Enhancing Mentor Preparedness and Development of Program Assistants through Reflective Feedback: Initial Findings from a Pre-Engineering Summer Program

Kristina Henry Collins, The University of Texas at San Antonio

Dr. Kristina Henry Collins is a research psychologist, educational consultant, and Lecturer in Engineering Education at the University of Texas at San Antonio. She is founder and principal of the Education Network Alliance (eDNA). Previously, she served as the inaugural Halbert & Nancy Robinson Endowed Executive Director of the University of Washington's Robinson Center for Young Scholars, Associate Director of the LBJ Institute for STEM Education & Research, and Professor of Talent Development at Texas State University. A nationally recognized leader in STEM identity, gifted and advanced talent development, and mentoring across the lifespan, Dr. Collins brings 30+ years of experience across K–12, higher education, community, and government sectors.

Dr. Araceli Martinez Ortiz, The University of Texas at San Antonio

Araceli Martinez Ortiz, PhD, is the Microsoft President's Endowed Professor of Engineering Education at the University of Texas at San Antonio, with a joint appointment in the Klesse College of Engineering and Integrated Design and the College of Education and Human Development. She is currently Professor and Director of the Engineering Education Graduate Program. She also serves as Executive Director of the Dr. Manuel P. Berriozábal Prefreshman Engineering Program (PREP), advancing STEM engagement and community-integrated research in engineering education. Her research focuses on pre-engineering pathways, skilled technical workforce development, challenge-based learning, STEM educator professional development, and the integration of artificial intelligence in engineering education. She previously served as Executive Director of the LBJ Institute for STEM Education and Research at Texas State, leading major initiatives supported by NASA and NSF. Dr. Martinez Ortiz holds degrees from the University of Michigan, Kettering University, Michigan State University, and Tufts University.

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Abstract

Near-peer mentoring is a common strategy in pre-college engineering outreach, but programs need practical evidence to guide mentor preparation and role clarity. This research-to-practice (RTP) paper reports initial findings from a four-week summer SUPCEP program using a matched pre–post design to examine changes in peer assistants' (PAs) self-perceived mentoring skills, characterize mentoring practices described in open-ended reflections, and explored how orientation feedback can inform newly targeted peer-mentoring activities embedded in the summer program. Thematic analysis indicated that pre-program reflections emphasized mentorship as confidence-building, role modeling, and navigation, while post-program reflections highlighted enacted strategies such as coaching through probing questions, personalization to students' interests, and differentiated support. Findings are discussed as early evidence to inform ongoing evaluation and iterative refinement of mentor training for pre-college engineering outreach contexts.

Introduction

In this mixed-methods study, a state university Pre-College Engineering Program (SUPCEP) provided a four-week summer intensive STEM experience for middle and high school students. Program assistants (PA) have played a key role in student engagement and success since the inception of the program in late 70's. Added to their role for the first time for the 2025 program implementation, PA's served as mentors to the students, tasked with providing psychosocial support in addition to academic guidance. To strengthen the PA's mentor preparedness, SUPCEP introduced a structured mentoring training model integrating reflective practice, skill-based assessment, and peer-led mentoring sessions. Before the orientation and first training session, mentors completed a pre-program survey assessing their perceived readiness and confidence in mentoring (see "Mentoring Matters" Scale in Appendix). After the first session, they also reflected on the prompt: "What additional training and support do you need to be a better mentor?" that was used to guide additional and responsive support for the PA's to support their development as mentors throughout the summer camp. They also completed the same survey as a post-program treatment after the program ended.

The purpose of this research-to-practice (RTP) paper is to report initial findings from a mentor training initiative aimed at improving mentoring, teaching, and coaching practices among program assistants (PA) who serve as mentors supporting pre-college STEM learners. It is positioned as early evidence within an ongoing evaluation cycle: we report initial pre–post shifts in mentors' self-perceived skills and triangulate these patterns with orientation feedback and open-ended reflections to inform iterative refinement of the mentor training model.

This study contributes early evidence on how brief, structured mentor training can produce measurable and practice-aligned shifts in perceived mentoring skill within a compressed, high-intensity pre-college STEM context. It further demonstrates how integrating quantitative change measures with qualitative reflection can inform real-time program improvement.

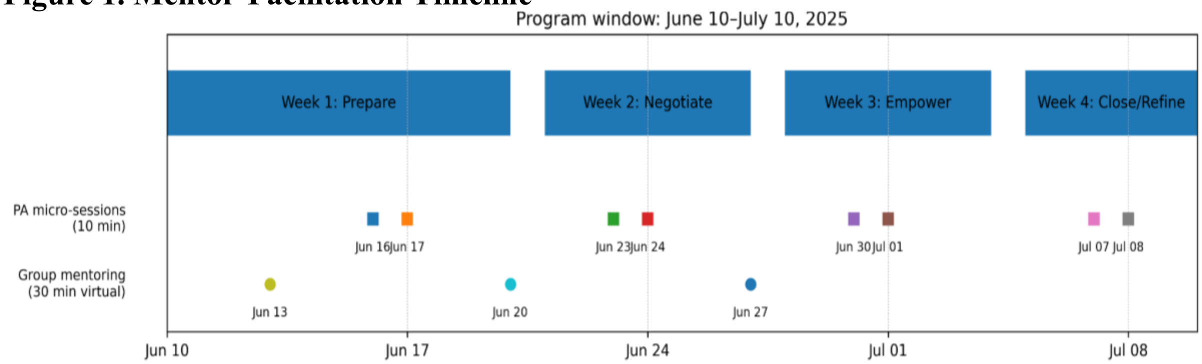
Background

Near-peer mentoring is a high-leverage component of pre-college STEM outreach because mentors shape learning climate, persistence, and students' sense of belonging during hands-on activities. Substantial scholarship has examined the preparation of graduate assistants and undergraduate peer assistants for instructional and mentoring roles. Despite this growing body of work, many peer assistants continue to enter instructional contexts with limited formal preparation in either structured mentoring practices or informal developmental support [1], [2]. This often results in broader, limited use of PA's as instructional coaches or teaching assistants – both of which are conceptually different from mentoring [3] – without clear evidence about the specific competencies mentors develop and the concrete strategies they use in practice. To address this gap, we evaluated a peer assistant (PA) mentoring component in a summer SUPCEP program using a mixed-methods approach that combines a reliable mentoring skill scale with open-ended reflections and orientation feedback. We report early evidence of changes in mentors' perceived mentoring competence and describe how mentors articulated and enacted engagement strategies over the summer, with results used directly to refine ongoing training structures. This study is beneficial in that it adds intentional 'reflection' to the prior work to self-assess and further inform mentor training needs. The reflection is positioned as both a data source and a mechanism for iterative mentor development.

Theoretical Framework

Near-peer mentoring in pre-college engineering outreach can be conceptualized through Vygotsky's social development theory, a seminal work which emphasized that learning and development are mediated through social interaction [4]. In this program context, peer assistants (Pas) function as More Knowledgeable Others (MKOs) who support mentees' participation, problem solving, and confidence through scaffolded interaction [5]. From this perspective, effective mentoring is not limited to content assistance; rather, it involves guiding learners within their Zone of Proximal Development (ZPD) by calibrating support to mentee needs and gradually transferring responsibility as competence develops [6]. This theoretical lens aligns with the competencies assessed and the practical mentoring strategies described in open-ended reflections within the *Mentoring Matters* scale. Mentor facilitation (Weeks 1-4) followed the four phases within the *Mentoring Matters* Relationship Building model Prepare, Negotiate, Empower, and Close/Refine), respectively implemented as a progression across program weeks [3] .

Figure 1. Mentor-Facilitation Timeline



Research Question(s)

1. To what extent do PA mentors' self-perceived mentoring skills change from pre to post, and how do mentors describe the mentoring practices and role clarity underlying these changes? (RQ1)
2. Which mentoring competencies show the largest pre–post shifts, and how do these map onto mentors' reported strategies and mentoring goals? (RQ2)

Literature Review

Mentoring operates through psychosocial mechanisms that shape engagement and persistence. Prior work suggests that students internalize values, strategies, and actions demonstrated by influential figures in their learning environment [7]. In STEM contexts, this implies that mentors closest to students' STEM development can provide the psychosocial support and personal-development guidance needed to mitigate the consequences of isolation, marginalization, and/or STEM access issues. Consistent with prior research, students from ethnically diverse backgrounds report isolation and a lack of connection, difficulty finding mentors who represent them, limited knowledge of resources, and challenges in feeling at home on campus [1][2]. In such contexts, mentoring becomes a mechanism for reinforcing belonging, confidence, and identity-relevant validation - all conditions that enable students to persist through challenge and remain engaged in STEM pathways.

This study is informed by conceptualizations of mentoring that extend beyond traditional dyadic relationships. Prior developmental work and program design efforts motivate a view of mentoring as vertical, collaborative, and integrated, emphasizing multi-level and nested structures that support both learners and mentors across roles [3]. This perspective is consistent with hybrid mentoring approaches that combine elements of structured learning communities and culturally responsive support [8][9][10]. With nested mentoring structures [11] and co-mentoring principles [12], such models aim to address the limitations of one-size-fits-all mentoring and to strengthen developmental responsiveness for historically marginalized learners [13]. In the present program, guided reflection and structured opportunities to facilitate mentoring sessions are treated as mechanisms through which PAs translate mentoring intentions into enacted practices, particularly those associated with learner calibration, inclusive engagement, and coordination with instructional staff.

Methods

This study employed a mixed methods design to examine mentors' preparedness and early skill development within the SUPCEP program, integrating quantitative self-assessment data with qualitative reflective feedback to provide a more comprehensive understanding of mentor preparedness and training needs. A mixed methods approach was selected to capture both measurable changes in mentors' self-perceived competencies and the contextual factors shaping those changes.

Participants

At baseline, mentors' academic backgrounds were primarily STEM-affiliated with deliberate representation from complementary disciplines often relevant to near-peer support and communication with adolescents. Overall, this distribution indicates a predominantly STEM mentor cohort with 12/26 (46.2%) reported being full-time college or university students in a STEM field, 1/26 (3.8%) reported being a part-time STEM student, and 7/26 (26.9%)reported being a recent graduate from a STEM field (total STEM student or graduate: 20/26, 76.9%). The remaining participants included 5/26 (19.2%) full-time students in non-STEM fields and 1/26 (3.8%) selecting "Other," with that respondent identifying as a K–12 professional (high school special education teacher). Specifically, a wide range of majors and training pathways included engineering (7/26, 26.9%); life sciences and health/pre-health (5/26, 19.2%); physical science and computing-related STEM fields (3/26, 11.5%); education-focused programs (3/26, 11.5%); business and economics (3/26, 11.5%); and humanities and social science fields (3/26, 11.5%). They were drawn from multiple partner campuses, with most based at the hosting university. (65.4%). Mentors were assigned across five SUPCEP instructional levels:

- Level 1: Engineering Design Logic & Algebraic Reasoning - Learn the engineering design process and develop solutions to technical problems.
- Level 2: Engineering Physics & Integrated Algebra - Explore physics, mathematics, and engineering practices to tackle real-world challenges.
- Level 3: Probability & Statistics and Technical Writing - Gain knowledge in probability theory, analytical statistics, and STEM technical writing.
- Level 4: Innovations in Engineering - Research and explore the latest trends in engineering science, with a focus on topics such as materials science and nanotechnology.
- Level 5: High School Senior Research Internship - Participate in research internships at engineering labs, mentored by host university faculty and graduate students.

The greatest concentration in earlier levels: SUPCEP Level 1 (12/26, 46.2%), Level 2 (6/26, 23.1%), Level 3 (4/26, 15.4%), Level 4 (3/26, 11.5%), and Level 5 (1/26, 3.8%).

Mentoring Matters Scale Reliability

The *Mentoring Matters* Survey used in PREP was adapted from the original *Mentoring Matters* Skillset Scale developed in 2017 [3] with minor contextual modifications to align with pre-college mentoring and program-specific implementation. The scale is a self-perception survey measuring mentor's knowledge and skills across 25 practices synthesized from established mentoring frameworks, including research on effective mentorship in STEM, mentoring models, and developmental mentoring theory [2],[3],[14]-[18]. These practices reflect an integrated model of mentoring that spans relational, instructional, and developmental domains aligned with the phases of mentoring relationships used in course instruction.

The scale has been used across multiple contexts, including a graduate-level mentoring course (2017–2019), STEM faculty research-mentor training, and an NSF-funded teacher development project focused on multi-level mentoring, supporting formative assessment of mentor development and instructional design.

Internal consistency was evaluated using Cronbach's alpha at pre and post. The scale demonstrated very strong internal consistency, supporting use of a composite score. Cronbach's alpha was 0.972 at pre for all pre respondents (n=26). Reliability remained high in the matched subgroup (alpha=0.976 at pre; n=12) and at post (alpha=0.965; n=12), indicating that the items function coherently as a single perceived-skill construct in this sample.

While the scale was developed as a practice-informed synthesis of mentoring competencies, the consistency of findings across contexts and alignment with established mentoring frameworks provide initial support for its interpretive use in applied settings.

Data Collection

The quantitative component captured changes in mentors' self-perceived competencies, while the qualitative component contextualized those changes by illuminating mentors' lived experience as part of the orientation session and perceived areas for growth. Quantitative and qualitative data were intentionally integrated to support formative assessment and iterative program improvement rather than summative evaluation alone.

Quantitative Data Collection

Quantitative data were collected using a 25-item "Mentoring Matters" Pre- and Post-skill survey administered before the first training and after the program ended for the summer. Items measured proficiency across mentoring domains including communication, goal setting, feedback, cultural awareness, and role modeling, using a 7-point confidence scale (1 = not at all skilled; 7 = extremely skilled).. To protect confidentiality, names were removed and replaced with participant codes (Q1). Twelve mentors (B0001–B0012) completed both pre and post surveys and therefore contributed to matched pre–post analyses. Fourteen additional mentors completed the pre survey only (R0001and R0003–R0015), contributing to baseline descriptives. Description analyses were used to examine patterns of change across skill areas and identify domains of early growth. Overall, there were 26 valid pre-respondents and 12 valid post-respondents, with 12 matched pairs.

Qualitative Data Collection
Qualitative data were gathered through open-ended pre- and post-program survey items , participant products, and a post-orientation prompt asking, "What additional training and support do you need to be a better mentor?". This layered analysis supported both interpretive depth and practical application. Responses from orientation were thematically coded and matched to three predetermined categorizations: mentoring, teaching, and coaching requests [3]. We used thematic content analysis to identify recurring ideas within and across timepoints. Responses were read in full, coded line-by-line, and then clustered into higher-level themes. We report theme prevalence (number and percent) of respondents whose response reflected each theme (response-level counts). These counts are descriptive and intended to support interpretation.

Analytic Approach

Analyses were conducted in two layers: Item-level descriptives were computed for each item at pre and post (means, standard deviations, medians, and distributional summaries), and inferential tests across 25 items, treated as exploratory and focused on the 12 mentors with matched pre and post data. Response categories were coded on a 7-point scale (1 = not at all skilled to 7 = extremely skilled), and item responses were treated as approximately continuous for analysis. Given the ordinal response format and small matched sample size, pre–post change was tested using the Wilcoxon signed-rank test. For transparency and because item-level composite means are commonly treated as approximately continuous in engineering education evaluation contexts [19] a paired samples t-test was also reported for the composite score. Effect sizes were reported as Cohen's dz for the paired t-test and rank-biserial correlation for Wilcoxon tests.

Integration of Quantitative and Qualitative Data
Mixed-method integration occurred through a convergent analytic approach in which quantitative trends were examined alongside qualitative themes to inform interpretation and program design. Qualitative findings were used to explain and extend survey results and directly informed the structures and focus of PA-facilitated mentoring activities implemented during the program (10-minute daily discussions and 30-minute virtual group mentoring blocks). This integration positioned mentor reflection as both a source of evidence and a mechanism for iterative mentor development, aligned assessment with practice.

Results & Discussion

Qualitative Findings: Orientation Feedback
Orientation feedback highlighted recurring needs for more practice-based examples, classroom management tools, and strategies for fostering mentee motivation and inclusivity. Findings indicated PAs valued structured reflection as a developmental tool and demonstrated increased clarity around their roles in fostering belonging, communication, and student engagement. Orientation feedback suggested a need for ongoing training in culturally responsive practices, conflict resolution, and learner-centered strategies. Together, these results provided (1) an interactive method for sharing results with PAs to reinforce reflective feedback as a continuous

learning process, and (2) informed the design of daily 10-minute PA-facilitated discussions and the weekly 30-minute virtual group mentoring activities. By positioning mentor reflection as both assessment and professional growth, this work contributes to the design of scalable pre-college mentor development frameworks that enhance the quality of engineering outreach programs.

These findings are consistent with prior research emphasizing that mentors require structured opportunities to develop relational, facilitation, and culturally responsive practices rather than relying solely on informal role modeling [1], [2]. The identified need for practice-based examples and inclusive engagement strategies reinforces literature highlighting mentoring as a learned, developmental skill set rather than an intuitive role.

Quantitative Findings: Pre- and Post-Program Skill Perception

Overall, the *Mentoring Matters* scale demonstrated strong internal consistency (alpha, 0.965–0.976), supporting use of a composite perceived-skill score. The baseline composite (mean) was M=5.68, SD=0.72 (median 5.86), corresponding to average responses between "Above Average" and "Highly Skilled."

Table 1. Quantitative findings for Q8 mentoring skill perceptions (7-point scale).

Outcome	Pre (n=26) All	Pre (n=12) Matched	Post (n=12) Matched	Change and Tests (Matched)
Cronbach's alpha (Items, 1-25)	0.972	0.976	0.965	—
Q8 composite mean (SD)	5.68 (0.72)	5.53 (0.81)	5.92 (0.63)	Mean change = 0.39; paired t(11)=2.33, p=0.0398, dz=0.67; Wilcoxon p=0.0558, rank-biserial=0.65
Q8 composite median	5.86	—	—	—
Pooled Q8 ratings 5 to 7	86.6%	—	—	—
Pooled Q8 ratings 6 to 7	63.2%	55.7%	73.0%	Increase in top-band concentration (6 to 7)
Pooled Q8 ratings at 7	—	18%	25%	Increase in Extremely Skilled/Masterful ratings
Participant-level direction of change (composite)	—	—	—	Improved: 8; no change: 1; decreased: 3

Note. **P**ercentages labeled pooled Q8 ratings are computed across all Q8 item responses (number of respondents x 25 items), not across participants. Matched analyses use mentors with both pre and post responses (B0001 to B0012; n=12).

As Table 1 outlines, in pooled baseline ratings across all items (26 mentors × 25 items), 86.6% of responses fell at "Above Average" or higher (5–7), and 63.2% were in the top two categories ("Highly Skilled" or "Extremely Skilled/Masterful," 6–7). Lower-end response options were available (including "Not skilled at all" and "Minimally skilled"), but they were rarely endorsed at baseline.

In matched analyses (n=12), mentors reported higher overall mentoring skill at the end of the summer than at the start (pre M=5.53, SD=0.81; post M=5.92, SD=0.63), reflecting a moderate improvement (mean gain 0.39). Initial ratings were relatively high, suggesting a possible ceiling effect that may have limited the magnitude of observed change. The paired t-test indicated statistically significant growth [t(11)=2.33, p=0.040; Cohen's dz=0.67], and the Wilcoxon signed-rank test showed a similarly sized directional shift (p=0.056; rank-biserial=0.65), approaching significance. This pattern is consistent with expectations for small samples, where nonparametric tests are more conservative but still reflect comparable effect magnitudes.

When ratings were summarized into a stakeholder-friendly threshold (ratings of Above Average, Highly Skilled or Extremely Skilled/Masterful, coded 5–7), ratings increasingly concentrated in the "Highly Skilled" and "Extremely Skilled/Masterful" categories (6–7), rising from 55.7% to 73.0% for the 25-item responses. The proportion of ratings at the very top category (7, Extremely Skilled/Masterful) increased from 18% at pre to 25% at post. At the participant level, most mentors (paired, n=12) improved: 8 increased, 1 showed no change, and 3 decreased on the composite score. Taken together, the composite results provide evidence of meaningful growth in self-rated mentoring skills from the beginning to the end of the program, with the strongest support coming from the composite-level paired analysis rather than individual item testing.

Item-level tests were exploratory and did not remain significant after multiple-comparison correction, but the largest descriptive gains clustered around estimating mentee readiness and coordinating with instructors. The patterns, which are better positioned as descriptive indicators of where growth concentrated rather than as confirmatory evidence given the small sample size, align with program expectations that mentors would gain confidence in calibrating support to mentee needs and navigating instructional collaboration. Open-ended items (Q9 and Q10) provided qualitative context for these quantitative trends.

The observed gains in communication, feedback, and relationship-building skills align with established mentoring literature identifying these competencies as foundational to effective mentoring and student persistence in STEM pathways [2], [7]. The comparatively smaller shifts in facilitation- and peer-dynamics-related skills further reinforce prior findings that these areas require more sustained practice and guided experience, particularly in contexts where mentors are expected to calibrate support within learners' developmental range.

Open-Ended Responses

Most mentors also provided qualitative reflections at baseline: 22/26 submitted open-ended responses to both Q9 and Q10, offering contextual detail on perceived mentorship impact and engagement strategies. Responding to their meaning of mentorship in STEM (Q9), pre-program responses emphasized mentorship as an enabling relationship that makes STEM feel possible, motivating, and navigable while post responses shifted from expectations to reflections on what mentors noticed and learned while supporting students. Five themes emerged pre-program: Confidence, motivation, and resilience (13/22; 59%); Near-peer role modeling and inspiration (12/22; 55%); Guidance and navigation (8/22; 36%); Access, exposure, and career awareness (7/22; 32%); and Belonging, trust, and supportive relationships (6/22; 27%) - largely framing mentorship as a mechanism for identity-support and persistence in STEM (see table 2 for details). Seven themes emerged post-program: Career pathways and early exposure (3/12; 25%);

Confidence, belonging, and validation (3/12; 25%); Perspective-taking and understanding learners (3/12; 25%); Recognizing student capability (2/12; 17%); Hands-on and real-world engagement (1/12; 8%); and Equity and opportunity (1/12; 8%) - indicating a deeper understanding of how support operates, learning to see through students' eyes, and strengthening their own commitment to mentoring (see table 3 for details).

Table 2. Pre-survey Q9 themes: Perceived impact of mentorship in STEM

Theme (Brief Description)	**Responses** **n (%)**	**Example Responses** **(Participant Codes)**
Confidence, Motivation, and Resilience *Helping students persist*	13/22 (59%)	"It takes a lot of self-confidence... not feel defeated. Having an encouraging mentor is critical." (B0005) "It helps them see what's possible... builds confidence... not alone in figuring things out." (R0009)
Near-peer role Modeling and Inspiration *Mentors as relatable exemplars*	12/22 (55%)	"Students can have role models... to support and foster their knowledge in STEM." (B0002) "Seeing how my PA's were... I wanted to be like them... now I am studying to become an electrical engineer." (B0004)
Guidance and Navigation *Practical support*	8/22 (36%)	"Someone who can guide... helping them find an answer through their own line of thinking." (R0004) "Helps students visualize what success looks like, navigate challenges more confidently." (R0010)
Access, Exposure, and Career Awareness *Broadening what students imagine as attainable*	7/22 (32%)	"We can help expose them to a different career path they might not have thought was possible." (B0006) "Provide insight into the field and clarify career goals." (R0015)
Belonging, Trust, and Supportive Relationships *Creating psychological safety for learning and risk-taking*	6/22 (27%)	"Creating relationships... so they feel comfortable trying new things, failing." (B0005) "It helps students feel more seen." (B0011)

Note. n=22 pre-survey respondents provided usable open-ended text for Q9. Theme counts reflect the number and percent) of responses that included the theme; responses could include multiple themes.

Table 3. Post-survey Q9 themes: Perceived impact of mentorship in STEM

Theme (Brief Description)	**Responses** n (%)	**Example Responses** (Participant Codes)
Commitment and Mentor Identity *Renewed commitment to youth STEM support and personal reward of the role*	5/12 (42%)	"It has made me more excited to serve younger students in STEM." (B0002) "This experience solidified my passions of being a professor/outreach coordinator." (B0006)
Career Pathways and Early Exposure *Early experiences clarify what STEM careers entail*	3/12 (25%)	"Many of my students did not know exactly what a STEM career entailed… I was able to bring in my experiences." (B0011)

Theme (Brief Description)	Responses n (%)	Example Responses (Participant Codes)
Confidence, Belonging, and Validation *Reinforced Pre-Survey beliefs that support helping students feel capable and sense of belonging*	3/12 (25%)	"There is an equal importance in building their confidence… that [they] 100% belong in the program." (B0003) "Encourage and support… to make them feel confident and capable." (B0012)
Perspective-Taking and Understanding Learners *Mentoring changed how they view learning, students' thinking, and what support looks like in practice*	3/12 (25%)	"See science from a student's perspective." (B0009) "Opened my eyes… the different way the students' brains work." (B0007)
Recognizing Student Capability *Students' competence and work ethic*	2/12 (17%)	"Many students are more skilled than I expected… worked hard and diligently." (B0008)
Hands-On and Real-World Engagement *Inquiry-based, real-world problem framing as a driver of engagement*	1/12 (8%)	"Hands-on, inquiry-based learning… connecting STEM with real world applications." (B0005)
Equity and Opportunity *Linked mentoring to access and opportunity gaps in STEM learning ecosystems*	1/12 (8%)	"Programs like these… give students… a chance in STEM education like other schools with more funding." (B0004)

Responding to anticipated approaches and strategies (Q10) mentors planned (pre) and actually used (post), pre-program responses were strategy-forward and emphasized relevance and relationship as the foundations of engagement while post-program responses became more operational and classroom-realistic, emphasizing coaching through questioning, personalization, and differentiated support. Six themes for planned strategies emerged pre-program: Relationship building and affirming support (12/22; 55%); Relevance through interests and real-world connection (12/22; 55%); Active learning, inquiry, and discussion; Scaffolding and clear explanations (4/22; 18%); Future orientation and resources (3/22; 14%); and Engagement moves (humor, competition, trends) (3/22; 14%) - anticipating that engagement would come from (a) knowing students well, (b) making STEM relevant, and (c) using inquiry and hands-on experiences (see table 4 for details). Eight themes emerged post-program representing concrete strategies that reflect real-time facilitation demands: Relevance through interests and trends (5/12; 42%); Inquiry coaching through probing questions (4/12; 33%); Relationship and trust building (4/12; 33%); Encouragement and positive feedback (3/12; 25%); Differentiation, patience, and equitable attention (2/12; 17%); Metaphors and analogies to make abstract ideas concrete (1/12; 8%); Future orientation (career path emphasis) (1/12; 8%); and Near-peer sharing (1/12; 8%) - enacting relevance and relationship strategies, but also emphasized a shift toward inquiry-based coaching, patience with varying paces, and structured encouragement (see table 5 for details).

Table 5. Q10 (Pre) Themes: Approaches and strategies mentors anticipated using

Theme (Brief Description)	Responses n (%)	Example responses (Participant Code)
Relationship Building and Affirming Support *Listen, connect personally, and create trust and psychological safety*	12/22 (55%)	"Getting to know the students on a personal level greatly helps engage students." (B0005) "Come into SUPCEP… with an open mind… listen to students' feedback." (R0006)
Relevance Through Interests and Real-World Connection *Linking content to everyday life, current events, and students' interests*	12/22 (55%)	"Connect their lessons with something of interest to them." (B0010) "Relating STEM concepts to real-world, everyday challenges." (R0010)
Active Learning, Inquiry, and Discussion *Hands-on experiences, guided dialogue, and inquiry structures*	7/22 (32%)	"Workshops… mini experiments to understand scientific principles." (B0006) "Guided discussion and socratic circles." (B0002)
Scaffolding and Clear Explanations *Stepwise instruction and accessible complex concepts*	4/22 (18%)	"Provide outlines or simpler examples… then apply… to more difficult [ideas]." (R0004) "Clear, simple explanations… encourage questions." (R0009)
Future Orientation and Resources *Career reinforcement and resourcing*	3/22 (14%)	"Providing them with resources to better research and understand their dream job." (R0013)
Engagement Approaches *Specific engagement tactics*	3/22 (14%)	"Maintain… a sense of humor… makes learning… more fun." (B0003) "Make a competition… and relate… to something in their lives." (B0008)

Table 6. Q10 Post-Survey Themes (Strategies Actually Used)

Theme *Brief Description*	**Responses** **n (%)**	**Example Responses** (Participant Code)
Relevance Through Interests and Trends *Anchoring explanations in student interests, hobbies, or trending topics*	5/12 (42%)	"Correlate the topic with the students' interests… compare the topic to the hobbies they enjoyed." (B0008) "Relate the work to trending topics so they would understand… better." (B0009)
Inquiry Coaching Through Probing Questions *Guiding students toward solutions rather than giving answers*	4/12 (33%)	"I asked probing questions… 'What could make this more stable?'" (B0005) "Leading them to the right answer… asking them questions to get them there." (B0004)
Relationship and Trust Building *Prioritizing trust, rapport, and learning who students are*	4/12 (33%)	"Once you build a sense of trust, the community follows." (B0001) "Took time to get to know them… favorite way to be creative." (B0007)

Theme *Brief Description*	**Responses n (%)**	**Example Responses** (Participant Code)
Encouragement and Positive Feedback *Affirming students and using feedback and compliments to build confidence*	3/12 (25%)	"Uplifting attitude… meaningful feedback and compliments… felt proud." (B0012) "Understanding and patient… extra help and encouragement." (B0003)
Differentiation, Patience, and Equitable Attention *Variability in pace and emphasis on patience and fairness in attention*	2/12 (17%)	"Every student has a different… pace… I was… understanding and patient." (B0003) "Give everyone an equal amount of time… every student had some chance to communicate." (B0006)
Metaphors and Analogies *Making abstract ideas concrete*	1/12 (8%)	"Metaphors help greatly… when they're able to relate it to their own life experiences, they thrive." (B0011)
Future Orientation *Career path emphasis*	1/12 (8%)	"Emphasized… impacting their future career path… help them… form… a long-term career goal." (B0010)
Near-Peer Sharing	1/12 (8%)	"I've been in your shoes before… being closer in age helps… feel secure." (B0004)

Across both time points, mentors consistently positioned mentoring as relational and relevance-driven. The post responses, however, showed a notable shift from broad intentions (for example, "make it relevant" and "build relationships") to specific mentoring practices: probing questions as a coaching tool, adapting to students' varied pace, and using metaphors and interest-based analogies to make STEM less abstract. Post reflections also elevated mentors' recognition that effective support includes confidence-building and belonging, not only content completion.

The shift from broad mentoring intentions (e.g., building relationships, making content relevant) to specific enacted practices (e.g., probing questions, differentiation, and analogy use) reflects movement consistent with Vygotsky's concept of scaffolding within the Zone of Proximal Development, where mentors increasingly calibrate support to learners' needs [4]–[6]. This transition also aligns with research on mentoring development, which suggests that novice mentors initially conceptualize mentoring in relational terms before developing more sophisticated instructional and coaching strategies.

Integrated Results

When examined together, the quantitative and qualitative findings converged to suggest meaningful growth in mentors' perceived mentoring competence over the summer. Demonstrated strong internal consistency, and matched analyses showed an increase in composite perceived skill from pre to post, a moderate gain accompanied by a distributional shift toward "Highly Skilled" or above. Orientation feedback contextualized these shifts, emphasizing needs for practice-based examples, classroom management tools, and inclusive, learner-centered strategies. Open-ended responses (Q9/Q10), positioned as complementary qualitative evidence to contextualize observed changes in self-rated mentoring skills, echoed and clarified this pattern:

pre responses framed mentorship as confidence-building and navigation, while post responses highlighted enacted mentoring practices and a stronger focus on belonging and confidence as outcomes. The results indicate that structured reflection and targeted training support helped mentors move from broad relational intentions to concrete facilitation moves, informing scalable mentor development structures in pre-college engineering outreach.

These findings extend prior work on near-peer mentoring by demonstrating how structured reflection and embedded practice opportunities support the translation of mentoring intentions into enacted strategies, particularly those associated with belonging, confidence-building, and learner calibration which are key mechanisms identified in mentoring and STEM persistence literature [1], [2], [7].

Conclusion

This study evaluated a near-peer mentoring component embedded in a summer SUPCEP program using a mixed-methods approach that combined a reliable 25-item skill-perception scale and PA reflection through orientation feedback and open-ended scale reflections. Quantitative findings indicated that mentors' self-perceived mentoring skills increased over the summer in the matched sample, with a moderate gain in the 25-item composite and a distributional shift toward higher-end skill ratings. At baseline, mentors already rated themselves in the upper range, suggesting that program effects are most visible as movement from "above average" toward "highly skilled" rather than from low to moderate competence. The largest observed shifts clustered around competencies that matter most for effective near-peer mentoring in outreach settings - calibrating support to mentee needs and coordinating with instructional staff. Qualitative evidence helps interpret what these quantitative shifts likely represent. Orientation feedback highlighted mentors' desire for practice-based examples, classroom management tools, and strategies that strengthen motivation, inclusivity, and culturally responsive support. Open-ended responses further showed a developmental progression in mentors' thinking: pre-program narratives framed mentorship as confidence-building, role modeling, and navigation, while post-program reflections emphasized enacted strategies along with a stronger focus on belonging and validation as outcomes.

Future Work

Future work will strengthen claims by increasing matched response rates, adding practice-based performance evidence (i.e., structured observation rubrics or scenario-based assessments), and examining links between mentor development and student-level outcomes (engagement, persistence, and STEM belonging).

Implications

Integrating structured reflection, feedback analysis, and applied mentoring opportunities enhances mentor self-efficacy and informs iterative improvement in pre-college STEM outreach. Taken together, the results suggest that structured mentor preparation paired with guided reflection supports mentors in translating broad relational intentions into concrete facilitation practices that can improve the consistency and quality of pre-college engineering outreach experiences. These findings directly inform necessary refinement of the mentor development model, including brief PA-facilitated reflection discussions and recurring group mentoring touchpoints designed to normalize reflective practice, reinforce inclusive engagement routines, and strengthen instructional coordination.

Overall, this study contributes early evidence and actionable design implications for scalable near-peer mentor training structures that support high-quality, inclusive engineering outreach in K–12 pipeline programs.

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Appendices

Appendix A. Mentoring Matters Scale (PREP Adapted Version, 2025)

Mentoring Matters Post-Survey for PREP Peer Mentors Instructions:
This survey assesses your perception of your ability to mentor students based on 25 critical skillsets, at the end of PREP Summer 2025. Conducted at two different stages of the mentoring training, this tool is designed to measure the differences in individual participants' responses over time to potentially assess the reasons for response changes by evaluating the differences in respondents' experiences - the easiest way to determine the effect of a strategically occurring event such as this one.

Q8. How skilled do you feel you are at this point in your experience and training?
Please rate each statement regarding how skilled you feel you are, as a mentor, at this point in your experience and training (prior to starting [SURCEP], and at the end of the [SURCEP] summer 2025). Scale: 1-7 with 1, not at all skilled and 7 extremely skilled.

	Not skilled at all.	Minimally skilled	Below average skills	Average/ Sufficiently Skilled	Above Average	Highly Skilled	Extremely Skilled/ Masterful.
1. Active Listening	○	○	○	○	○	○	○
2. Providing constructive feedback	○	○	○	○	○	○	○
3. Establishing a relationship based on trust	○	○	○	○	○	○	○
4. Identifying and accommodating different communication styles	○	○	○	○	○	○	○
5. Employing strategies to improve communication with mentees	○	○	○	○	○	○	○
6. Coordinating effectively with your assigned PREP instructor	○	○	○	○	○	○	○
7. Working with mentees to set clear expectations of the mentoring relationship	○	○	○	○	○	○	○
8. Aligning your expectations with your mentees	○	○	○	○	○	○	○
9. Considering how personal and professional differences may impact expectations	○	○	○	○	○	○	○
10. Working with mentees to set academic/ career goals	○	○	○	○	○	○	○
11. Helping mentees develop strategies to meet goals	○	○	○	○	○	○	○
12. Accurately estimating your mentees' level of content knowledgeability to be successful in PREP	○	○	○	○	○	○	○
13. Accurately estimating your mentees' STEM skills/ critical thinking	○	○	○	○	○	○	○
14. Employing strategies to enhance your mentees' knowledge and abilities	○	○	○	○	○	○	○
15. Motivating your mentees	○	○	○	○	○	○	○
16. Building mentees' confidence	○	○	○	○	○	○	○
17. Stimulating your mentees' creativity	○	○	○	○	○	○	○
18. Acknowledging your mentees' contribution to the mentoring relationship	○	○	○	○	○	○	○
19. Negotiating a path to academic and career planning independence with your mentees	○	○	○	○	○	○	○
20. Taking into account the biases and prejudices you bring to the mentor/mentee relationship	○	○	○	○	○	○	○
21. Working effectively with mentees whose personal background is different from your own (age, race, gender, class, culture, religion, etc.)	○	○	○	○	○	○	○
22. Helping your mentees work with their student peers effectively	○	○	○	○	○	○	○
23. Helping your mentees balance academic responsibilities and personal/hobby interests	○	○	○	○	○	○	○
24. Understanding your impact as a role model.	○	○	○	○	○	○	○
25. Helping your mentees acquire resources (e.g. information on scholarships, class options at their schools, city camps, etc.)	○	○	○	○	○	○	○