beyond financial and performance-based pressures, the unique academic needs of engineering further highlight the importance of outreach. Engineering disciplines require long-term, highly specialized preparation and continue to face persistent challenges - such as declining interest in STEM, workforce shortages, and a lack of diversity [2], [12] - [14]. Against this backdrop, STEM outreach serves dual purposes: fostering early STEM interest among youth and building a future engineering pipeline [1], [15].

Despite growing institutional efforts, most prior outreach studies in engineering education have focused either on learners or on educational programs themselves. Early research often introduced individual camps or workshops and assessed their influence on students' engineering perceptions or career intentions [1], [16]. Later studies explored longer-term outcomes, such as college choice, STEM persistence, and self-efficacy, but still maintained a learner-centered perspective [17] - [19]. More recently, attention has expanded to program design and evaluation frameworks [3], [20]. However, across this literature, the role of faculty, which is the other key agent in outreach, has remained underexplored [3].

The role of faculty in education remains pivotal. In educational contexts, the instructor is not merely a facilitator but a co-constructor of the learning experience, as conceptualized by Amidon [21]. While learner-centered paradigms rightly emphasize student agency, it is essential to recognize that education is an interactional process shaped by both teachers and students [22]. As often quoted, "The quality of an educational system cannot exceed the quality of its teachers" [23] - a principle equally applicable to outreach programs. Understanding the motivations, experiences, and challenges of faculty participants can provide critical insights for enhancing outreach quality.

Why, then, is it important to examine outreach from the faculty perspective? For many faculty members, participating in outreach entails considerable opportunity costs. Studies have documented barriers such as limited time, unclear institutional rewards, vague evaluation standards, and pressure to prioritize research over service [24] - [26]. Outreach is often framed as voluntary labor, secondary to core academic responsibilities, and may be undervalued by peers and administrators alike [27]. These structural challenges are rooted in a broader academic culture that, since the 20th century, has increasingly prioritized research productivity while marginalizing the civic and moral dimensions of scholarship [28]. Today's universities operate under intensifying demands for accountability and performance metrics [29], [30], often placing community engagement lower in institutional hierarchies than research [31], [32]. As faculty devote disproportionate time to grant writing and publishing, outreach efforts are frequently deprioritized. Practical barriers, such as the lack of institutional recognition in promotion and tenure, limited funding, inadequate administrative support, and challenges in assessing long-term impact, further constrain the sustainability of STEM outreach [33].

Faculty engagement and motivation

The concept of motivation originates in psychology and human development and broadly refers to the reasons why individuals act toward specific goals. Prior studies distinguished motivation as the reasons faculty choose to participate and engagement as the observable participation in outreach or community-engaged activities [26], [29]. Traditionally, motivation research has

examined this through a dichotomy of internal or external drivers that explain why individuals engage in particular tasks. The former involves one's personal goals, values, and sense of competence, while the latter pertains to external conditions or incentives that encourage action or shape behavioral consequences [34], [35]. Although scholars have long discussed the roles of individual goals and external environments in shaping faculty motivation, many argue that this simple intrinsic-extrinsic binary is insufficient for capturing the complexity of faculty engagement in participatory scholarship [36]. In response, recent studies have moved toward multi-dimensional models of motivation that extend beyond the individual level [26], [29], [37], [38].

A notable point in motivation research is that motivation is not merely an individual-level phenomenon, but a collective-level phenomenon that manifests in communities, social movements, generational dynamics, political ideologies, workplace environments, policies, and socialization processes [37]. Faculty motivation, shaped by both individual and collective influences, can be understood as a predictor of the observable phenomenon - faculty engagement. In other words, the values and goals that drive faculty members shape the depth of their participation in outreach activities. Faculty engagement cannot be explained solely by individual factors such as personal inclination or passion; capturing its complexity requires a multidimensional approach. Therefore, to understand faculty engagement, we will examine representative research models that explain it through a multidimensional motivation framework and review their limitations, as well as opportunities for conceptual expansion.

The most renowned study in faculty community engagement, O'Meara [26], identified a typology of seven motivations for faculty participation in community-based activities [39]. O'Meara analyzed narrative essays written by 68 exemplars (62% from social sciences and humanities) across disciplines and used grounded theory to analyze the motivations driving U.S. university professors to engage in outreach and community work [26]. The findings revealed the following motivations in descending order of frequency (percentage): To facilitate student learning and growth (94%), Personal/professional identity (60%), To achieve disciplinary goals (53%), Personal commitments to specific social issues, places, and people (50%), Institutional type and mission, appointment type, and/or an enabling reward system and culture for community engagement (50%), A desire for collaboration, relationships, partners, and public-making (47%), and Pursuit of rigorous scholarship and learning (44%). This study is significant as it marks the beginning of multifaceted research into why faculty engage in community-engaged activities across all academic disciplines, whereas earlier studies largely focused on barriers to engagement [8]. Subsequently, O'Meara [37] utilized Astin's I-E-O (Input-Environment-Outcome) model [40] to emphasize that faculty participation is shaped not only by personal attributes but also through interactions within institutional and academic environments. She claimed that professors develop self-efficacy, expertise, and a strong sense of academic agency through participatory engagement, framing such involvement as opportunities for scholarly growth that extend beyond voluntary service.

Wade and Demb proposed the Faculty Engagement Model (FEM) to offer a more comprehensive perspective on faculty engagement [29]. They identified three main dimensions: personal dimension (identity, self-efficacy, values, etc.), professional dimension (academic norms, career stage, balance of research-teaching-service, etc.), and institutional dimension (organizational

culture, promotion and reward systems, leadership, resources, etc.) [29]. They argued that engagement is formed through the interaction among these dimensions. The FEM particularly emphasized the interaction between dimensions, asserting that faculty engagement is not simply the independent sum of the three factors but rather the result of their interactions. Even if an individual professor possesses a strong commitment to the public good, sustained participation may be limited if the specific academic field or institutional support is weak. However, this model was also presented more as a conceptual framework than as empirically validated, and the specific pathways and causal relationships between motivations at each level remain insufficiently clarified. Specifically, the model's tendency to group non-personal motivations, such as interpersonal relationships, community commitment, and policy-level social factors, into a single broad category risks obscuring differences in the actual operational levels of motivation [8]. Differences across academic disciplines have also been consistently observed [26], [29], yet how these disciplinary contexts affect the motivational dynamics underlying outreach engagement remains insufficiently understood.

Despite advances in multifaceted studies on faculty and motivation for community engagement activities, existing research still exhibits the following gaps. First, impersonal factors are defined too broadly, obscuring differences in motivation across levels [8]. Specifically, interpersonal, community, and social motivation are grouped under impersonal or environmental factors, despite being distinct motivations, limiting the ability to highlight their differences. Second, despite the general recognition of overlap between personal and impersonal motivations, the interactions among motivations remain poorly understood [36], [37]. While the FEM model acknowledges the importance of interactions between dimensions through bidirectional arrows, further research is needed to specify these interactions.

Pre-college Outreach Program Overview

The University of Illinois Urbana-Champaign has been offering a wide range of summer camps for high school students for decades. However, opportunities for middle school students to participate in engineering-related activities are limited. Across the U.S., only a few universities located in major cities, such as Carnegie Mellon University, Georgia Institute of Technology, Johns Hopkins University, Massachusetts Institute of Technology, New York University, and Northwestern University offer recurring engineering summer camps or summer courses at the middle school level [41] - [46]. The primary goal of this summer camp is to introduce middle school students to fundamental electrical and computer engineering topics and hands-on STEM learning. Upon completion of the summer camp, the program aims to spark curiosity in electrical engineering at an early age, foster students' confidence in teamwork and project-based learning, and provide opportunities for connections with university faculty, and undergraduate student mentors.

The camp was founded in 2023, and runs each summer. There are two faculty coordinators for the camp: one with over 15 years of experience in STEM outreach, working extensively with K-12 students and educators, and the other with multiple volunteering roles in K-12 settings. Before finalizing the schedule for subsequent offerings, the faculty coordinators will review each session and adjust the curriculum to better fit middle school learners. First-time faculty

instructors are invited to meet with a Ph.D. student in education to ensure contents and teaching pedagogy used are age appropriate.

The camp runs a week-long in-person program, and welcomes about 20 - 25 campers each year. Campers arrive at 9am in the morning and wrap up at 5pm in the afternoon. Each day is divided into a series of 1.5-hour sessions, with each session started with introducing the concepts and followed by hands-on activities. Faculty members have the freedom to choose what topic they would like to discuss in their session and provide chances for lab tours and/or using lab equipment for hands-on projects. The Summer 2025 offering covered a variety of topics, including circuits, digital logic, probability, optics, robotics, green energy, and many others. Most sessions were delivered to the full cohort; however, the bioengineering module and the analog signal processing laboratory experience were divided into two parallel, back-to-back sessions to accommodate space and equipment limitations. Each session was designed to be modular, age-appropriate for middle school students, and hands-on. The camp also incorporates fun social activities such as bowling and billiard to allow campers to build relationships with each other and get a taste of college life. At the end of each day, the camps would fill out a daily survey about their reflections on the daily activities. Then, the campers would work on hands-on projects in teams of 2 or 3 under guidance of a lab assistant using SparkFun inventor's kit for 90 minutes.

At the start of the camp, expectations for behavior and participation were informally discussed during the icebreaker activities. We emphasized respect for peers and faculty. Students were encouraged to actively participate during hands-on sessions and ask for help before becoming frustrated. While there was no formal policy on cell phone usage during the camp, faculty coordinators have observed that the hands-on format of the sessions typically kept students focused and limited their cell phone use.

Lab assistant role overview

The weekly-long activities are supervised by lab assistants, who were undergraduate students from the ECE department. The LAs provided technical assistance for hands-on electronic activities since many campers had never used electronics or programed codes before. Prior to the camp start date, LAs had a one-hour training session with the camp coordinator on the learning objectives and their role in technical and mentoring activities. The training included a brief overview of the electronics projects and discussion on how to support the middle school students. The LAs were encouraged to guide students through the projects rather than correct their mistakes.

Methods

This study employed a basic qualitative research design to examine faculty experiences and the processes underlying their motivation in pre-college engineering outreach. A basic qualitative study was chosen to gain an in-depth exploration of people's experiences and interpretations [47], particularly when addressing a problem of educational practice [48]. Given that motivation is not merely an individual trait but is socially and contextually constructed, the basic qualitative design was necessary to capture these nuanced interpretations. By focusing on faculty members

who served as instructors in the camp, this study aimed to comprehend how they interpret and construct meaning from their engagement in outreach teaching from their own experiences [47].

Participants

This study enrolled five faculty members, all of whom served as instructors in the pre-college engineering outreach summer camp. Initially, six faculty voluntarily agreed to participate in the study, but due to summer scheduling constraints, five ultimately completed the interview process. Out of the five participants, four completed a year-long training program through the college for new faculty on teaching & learning. Participants had minimum outreach experience prior to becoming instructors for this summer camp. Purposive sampling [49] was used to intentionally select participants who had direct involvement in teaching at the camp and could describe their experiences as instructors. The inclusion criteria were as follows: (1) faculty affiliated with the host department who served as instructors in the 2025 pre-college summer outreach program, (2) individuals who joined the camp as voluntary instructors rather than program organizers or administrators, (3) those who taught a session instead of only showing a lab demo, and (4) preferably, faculty who were willing to actively participate in interviews and had completed their instructional role in the program.

After the completion of the summer camp, program coordinators informed faculty instructors about this study and asked whether they were willing to be contacted by the research team. Only those who agreed had their contact information shared with the research team, who then sent individual email invitations and scheduled interviews after obtaining consent. Variation in academic rank, gender, and prior outreach experience were intentionally considered to foster diversity within the qualitative research sample [50]. The reason for more teaching faculty being interviewed is that tenure-track faculty are usually the ones who have a research lab and are being asked to do lab demos. Detailed demographic and background information of the study participants is presented in Table 1.

Table 1: Participant Characteristics and Instructional Involvement in the Pre-College Engineering Outreach Camp

Participant	Academic rank	ECE teaching experience	Camp participation	Gender
1	Postdoctoral Researcher	Early-career	First time	Female
2	Assistant Professor	Mid-career	Second time	Male
3	Teaching Assistant Professor	Mid-career	First time	Male
4	Teaching Associate Professor	Late-career	Third time	Male
5	Teaching Assistant Professor	Mid-career	Second time	Female

Data collection

This study primarily utilized data collected through in-depth interviews with participants. Additionally, the researcher's observation and reflection notes served as supplementary materials. The interviews were conducted remotely once via Zoom from June 24 to July 29, 2025, within 1 month of the camp's conclusion. Individual 1:1 interviews averaged approximately 45 minutes (range: 30-60 minutes) and were based on a semi-structured questionnaire. The interview protocol was designed to elicit reflections on motivations, memorable instructional moments, and perceived challenges. This protocol was informed by prior studies on faculty community engagement and motivation [26], [29]. Example interview questions included:

- What expectations did you have before the camp, and how did these compare with your actual experience?
- What motivated you to participate in the summer camp?
- What were the most memorable moments during the camp and why?
- What challenges did you encounter before or during the camp?
- What personal or professional significance does this outreach experience hold for you?
- Please give us recommendations for future iterations of the camp.

Probing questions were used selectively to deepen reflection when participants recalled memorable events and to understand the meaning they attributed to them. In addition to interview data, two interviewers attended the camp as participant observers to gain a contextual understanding of the camp environment. Their role was limited to observing sessions and interacting informally with K-12 students and the faculty members.

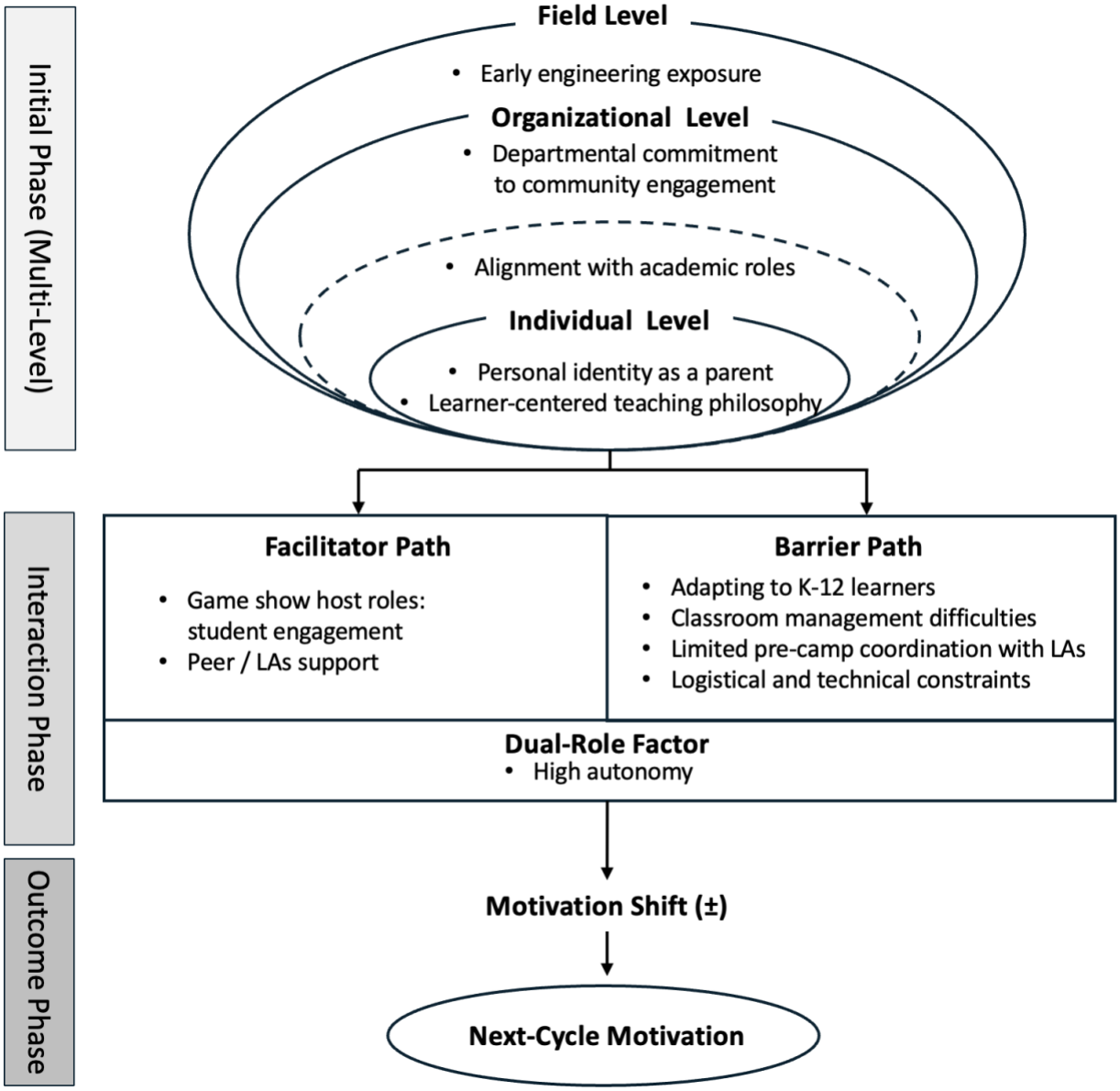
Data analysis

This study employed thematic analysis and followed Lochmiller and Lester's seven phases [51]. Thematic analysis served as a flexible framework that encompassed a range of approaches focused on identifying recurring patterns, or "themes", within qualitative data [52]. Because it can generate findings based either on established theoretical frameworks or emerging directly from the data, it is adaptable to a variety of research questions [53]. Its seven phases generally involve preparing and organizing the data, transcribing the data, becoming familiar with the data corpus, memoing the data, coding the data, producing categories and themes from underlying coded passages, and making the analysis process transparent [54]. Data were coded using MAXQDA (v. 24.11), a qualitative data analysis software. The first author conducted the primary coding and analysis. The codes were inductively generated, while both emergent patterns and existing faculty engagement models informed theme formation. To strengthen analytical rigor, two co-authors with expertise in engineering education and outreach reviewed the coding structure and emerging interpretations, and category definitions were refined through iterative discussion. The researchers engaged in ongoing reflexive examination and cross-validation across data resources. Credibility was further supported by sharing preliminary interpretations with participants for member-checking and by conducting peer debriefing with co-researchers throughout the analytic process. These iterative procedures occurred in a cyclical rather than linear manner, allowing interpretations to evolve and refine progressively [54]. Furthermore, given the small sample drawn from a single summer camp, the findings are intended to provide in-depth contextual insight rather than generalization.

Results

The findings revealed that faculty engagement in pre-college outreach was constructed through a constellation of motivations and conditions operating across multiple, interconnected levels. As illustrated in Figure 1, initial motivations emerged through overlapping individual, individual–organizational, organizational, and field levels, rather than as discrete or independent factors. Individual-level motivations, such as personal identity and learner-centered teaching philosophy, were embedded within and reinforced by alignment with academic roles, departmental commitments to community engagement, and broader disciplinary and educational purposes of providing early exposure to engineering.

Figure 1. Multilevel Process Model of Faculty Motivation and Engagement for Pre-College Outreach Participation



These multilevel motivations represent an initial phase of engagement. As indicated by the vertical axis, faculty engagement evolved during the interaction phase of camp participation, where experiences were shaped by both facilitating and constraining conditions. Engagement was strengthened through facilitators such as students' visible engagement and growth and peer or lab assistant support, while it was challenged by barriers including adapting to K–12 learners, classroom management difficulties, limited coordination with lab assistants, and logistical or technical constraints. Notably, high instructional autonomy functioned as a dual-role factor, simultaneously enabling creative instructional engagement and generating adjustment-related strain. These experiences contributed to shifts in motivation, influencing faculty members' willingness and orientation toward participation in subsequent outreach cycles.

Initial Motivation

At the individual level, faculty members' individual motivations for participating in summer outreach were strongly shaped by personal identities and affective connections to children. Participants described their engagement as grounded in their roles as parents or in a broader personal fondness for working with youth. These affective orientations toward youth contributed to a positive emotional readiness for engagement and framed outreach teaching as a personally rewarding experience rather than an additional professional obligation.

I like kids, and I think it's fun to interact with them. I have a son, and I kind of think about him growing up, going to school, and his future. He's only three years old now, but thinking about his future makes interacting with other students feel heartwarming to me. (P02)

I have a daughter, and she's now 16. Unfortunately, she doesn't like engineering, but I think it would have been a great experience for her if she had done something like this. Seeing the students actually enjoying being there and having fun was meaningful to me. (P03)

Furthermore, faculty members' learner-centered teaching philosophies emerged as a key source for outreach participation. Participants consistently emphasized the educational value of creating opportunities for students to learn through direct experience, exploration, and hands-on engagement rather than passive instruction. Faculty described meaningful teaching as a relational process in which learners actively construct understanding and develop confidence through doing, questioning, and experimenting. Within this context, as camp instructors, faculty members enact their pedagogical beliefs by supporting students as they take their first steps into the engineering world.

I always want to help students get the best experience and learn as much as they can while they're here. I get excited about that. … I wanted them to have quite a bit of hands-on experience, so I chose two or three topics that I thought would be interesting for students and that I could easily create hands-on activities for. (P03)

At the individual-organizational level, faculty members' motivations were reinforced by the alignment between outreach teaching and their academic roles. Participants described adapting topics drawn from their research areas or college-level courses for a middle school audience.

This alignment reduced the perceived burden of participation by allowing faculty to draw on familiar content and expertise, rather than developing entirely new instructional materials. Thus, outreach teaching was experienced not as an additional obligation but as a manageable and meaningful extension of their ongoing research and teaching work.

I basically led one activity on the topic of probability and codes, which is very related to my research. I thought this could be a way of doing something that would still be somewhat aligned with my research. (P02)

I was going to expose them a little bit to circuits, which is one of the courses that I teach. … I had already run the whole session for my college students, so it did not require too much additional organization. (P05)

Faculty motivations were also shaped by organizational-level considerations, particularly a shared awareness of the department's commitment to community engagement and public visibility. Participants articulated the understanding that the outreach camp served as a mechanism for strengthening the department's relationship with the local community and enhancing its public image. Faculty expressed a desire to contribute to these shared goals as departmental members, indicating that the organizational mission and identity served as meaningful motivations for participation alongside individual interests.

I think this is something that looks good for the department, the ECE department as a whole, to engage with the community. It is also a way for me to support some of the community engagement elements of the department. (P02)

This is more of a departmental goal, to get exposure for our department, so that people know that we are there and understand what kind of work we do. (P03)

At the field level, faculty members framed their outreach participation as contributing to students' exposure to engineering and shaping early positive perceptions of the field. Participation highlighted the importance of introducing the engineering field to students who may otherwise have limited opportunities to encounter it and supporting them to interpret the field as approachable and enjoyable. This sense of responsibility extended beyond the department to the disciplinary mission of broadening participation in STEM. When individual values, departmental goals, and broader educational purpose aligned, faculty engagement emerged in a natural and meaningful form of contribution rather than a mandated service activity.

The thing that makes it so important is that it's an opportunity for kids from kind of all different backgrounds to be exposed to like these engineering topics that can hopefully like spark an interest whether or not they become engineers, but at least like show them that, you know, these are topics that they can grasp and they can have fun learning. (P01)

I think this is very important. You never have a second chance to make a first impression, and you have a lot of responsibility. If you do a bad job, if you are boring or annoying, or if you do not align with young people's expectations, it can create a negative reaction. (P05)

Facilitators and Barriers to Faculty Engagement

Beyond initial motivation, faculty engagement was not static or solely driven by individual predispositions; it was continuously shaped by interactions with students, lab assistants, and the teaching environment during the camp. These contextual factors either strengthened or constrained faculty engagement over time. One of the most salient facilitators was observing students' high engagement and growth. Faculty described moments of intense curiosity, sustained attention, and active questioning as particularly energizing, often exceeding their expectations. Witnessing students' enthusiasm for learning reinforced faculty members' sense of instructional efficacy and made them feel like game show hosts.

As soon as the activity started and I could tell that they were interested, I found it exciting and fun. I really got into it, almost like a game show host kind of attitude, and I enjoyed that. (P02)

I could not believe how many of them wanted to take pictures of the board and write things down. They pleasantly surprised me by how interested they were in the actual principles behind it. … My number one moment was when my session ended, we finished going over the optics, and I saw how many kids were coming up to ask questions. That was definitely my favorite moment. (P01)

Additionally, support from peer faculty members and undergraduate lab assistants also facilitates engagement. Faculty benefited from informal learning opportunities, such as observing colleagues' outreach practices through shared instructional materials or videos, as well as from in-session assistance with classroom management and hands-on activities. These collaborative dynamics reduced instructional strain and enabled faculty to focus more fully on teaching and student interaction.

When it came to preparing to actually do the activities, Colleague 1 is so involved with teaching and outreach that he has made YouTube videos of him doing these activities, sometimes with his kids. He has also led things where he teaches other instructors how to do them. I was in a really fortunate spot where I watched a few hours of YouTube videos from Colleague 1. For the projector, I watched his video and read the instructions, making sure I knew how it would work. (P01)

I think Camp Coordinator 1 was there when I ran the session, as well as two student helpers, and they were very helpful. The student helpers, especially LA 1, were going around answering questions and helping prepare materials. I think it was a good system of instructors. (P01)

Meanwhile, the faculty encountered several challenges that complicated their participation. A primary one involved adapting instructional content and interaction styles to suit middle school learners. Participants expressed uncertainty about age-appropriate pedagogy and classroom interaction strategies, noting that limited prior experience with this age group heightened anxiety and reduced confidence. These concerns highlighted the need for targeted instructional support or preparation to help faculty translate college-level material effectively for younger audiences.

I am in front of a classroom quite often, but this felt very different from my usual classroom experience. Both times, I felt a little nervous, wondering what if students did not care or were really rowdy. I do not have a lot of training in dealing with middle school students, so I am always a little nervous about that. (P02)

I am bad at teaching kids in school. I feel like you need to have an educational background to handle younger students, because their psychology, perception, and the way they think and handle things are completely different. (P05)

Second, classroom management emerged as another challenge, particularly in sessions with large numbers of students. Faculty described difficulty balancing attention between students at different learning paces and managing distractions such as cell phone use. These challenges occasionally disrupted instructional flow and diverted faculty attention away from teaching content, contributing to moments of frustration.

With so many students, it was a little hard to answer questions all at the same time, because it was difficult to decide whether to prioritize helping the students who were a bit behind, or to encourage them to talk more with their neighbors and respond to questions from students who were ahead. (P01)

A lot of them were on their cell phones and were not paying attention to the instructions, so we had to go and help them. … I think there should be a policy of no cell phones during the activities, because it is distracting. (P03)

Third, while lab assistants were generally viewed as supportive, limited pre-camp communication with them posed challenges. Faculty noted that insufficient coordination occurred before sessions and that troubleshooting hands-on activities collaboratively. Given the practice-oriented nature of the camp, participants emphasized that stronger pre-session collaboration with lab assistants could enhance instructional coherence and reduce in-the-moment difficulties.

I think it would have helped if I had contact with the assistants. In the end, there were four or five people assisting the students, and I had asked a few days before whether I would have anyone assisting. I would have liked to meet with them beforehand so I could explain why it was needed and coordinate better. (P03)

I think it would be nice to have some time with the lab assistants before the students arrive. They are hired hourly, so it would have been possible to schedule hours prior to the actual camp. (P05)

Lastly, faculty engagement was also constrained by logistical and technical challenges related to program organization and instructional infrastructure. Participants noted issues, including limited instructional resources and inadequate classroom facilities, which occasionally disrupted instructional flow.

I think the issue was that not everybody had a kit. We did not have many resources, and the room

did not support that many students. There was no projector, and there were only two music workstations. Not everyone even had a chance to play around with the continuum, for example. (P04)

There were also some technical difficulties, which are not fully controllable. It was a bit funny because I wanted to use a remote control to switch slides, but it had old batteries. I had not checked it beforehand, so I had to walk around the room and click the slides myself. (P05)

Notably, high levels of instructional autonomy served both as a facilitator and a barrier to faculty engagement. On one hand, limited structured guidance leads to uncertainty and stress, particularly for first-time outreach instructors. On the other hand, this autonomy enabled faculty to exercise creativity, respond flexibly to teachable moments, and tailor instruction to their strengths. As such, instructional autonomy operated as a double-edged sword - simultaneously creating logistical strain while supporting deep engagement and pedagogical experimentation.

Everything seemed pretty open, but there was not anything structured for me. (P01)

At first, I did not feel like there was much guidance about what was good or what was appropriate, and I did not feel there was much support for someone creating a new activity. (P02)

In retrospect, I think that was also helpful because it gave me the freedom to do whatever I wanted, and it worked. … In the end, that freedom was helpful for me to think and do things in my own way. (P02)

It was very independent, so I could just go and do my own thing. That also helped with scheduling around my own teaching, because I teach every morning during the summer. … I had to plan around that and be creative to make it to my own class on time afterward. (P05)

Discussion

This study explored engineering faculty members' motivations, facilitating factors, and barriers in participating in a pre-college engineering outreach camp through a multi-level lens. By doing so, it conceptualizes faculty engagement as a complex and process-oriented phenomenon that cannot be reduced to individual factors or organizational conditions alone. Whereas prior studies on faculty engagement and motivation have typically categorized factors as personal beliefs, institutional rewards, or social missions [26], [29], the findings of this study suggest that, in practice, these influences are not experienced as discrete factors. Instead, faculty described their outreach participation as a meaning-making process shaped by the simultaneous and interconnected operation of motivations at various levels. Specifically, the facilitators and barriers identified in this study reflect more than simple expressions of emotional satisfaction or unfulfillment. Instead, they indicate conditions that shape faculty members' perceived feasibility and willingness to continue outreach participation, influencing how they approach future involvement. Moreover, this perspective moves beyond viewing outreach participation as an activity dependent on individual faculty commitment. It highlights the importance of designing an organizational or field context under which multiple sources of motivation can converge. From this standpoint, the study offers four insights into sustainable faculty participation and

instructional quality in pre-college engineering outreach.

First, this study extends existing faculty engagement frameworks by offering a level-based interpretation of faculty motivation. Although prior frameworks have focused on the multidimensional nature of faculty engagement [29], they have paid comparatively little attention to clarifying the levels at which different motivations operate. For example, O'Meara identified a broad range of motivations, such as identity, disciplinary commitments, etc., but did not explicitly distinguish whether these motivations function primarily at the individual, organizational, or field level [26]. In contrast, this study analytically distinguished faculty motivations at the individual, individual-organizational, organizational, and field levels using faculty narratives. Importantly, this distinction does not imply that motivations were experienced as separate. In fact, faculty tended to describe their participation by weaving together personal meaning, alignment with departmental goals, and broader educational purpose into a single interpretive account. This pattern suggests that the multi-level framework proposed here serves as an interpretive model that captures how they make meanings of their outreach participation, rather than as a causal model specifying necessary or sufficient conditions for engagement. By clarifying the level at which motivations are situated, this framework provides a structured foundation for future research to more clearly link individual- and organizational-level variables, and for outreach programs to identify more precise points of intervention beyond reliance on individual faculty commitment.

Second, this study reveals that barriers to faculty engagement emerged through the interaction of multiple factors. Faculty described several challenges during camp participation, with difficulties adapting to the K-12 learning environment being most consistently evident. They reported uncertainty and low self-efficacy related to age-appropriate pedagogy and classroom management - challenges that were based on teaching in a context different from their typical settings. These difficulties were compounded by limited pre-camp coordination with LAs, constrained instructional resources, and unexpected technical or logistical challenges. Together, these factors made it difficult to fully enact their planned instruction and increase overall cognitive and emotional demands. Importantly, these constraints should not be interpreted as individual faculty deficits or resistance. Rather, they reflect tensions between the expectations placed on faculty roles and the organizational support available to meet them. This finding suggests that faculty engagement challenges are shaped not only by individual readiness but also by the structural design of outreach programs that support teaching in K-12 contexts.

Lastly, the findings illustrate the dual role of instructional autonomy as both a facilitator and a barrier. High levels of autonomy enabled faculty to design sessions aligned with their expertise and pedagogical philosophy, fostering creativity and ownership in teaching. At the same time, in the absence of clear guidance, autonomy also leads to uncertainty and additional burden, particularly for faculties participating for the first time. This duality suggests that the effects of autonomy depend on how it is embedded within organizational structures that provide appropriate support, rather than on autonomy itself.

Taken together, these findings suggest that designing pre-college engineering outreach programs for sustained faculty engagement requires attention to how individual motivations are structurally supported at the organizational level. Outreach programs should make explicit

connections between faculty members' teaching pedagogy, disciplinary expertise, and the broader organizational goals of outreach - such as including public engagement as part of the Promotion & Tenure Dossier, enabling faculty to interpret participation as an integrated part of their academic role rather than optional service. In addition, programs should provide structured instructional scaffolding to support faculty teaching in K-12 contexts, such as brief orientations, shared instructional resources, and opportunities for collaborative planning with education-focused staff or graduate students, framed as complementary expertise rather than corrective oversight. Coordination with undergraduate lab assistants and clarification of roles, instructional goals, and logistics can further reduce in-the-moment burdens on faculty and allow greater focus on teaching and student interaction. Finally, effective outreach design requires balancing instructional autonomy with clear guidance by offering flexible frameworks that preserve faculty creativity while reducing uncertainty, particularly for first-time participants.

Conclusion

This study contributes to pre-college engineering education research by examining how faculty engagement in an outreach summer camp is constructed through the interplay of motivations, facilitators, and barriers across multiple levels. Faculty engagement emerged as a dynamic meaning-making process shaped by the convergence of individual values, organizational conditions, and disciplinary purposes within the outreach experience.

By centering faculty as active sense-makers rather than peripheral implementers, this study addresses a critical gap in prior outreach research that has largely emphasized student outcomes and program design. The multi-level framework in Figure 1 highlights how faculty motivations are not flattened into a single category, but instead operate across individual, individual–organizational, organizational, and disciplinary levels, becoming strengthened or constrained through interaction with contextual conditions during participation.

In summary, this study underscores that sustainable faculty engagement in pre-college engineering outreach depends on designing organizational conditions that enable faculty to adapt, teach, and find meaning in K-12 contexts. The proposed multi-level model provides a conceptual foundation for future research on faculty engagement in discipline-specific outreach settings and offers practical insights for outreach programs seeking to strengthen instructional quality through faculty participation.

References

[1] A. T. Jeffers, A. G. Safferman, and S. I. Safferman, “Understanding K–12 engineering outreach programs,” *Journal of Professional Issues in Engineering Education and Practice*, vol. 130, no. 2, pp. 95–108, 2004, doi: 10.1061/(ASCE)1052-3928(2004)130:2(95).

[2] M. F. Bugallo and A. M. Kelly, “Engineering outreach: Yesterday, today, and tomorrow [SP education],” *IEEE Signal Processing Magazine*, vol. 34, no. 3, pp. 69–100, 2017, doi: 10.1109/MSP.2017.2673018.

[3] R. C. Tillinghast, D. C. Appel, C. Winsor, and M. Mansouri, “STEM outreach: A literature review and definition,” in *Proc. IEEE Integrated STEM Education Conf. (ISEC)*, 2020, pp. 1–20, doi: 10.1109/ISEC49744.2020.9280745.

[4] K. O’Meara, “Motivation for faculty community engagement: Learning from exemplars,” *Journal of Higher Education Outreach and Engagement*, vol. 12, no. 1, pp. 7–30, 2008.

[5] K. O’Meara, “Research on faculty motivations for service learning and community engagement,” in *Research on Service Learning*, 1st ed., New York, NY, USA: Routledge, 2023, pp. 215–243, doi: 10.4324/9781003446750-12.

[6] A. Wade and A. Demb, “A conceptual model to explore faculty community engagement,” *Michigan Journal of Community Service Learning*, vol. 15, no. 2, pp. 5–16, 2009.

[7] M. Denham, L. M. Miller, J. K. McCauley, D. Schieber, T. L. Morrison, and C. Drumm, “This is why we do it: Faculty motivations for embracing community-engaged pedagogy,” *Journal of Community Engagement and Higher Education*, vol. 16, no. 1, pp. 38–55, 2024. [Online]. Available: https://files.eric.ed.gov/fulltext/EJ1423338.pdf

[8] M. Rios and L. Saco, “A Qualitative Study of Multilevel Faculty Motivations for Pursuing Engaged Scholarship,” *Journal of Higher Education Outreach and Engagement*, vol. 27, no. 4, Dec. 2023, Accessed: Nov. 29, 2025. [Online]. Available: https://openjournals.libs.uga.edu/jheoe/article/view/2691

[9] E. L. Boyer, “The scholarship of engagement,” in *Building the Field of Higher Education Engagement*, New York, NY, USA: Routledge, 2019, pp. 15–28.

[10] National Science Board, *Undergraduate Science, Mathematics, and Engineering Education: Report of the National Science Board Task Committee on Undergraduate Science and Engineering Education*. Washington, DC, USA: National Science Foundation, 1986.

[11] L. J. K. Durbin, “Education programming at the National Science Foundation: A fifty year retrospective,” *Journal of STEM Education: Innovations and Research*, vol. 2, no. 1, pp. 28–35, 2001.

[12] National Governors Association, *Strategies to Address Engineering Workforce Challenges*.

Washington, DC, USA: National Governors Association, 2023.

[13] D. J. Cline, "STEM crisis or STEM surplus? Yes and yes," *Monthly Labor Review*, U.S. Bureau of Labor Statistics, vol. 137, no. 11, pp. 1–12, Nov. 2014.

[14] E. Collins and R. L. Williams, "Examining the impact of a summer engineering program on academic self-efficacy," presented at the ASEE Annual Conference & Exposition, June 2023. [Online]. Available: https://peer.asee.org/examining-the-impact-of-a-summer-engineering-program-on-academic-self-efficacy

[15] K. Sadler, E. Eilam, S. W. Bigger, and F. Barry, "University-led STEM outreach programs: Purposes, impacts, stakeholder needs and institutional support at nine Australian universities," *Studies in Higher Education*, vol. 43, no. 3, pp. 586–599, Mar. 2018, doi: 10.1080/03075079.2016.1185775.

[16] L. S. Nadelson and J. M. Callahan, "A comparison of two engineering outreach programs for adolescents," *Journal of STEM Education*, vol. 12, no. 1, pp. 43–54, 2011. [Online]. Available: https://scholarworks.boisestate.edu/cgi/viewcontent.cgi?article=1097&context=stem_facpubs

[17] K. Miller, G. Sonnert, and P. Sadler, "The Influence of Student Enrollment in Pre-College Engineering Courses on Their Interest in Engineering Careers," *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 10, no. 1, May 2020, doi: 10.7771/2157-9288.1235.

[18] J. E. Katz, R. J. Rajarathinam, Y. V. Shao, and Y. W. Chen, "Understanding the influence of a week-long electrical and computer engineering summer camp on middle school students' interests in STEM (RTP)," presented at the ASEE Annual Conference & Exposition, June 2024. [Online]. Available: https://peer.asee.org/understanding-the-influence-of-a-week-long-electrical-and-computer-engineering-summer-camp-on-middle-school-students-interests-in-stem-rtp

[19] E. Collins and R. L. Williams, "Examining the impact of a summer engineering program on academic self-efficacy," presented at the 2023 ASEE Annual Conference & Exposition, June 2023. Accessed: Nov. 29, 2025. [Online]. Available: https://peer.asee.org/examining-the-impact-of-a-summer-engineering-program-on-academic-self-efficacy

[20] E. L. Rengifo-López, C. E. Pierce, and F. Matta, "Adaptable framework for K-12 STEM outreach activities: The case of a civil engineering workshop on sustainable and hazard-resistant earth masonry," *Journal of Civil Engineering Education*, vol. 150, no. 4, p. 05024005, Oct. 2024, doi: 10.1061/JCEECD.EIENG-2028.

[21] I. Rajagopalan, "Concept of teaching," *Shanlax International Journal of Education*, vol. 7, no. 2, pp. 5–8, Mar. 2019.

[22] L. S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA, USA: Harvard Univ. Press, 1978.

[23] M. Sheehan and P. E. Childs, “The quality of an educational system cannot exceed the quality of its teachers,” 2007.

[24] C. L. Colbeck and P. Wharton-Michael, “Individual and organizational influences on faculty members’ engagement in public scholarship,” *New Directions for Teaching and Learning*, no. 105, pp. 17–26, 2006, doi: 10.1002/tl.221.

[25] J. Ellison and T. K. Eatman, *Scholarship in Public: Knowledge Creation and Tenure Policy in the Engaged University*. Syracuse, NY, USA: Imagining America, 2008.

[26] K. O’Meara, “Motivation for faculty community engagement: Learning from exemplars,” *Journal of Higher Education Outreach and Engagement*, vol. 12, no. 1, pp. 7–30, 2008.

[27] A. Neumann and A. L. Terosky, “To give and to receive: Recently tenured professors’ experiences of service in major research universities,” *The Journal of Higher Education*, vol. 78, no. 3, pp. 282–310, 2007.

[28] A. Colby, T. Ehrlich, E. Beaumont, and J. Stephens, *Educating Citizens: Preparing America’s Undergraduates for Lives of Moral and Civic Responsibility*. San Francisco, CA, USA: Jossey-Bass/John Wiley & Sons, 2003.

[29] A. Wade and A. Demb, “A conceptual model to explore faculty community engagement,” *Michigan Journal of Community Service Learning*, vol. 15, no. 2, pp. 5–16, 2009.

[30] N. Macheridis and A. Paulsson, “Tracing accountability in higher education,” *Research in Education*, vol. 110, no. 1, pp. 78–97, Aug. 2021, doi: 10.1177/0034523721993143.

[31] K. O’Meara, “Rewarding multiple forms of scholarship: Promotion and tenure,” in *Handbook of Engaged Scholarship: Contemporary Landscapes, Future Directions*, vol. 1, pp. 271–294, 2010.

[32] A. Hofmeyer, M. Newton, and C. Scott, “Valuing the scholarship of integration and the scholarship of application in the academy for health sciences scholars: Recommended methods,” *Health Research Policy and Systems*, vol. 5, no. 1, p. 5, 2007.

[33] L. A. Wendling, “Evaluating community-engaged research in promotion and tenure,” *Metropolitan Universities*, vol. 34, no. 5, pp. 58–83, 2023.

[34] A. E. Austin and Z. F. Gamson, *Academic Workplace: New Demands, Heightened Tensions. ASHE–ERIC Higher Education Research Report No. 10, 1983*. Washington, DC, USA: Association for the Study of Higher Education, 1983. [Online]. Available: https://eric.ed.gov/?id=ED243397

[35] R. T. Blackburn and J. H. Lawrence, *Faculty at Work: Motivation, Expectation, Satisfaction*. Baltimore, MD, USA: Johns Hopkins Univ. Press, 1995.

[36] C. L. Colbeck and L. D. Weaver, “Faculty engagement in public scholarship: A motivation systems theory perspective,” *Journal of Higher Education Outreach and Engagement*, vol. 12, no. 2, pp. 7–32, 2008.

[37] K. O’Meara, “Research on faculty motivations for service learning and community engagement,” in *Research on Service Learning*, 1st ed., New York, NY, USA: Routledge, 2023, pp. 215–243, doi: 10.4324/9781003446750-12.

[38] M. Denham, L. Miller, J. McCauley, D. Schieber, T. Morrison, and C. Drumm, “This is why we do it: Faculty motivations for embracing community-engaged pedagogy,” *Journal of Community Engagement and Higher Education*, vol. 16, no. 1, pp. 38–55, 2025. [Online]. Available: https://scholars.indianastate.edu/jcehe/vol16/iss1/4

[39] E. Morrison and W. Wagner, “A community-engaged faculty typology: A self-referent approach to understanding faculty perspectives,” *Michigan Journal of Community Service Learning*, vol. 23, no. 2, pp. 117–130, 2017.

[40] M. B. Magolda and A. W. Astin, “What matters in college: Four critical years revisited,” *Educational Researcher*, vol. 22, no. 8, p. 32, 1993.

[41] Carnegie Mellon University, “Summer Engineering Experience (SEE),” Carnegie Mellon University College of Engineering. [Online]. Available: https://engineering.cmu.edu/education/outreach/programs/see.html. [Accessed: Feb. 12, 2026].

[42] Georgia Institute of Technology, “Expanded Learning Programs at CEISMC,” Center for Education Integrating Science, Mathematics, and Computing. [Online]. Available: https://expandedlearning.ceismc.gatech.edu/ [Accessed: Feb. 12, 2026].

[43] Johns Hopkins University, “Discover, experience, and achieve with CTY,” Center for Talented Youth. [Online]. Available: https://cty.jhu.edu/ [Accessed: Feb. 12, 2026].

[44] Massachusetts Institute of Technology, “dynaMIT: Igniting the STEM interests of the next generation,” Dynamic Engineering Experiences at MIT. [Online]. Available: https://dynamit.mit.edu/ [Accessed: Feb. 12, 2026].

[45] New York University, “K12 STEM Education,” NYU Tandon School of Engineering K-12 STEM Education. [Online]. Available: https://k12stem.engineering.nyu.edu/programs/sosc. [Accessed: Feb. 12, 2026].

[46] Northwestern University, “3-Week Academic Summer Camps,” Center for Talent Development, Northwestern University. [Online]. Available: https://www.ctd.northwestern.edu/3-week-academic-summer-camps. [Accessed: Feb. 12, 2026].

[47] E. J. Tisdell, S. B. Merriam, and H. L. Stuckey-Peyrot, *Qualitative Research: A Guide to Design and Implementation*. San Francisco, CA, USA: John Wiley & Sons, 2025.

[48] J. Zarestky, “Navigating multiple approaches to qualitative research in HRD,” *Human Resource Development Review*, vol. 22, no. 1, pp. 126–138, Mar. 2023, doi: 10.1177/15344843221142106.

[49] J. W. Creswell and C. N. Poth, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. Thousand Oaks, CA, USA: SAGE Publications, 2016.

[50] S. Stainback and W. Stainback, *Understanding and Conducting Qualitative Research*. Reston, VA, USA: Council for Exceptional Children, 1988.

[51] C. R. Lochmiller and J. N. Lester, *An Introduction to Educational Research: Connecting Methods to Practice*. Thousand Oaks, CA, USA: SAGE Publications, 2015.

[52] V. Braun and V. Clarke, “Using thematic analysis in psychology,” *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, Jan. 2006, doi: 10.1191/1478088706qp063oa.

[53] V. Clarke and V. Braun, “Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning,” *The Psychologist*, vol. 26, no. 2, pp. 120–123, 2013.

[54] J. N. Lester, Y. Cho, and C. R. Lochmiller, “Learning to do qualitative data analysis: A starting point,” *Human Resource Development Review*, vol. 19, no. 1, pp. 94–106, Mar. 2020, doi: 10.1177/1534484320903890.