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Problem-Based Teaching: An Exploratory Analysis of Discourse Methods of Peer Facilitators in a Summer Engineering Bridge Program

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Abstract: As engineering educators attempt to develop solutions to increase student retention and graduation rates and decrease student departures from their majors during the first two years of study, findings from a summer bridge program at a large minority-serving institution (MSI) show promise for practices that could potentially help to mitigate these issues. Summer bridge strategies have been shown to be effective in assisting in college students' transition from first to sophomore year. This study comprises a case study of a chemical engineering summer bridge program in which undergraduate peer facilitators introduced sophomore-level chemical engineering material and energy balance course material to their peers. The goal of this study was to understand the types of discourse methods used during problem-solving sessions by peer facilitators and how students' learning experiences were impacted. Data for this study were collected via video observations and a post-program open-ended survey. Authors found that peer facilitators created an environment where students felt encouraged and supported and could relate to facilitators and course materials in new ways. This work further illustrates promising practices of using peer facilitators that need further attention, along with the potential for how engagement and learning could be enhanced by the more formal preparation of peer facilitators.

Keywords: classroom discourse; summer bridge program; chemical engineering; peer facilitators; engineering education

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1. Introduction

Though the number of engineering jobs is expected to increase by 140,000 new jobs between 2016 and 2026, the USA is not positioned to keep up with the demand for engineers [1]. Specifically, student retention and college degree completion rates among engineering students remain a challenge [2]. As there continues to be an emphasis on broadening participation in engineering, gaining a better understanding of the academic and professional pathways traveled by individuals and groups is important and necessary to reach these future participation goals. Gaining greater awareness of where aspiring engineers trip, stumble, and exit as well as excel, gain momentum, and thrive along their educational pathway adds to the conversation and strategies that could assist with producing larger groups of future engineers.

Though current literature on the topic is replete with studies that seek to understand the experiences of engineering students in their initial year on campus, one area where many aspiring engineers struggle in their academic journey, which has not been explored thoroughly, is between their first and second years in college [3]. The sophomore year is a pivotal time that can determine whether the aspiring engineer meets their graduation goal or leaves their major altogether [4,5]. More specifically, when compared with other academic fields and disciplines, engineering students switch majors more often than non-engineering majors [5].

Researchers have uncovered myriad reasons for differences in who persists and who does not, such as larger course workloads, academic and personal difficulty, lack of community connections, and feelings of isolation and racism [2,6,7]. To address the challenges associated with academic difficulties, institutions have implemented curricular interventions designed to help students succeed in their academic studies. Some of these interventions include bridge programs, student success programs, mentoring, tutoring, and peer-facilitated learning [8]. Though peer-facilitated learning has been shown to be a promising practice [9,10], less work has identified what happens in peer-facilitated learning spaces. Gleaning from understandings researchers have uncovered related to classroom discourse among students and educators, this study explores the discourse methods peer facilitators used to introduce gateway-level coursework to their peers in a summer bridge program for chemical engineering students going into their second year. This study was guided by the following research questions: (1) What types of discourse methods do peer facilitators use when introducing problem solving for gateway-level chemical engineering courses during a summer bridge program? (2) How were student experiences impacted by peer facilitators?

1.1. Relevant Literature

A growing body of literature is situated in classroom discourse analysis and programs to prepare or help improve undergraduate student grades and retention [8,11–16]. This section focuses on two major concepts from the literature that provide further context for this case study. These concepts first address the intended purpose and impact of intervention programs on undergraduate student success and, next, how what is said in classrooms by instructors and how it is said impacts how students learn, how engaged they are in co-creating knowledge with instructors, and how and if content knowledge is mastered as a result. Given the importance of using various methods and strategies of teaching when working with a diverse and changing student body population [17], this discussion provides context and an impetus for examining the potential value of discourse methods on the learning of engineering students.

1.2. Bridge Programs

Bridge programs serve as an avenue to enhance student learning and success and often focus on recruiting and retaining specific populations of students. Institutions of higher education frequently use these programs to assist students transitioning into college for the first time and those enrolled in the institution who must meet entry-level competencies for their majors before being admitted [8,15,16]. The goal of these bridge programs is to help students to successfully meet the needed course completion requirements, such as Calculus I for engineering students. Grace-Odeleye and colleagues [15] suggest that bridge programs “provide a unique opportunity for students to succeed by refining their academic skills and gaining a better understanding of the rigors of college life through academic coursework” (p. 39). Bridge programs can range in duration and format depending on the goals of the host.

In engineering colleges, bridge programs have been used for several goals, including increasing early interest in engineering and STEM fields and preparing students already in college for the academic rigor needed to earn a degree in engineering [8,16]. Many have suggested that there is a lack of interest in STEM and engineering, which is the reason for the projected shortages in workforce needs. In their 2018 study, Kitchen and colleagues [16] found that students who participated in high school summer bridge programs that included the real-life relevance of STEM in the curriculum were more likely to have post-high school

STEM aspirations than those who did not when controlling for demographic characteristics. The authors suggest, accordingly, that these types of summer bridge programs could ultimately help increase and broaden participation in STEM. In another study, Cancado and colleagues [8] looked at one engineering school's summer bridge program to better understand its impact on improving students' math competencies. Their program aimed to raise math placement scores for entering students and prepare them to take Calculus 1 as freshmen, as required for engineering. The authors [8] found that initially, the program helped increase student's math placement scores but did little to increase retention or degree completion.

These studies provide evidence to support the positive aspects and the impact bridge programs can have on increasing early interest in STEM and supporting students before and during their college studies. The other part of our focus within this section is on the importance of discourse methods in creating spaces where students and faculty can work together to co-create knowledge and how, through these methods, content knowledge is mastered and power dynamics are lessened [18].

1.3. Discourse Methods

A growing body of literature has sought to characterize and analyze the discourse between students and their instructors [11–13,19–21]. Though much of the related literature focuses on students and teachers more broadly, this research was motivated by trying to understand the interactions specifically between undergraduate engineering students and their peer facilitators. One discourse method that is often referred to in the literature is IRE, or the initiate, respond, and evaluate method, which has been used by instructors from primary school to the post-secondary level [14] as a way of structuring classroom discussions between instructors and students. Within the IRE method, the instructor initiates the discussion of a topic with students, then responds to students' questions and comments, and lastly evaluates student responses [14].

While the IRE method is seen as the default way of teaching, literature from works such as [11] suggests that this method may hinder classroom discussion and student participation. For example, an analysis of undergraduate classroom discourse points to authoritative discourse methods as the primary way professors and instructors teach, despite how these methods negatively impact how students discuss topics in class [11–13]. Alkhouri and colleagues [12], in their study of 35 college-level STEM instructors in 74 lecture sessions, found that instructors guide students in active learning activities. Still, they used authoritative discourse approaches while doing so. This implies that instructors often disregard or deemphasize students' thoughts when teaching a subject. Research has also suggested a difference in how instructors approach discourse in their classes differently based on discipline. Others have also found that when compared to other majors, engineering students contribute the least to classroom discourse. For example, [13], in their study of three mathematics classrooms at business, liberal arts, and engineering colleges, found that out of the three colleges, the engineering classes had students interact the least. In contrast, students interacted the most in the business college. There is a link between forms of teaching and how students interact with the material and the discussion. To address the academic challenges of earning a college degree, institutions have implemented various programs to help students persist through graduation.

Our understanding of how classroom discourse emerges in engineering environments remains limited. For example, most existing research has focused on teacher–student interaction [19,20] and may, therefore, be limited in explaining the plethora of ways discourse can occur in an engineering classroom. For this reason, our study aimed to (a) understand the types of discourse methods peer facilitators use when introducing problem solving for gateway-level chemical engineering courses during a summer bridge program and (b) understand how students believed that their academic experiences were impacted by peer facilitators' actions. We focus our work on peer-facilitated learning and peer-to-peer discourse in one chemical engineering summer bridge program.

2. Materials and Methods

This study comprises a case study of a summer bridge program completing its first year of implementation at one institution. A case study is an approach to inquiry in which the researcher examines one case—"a contemporary phenomenon within its real-life context" [22] p. 13. For this case study, we consider our data part of a single holistic design, where the program is our single case or unit of analysis.

2.1. Single Case Summer Bridge Program

During this iteration of the summer bridge program, participants were part of a five-week program that met for five hours each day (not including a one-hour lunch break). Implementers of this summer bridge program focused on chemical engineering students' first-year-to-sophomore-year transition. The goal of the program was to offer a preview of key sophomore-level "gateway" course content, provide workshops for academic and professional development, and host social and networking activities for community building. As part of the curriculum, students were introduced to the first four weeks of what is called gateway-level course content, which is considered part of the introductory courses of that major. Examples of gateway-level course content for chemical engineering students include courses such as Material and Energy Balances and Thermodynamics. Within the program, a chemical engineering professor introduced the content each day, and then students practiced what they learned with the guidance of peer facilitators who led the group in solving the given problems. At the end of each week, students took a quiz (i.e., assessment) on that week's content and a practice exam on the fifth week.

2.2. Institutional Context

This case occurred at Laurinburg University (pseudonym), a large public doctoral university with very high research activity [23]. Laurinburg University is also designated as a Hispanic-serving institution (HSI) and an Asian American and Native American Pacific Islander-serving institution (AANAPISI). In addition to having a student body that is racially and ethnically diverse, Laurinburg University is also diverse economically. One variable often used in studies to understand an institution's economic diversity within its student body is the percentage of students who qualify for the Pell Grant program. The Pell Grant is a federal financial aid program that awards needs-based funds for undergraduate students with exceptional financial need. These funds do not need to be repaid by the grantee in most circumstances, and the amount received is based on the expected family contribution (EFC) and cost of attendance.

According to the most recent institutional data, 40% of Laurinburg's student body qualifies for the Pell Grant. Racially, the undergraduate population is composed of 10.2% Black students, 23% Asian students, 36.5% Hispanic students, 3.8% international students, 21.2% White students, and 5.3% other. Regarding gender, although women outnumber men on the broader campus, the College of Engineering has 27.4% women and 72.6% men.

Table 1 shows representation by ethnicity/race for chemical engineering students and the first-time-in-college (FTIC) first-year-to-sophomore-year (College of Engineering) retention versus sophomore-to-junior-year retention. Specifically, the sophomore-to-junior-year retention rate by race/ethnicity is lowest for Black (67%) and Hispanic students (73%) and highest for Asian American (89%) and international students (89%).

2.3. Study Participants

We recruited students to participate in this Institutional Review Board (IRB)-approved study from among those who participated in the bridge program during its first year of implementation (2023). As we describe in Table 2, eight students participated in this study. Three study participants were peer facilitators, and five were student summer bridge participants—seven identified as male, and one as female. The peer facilitators included two current chemical engineering students and one recent chemical engineering graduate.

All peer facilitators were students who passed the gateway-level courses being introduced during the program with a grade of "B" or higher. The five students were first-year chemical engineering students transitioning into their sophomore year the following fall semester. All peer facilitators and first-year students responded to an email agreeing to participate in the study.

Table 1. Laurinburg University chemical engineering enrollment and retention.

	Enrollment (%)	First-Year-to-Sophomore Retention (%)	Sophomore-to-Junior Retention (%)	Difference in Retention (5)
Asian American	30	91	75	−16
Black	8	94	84	−10
Hispanic	22	84	76	−8
International	10	91	79	−11
Other	3	90	84	−6
White	27	83	67	−16
All	100	88	77	−11

Table 2. Selected participant demographics.

Participant	Self-Reported Race/Ethnic Identity	Self-Reported Gender
Participant 1	Asian American	Male
Participant 2	Hispanic (White)	Female
Participant 3	Hispanic	Male
Participant 4	Hispanic	Male
Participant 5	White	Male
Facilitator 1	Black	Male
Facilitator 2	Arab	Male
Facilitator 3	Hispanic	Male

2.4. Data Collection

Data for this study were collected through observations, video recordings of problem-solving sessions between peer facilitators and students, and a post-survey. Institutional course grade data were also collected to understand student outcomes following the summer bridge program. Observations and recording sessions took place after instruction from a chemical engineering professor at the institution. Seven observations were conducted, with 5 of the 7 observations being recorded for post-processing analysis. The first two observations were conducted as training with the observation protocol. Observations involved documenting the frequency of specific discourse methods or under the specific group and memoing details about interactions between students and facilitators during sessions. Each recording/observation lasted between 15 and 45 min, based on the time it took for the cohort to finish a problem as a group. Each session involved a problem being presented on the board and read aloud; then, the students would be given time to work in a group or alone. Once all students and groups had completed the problem, students and facilitators came together to work on the problem.

Our work is motivated and shaped by [19]'s preliminary framework for characterizing engineering outreach educators' teaching moves, which builds from [24]'s taxonomy of "talk moves." Ref. [19] previously used this protocol to make sense of video recordings of a university-led engineering outreach program led by novice engineering outreach educators. To that end, because peer facilitators were novice engineering educators, we found this framework useful for our discourse analysis procedures described below. Table 3 describes the discourse patterns (i.e., ambitious, conservative, and inclusive) used for our observation protocol. The complete codebook used to describe the subcategory within each discourse pattern further is provided in the Appendix A in Table A1 [19,24].

Table 3. Observation protocol discourse method and descriptions *.

Discourse Method	Description
Ambitious	Employ participants to reason and exhibit extensions of their understanding of a design problem or solution
Conservative	Prompt students to provide an anticipated answer or recite information
Inclusive	Elicit participation from multiple students in the problem-solving process

* Adapted from [18,23].

2.5. Survey

To help answer research question two, which will be discussed later, a survey instrument was sent to all student participants during the fall semester at the start of their sophomore year, following the completion of the summer bridge program. All participants responded to the survey, which included five open-ended questions such as, "What actions did the facilitators take to take that most impacted learning their learning course material?".

2.6. Data Analysis

We took a team approach to data analysis. Three researchers analyzed the unedited observation video recordings in two phases (authors 1, 3, and 4). Video recordings were reviewed using the ambitious science teaching framework [24], which consisted of categorizing the classroom talk as conservative, ambitious, or inclusive. First, the researchers viewed a single recording together using a team approach. The reviewers would pause every few minutes to note the time of a perceived discourse method (DM) and then have a discussion to determine which of the three main categories the instance/speaking turn represented. After selecting a main category, the instance was also categorized using one of the specific descriptive methods. The start of a DM was defined as an interaction initiated by facilitators directed at students. The analysis also included noting the time and instance of a DM being used and quotes from facilitators aligning with the framework categories. Following the initial analysis, the videos were reviewed again with the framework, but the second time, researchers 1, 3, and 4 looked more at the context surrounding the quotes and noted responses from students to refine and justify how instances were categorized. After the second stage, findings were plotted based on the broad category (conservative, ambitious, inclusive) to compare the percentage of times each type was used, and quotations were used as supported evidence. Table 4 outlines an example of DM categorization.

Table 4. Example discourse categorization.

Peer Facilitator 1: "What's in our flue gas? Can you tell me A?"

- The above example quote was classified as a conservative display question; the category was determined by the type of question asked; the facilitator asked for a detail from a problem, which means he was trying to elicit an anticipated answer, and the question was a request for simple facts given in the wording of the problem.
- Examples of memoing/notes that we took while reviewing the video include the following:
- He [the facilitator] asked a specific student for information about the problem. This makes it a clear example of a display question, as the facts are simple to answer with the given information.
- The student who was called on was able to [answer] confidently, as shown by how quickly they were able to give the answer.

Our analysis of open-ended survey questions was informed by the six phases of thematic analysis: (a) data familiarization, (b) generating codes, (c) constructing themes, (d) reviewing themes, (e) defining themes, and (f) writing up the findings [25]. Specifically, after each read of the survey responses, we (the first, second, and seventh authors) discussed our reflections and instances of disagreement until our codes aligned. We created a matrix in Excel to illustrate our inductive themes with excerpts from the participants' responses. We moved forward with data analysis using a team approach. This team approach has worked for us in the past, allowing for mentorship between more experienced authors and undergraduate researchers [26]. We convened with the first author during what we call times of calibration to discuss emergent findings [27]. These times of calibration provided an opportunity to gain consensus on the definitions of the themes. Once all of the survey responses were examined, potential themes were noted and placed into Excel spreadsheets (by the first, second, and seventh authors). Next, the team agreed upon the final themes. All of the authors contributed significantly to manuscript preparation and times of calibration.

2.7. Quality

Ref. [28]'s quality framework, a quality measure in engineering education research, was employed to ensure thoughtful quality integration into all facets of the project (i.e., from ideation to implementation to dissemination). We focused on theoretical, procedural, communicative, and pragmatic validation, as well as process reliability during both "making data" and "handling data" [28,29]. In making data, we gathered a team with varying levels of experience and positionalities and took a team approach to collecting data (e.g., multiple team members participated in observations).

As not to rely solely on our memories, we also recorded peer-facilitated sessions. One author served as a peer debriefer immediately following each session. In handling data, the team spent considerable time with the data and repeatedly referred to and discussed the theoretical underpinnings of engaging in the observation protocol. Data were analyzed via a team approach to help mitigate the biases of individual team members. Last, we collectively situated ourselves in this study via a positionality statement to ensure that we were aware of aspects of our experiences that might influence the research process in positive and limiting ways [30].

2.8. Positionality

The identities and positionalities of the researchers in this study are important considerations. Researchers must examine their identities, reflect, and consider the context that the researcher and participants inhabit [31]. Despite having some shared characteristics, we each have unique and diverse identities, which researchers have highlighted as strengths [32] that helped in the project design and data analysis process. In the following paragraphs, we describe aspects of our identities and positionalities that we judged relevant to this study.

The first author is a Black male in his fifth year of study as an undergraduate mechanical engineering technology major. As an undergraduate student, he provides an insider perspective on the experiences of current students. His dual role as a student and researcher enhanced his insights and contribution to the research. He led data collection and team meetings and co-led data analysis and manuscript preparation. The second author identifies as a Black male and is an assistant research professor in the College of Engineering. He holds undergraduate and graduate degrees in History and a doctorate in Higher Education Administration. His scholarly and service interests center on Black male excellence, and his identity as a Black male and college degree holder contribute to his insider status. His insider status also provides a relatedness and vested interest in the topic. Author two does not have a background in engineering, thus giving him outsider status as having a non-engineering academic and professional background. This author co-led manuscript revisions and data analysis discussions. The third author is a Black male electrical engineering student who helped with data analysis. The fourth author is a Black female undergraduate student who also helped with team-based data analysis. The fifth author is a Black woman who is an assistant professor in the social sciences. She earned a bachelor's degree in engineering and intentionally left engineering early in her career in pursuit of career options that were more fulfilling to her. She later earned a master's degree in education and a PhD in the social sciences. She is dedicated to helping other people seek and find meaningful and sustainable careers, with an emphasis on the learning and development that is required for career development. She is a co-designer and implementer of the bridge program. Author six is a professor of physics and Associate Dean of Undergraduate Affairs and Student Success in the College of Natural Sciences and Mathematics and identifies as a Black female. Her research focuses on improving STEM/physics student success, especially for underserved groups, and on STEM teacher education utilizing culturally relevant approaches. She is a co-designer and implementer of the bridge program. The seventh (corresponding author) is an assistant professor of engineering who initiated the study and is a co-designer of the bridge program described in this manuscript. He identifies as a Black man and has earned a bachelor's, master's, and PhD in engineering. He seeks to understand his students' experiences with empathy and always strives to humanize participants. He co-led the data collection, analysis, and manuscript development.

3. Results

In answering research question 1, "What types of discourse methods do peer facilitators use in a summer bridge course when introducing problem solving for gateway-level chemical engineering courses during a summer bridge program?", we saw evidence of all three types of discourse methods being used. As shown in Figure 1, facilitators mostly used conservative methods. Overall, when looking at the frequency of the three broad categories of discourse methods, we found that conservative moves occurred the most often (55%), followed by inclusive (24%) and then ambitious (21%).

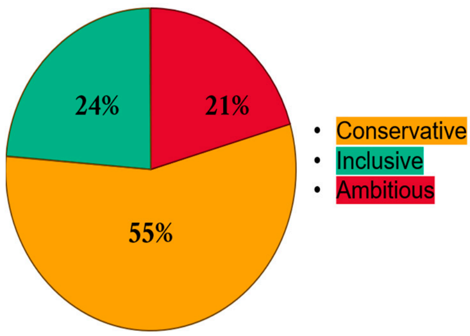

Figure 1. Pie chart representation of discourse methods used in peer-facilitated sessions.

An example of a conservative method is when Facilitator 1 said, "Looking at process spec 2, what do we have here?" Facilitator 1 asked this question to prompt the participants to gather information from the problem and recite it. Another example from Facilitator 1 during the same session was the use of display questions such as, "So we know x, our conversion of methane is equal to what?", "Our equation for conversion is what?", and "Can someone tell me how much nitrogen and oxygen we have coming in?" All of these questions were prompts for participants to give a precise, correct answer. Last, conservative methods of discourse also manifested as mini-lectures. One example was during the same session, Facilitator 1 said, "Just to show yall again... If we were to do an oxygen balance." Facilitators appeared to be most comfortable using conservative methods, as evidenced by the frequency of occurrence.

Examples of ambitious moves frequently took the shape of facilitators pressing participants for explanations. For example, when solving a problem, Facilitator 3 said to Participant 4, "[Participant 4], can you tell me any missing components?" Another example from the same session was when Facilitator 3 said, "[Participant 3], what do you think we can do to start solving for our unknowns?" Facilitator 3 not only pressed participants for explanations but also called them by name. Referring to students by their names is important to building in-class engagement.

Another manifestation of the ambitious method was the use of "check-ins." In one session, Facilitator 1 said the following: "Everybody understand? Nobody got stuck, though, right? No issues?" During the same session, Facilitator 1 verbalized six check-ins with similar questions, such as, "Does that make sense for everybody?" and "Is everybody clear on this one?" Facilitator 1's check-ins demonstrated a care for learning and including everyone in the process. A final example of ambitious methods that facilitators used was probing questions. During a session, Facilitator 1 said, "What does that mean from what we know about algebra?" In this way, facilitators helped point participants to things that they knew so that they might better understand the gateway course material.

Last, we demonstrate examples of inclusive methods that peer facilitators used. This was illuminated through repetition and the distribution of participation. During one of the sessions, Facilitator 1 used repetition when he said, "15 times 1 correct." He acknowledged the correct answer given by a participant. Examples of the distribution of participation occurred in a session when Facilitator 1 said, "And why do you want to do hydrogen, [Participant 4]?" "[Participant 5] take me through it." "If we know this, what else do we know [Participant 3]?" Not only did Facilitator 1 distribute participation, but he often called on specific participants by name to engage them in the discussion.

The observation of sessions revealed that this summer bridge learning space was a dynamic environment where peer facilitators incorporated conservative, ambitious, and inclusive discourse methods into problem solving. Peer facilitators reverted more often to conservative discourse methods, likely because of their exposure to these methods in traditional college classrooms. Their inclusion of ambitious and inclusive methods is promising.

In answering research question 2, "How were student experiences impacted by peer facilitators?", the major theme that emerged was relatability. Participants explained how their positionalities as peers with the facilitators in the same major made them feel more relatable and more like equals in the classroom. For example, Participant 3 stated, "To know that we are learning and developing throughout this Chemical Engineering degree. I feel like having a peer facilitator made it more relatable, knowing that we are all struggling."

Additionally, relatability as peers may have made communication between the facilitator and learner easier for the learners. Participant 4 explained, "They were easy to talk to and reach out to for help." Participant 4 seemed to appreciate several layers, which strengthened his ability to learn. First, the facilitators were "easy to talk to and reach out to for help." Lowering the barrier to access seemed to be an essential facet of engagement within this community of learners. Participant 4 explained, "They didn't just teach the material but also showed us tips and tricks for remembering concepts and demonstrated how the content would come back in upcoming classes." Participant 4 also appreciated how the peer facilitators presented material as a form of learning techniques, or "tips and tricks," and related it to material that he would see in future courses. This notion of explicitly pointing learnings to connections may be necessary for success in STEM learning environments.

Next, when asked about the most important aspect of having peer facilitators lead the problem-solving community, relatedness manifested as not feeling judged. For example, Participant 5 explained, "They helped answer questions more thoroughly and in depth without the judgment of a professor during office hours." Participant 5's direct comparison of facilitators to professors highlights a potential barrier to student learning, feeling judged, that did not seem to be present among the facilitators. Unfortunately, Participant 5 has felt judged during professors' office hours, which is supposed to be designed as a space for students to ask questions freely about course materials.

Limitations

As with other studies, limitations may have impacted parts of our presented study. First, the observation protocol and codebook that we used in this study were not designed specifically for peer-facilitated learning. Therefore, our analysis may be limited by the tools we used. To mitigate this limitation during coding, though we used Miel and colleague's [19] code book, we also left room for emergent codes. Next, in this case, the facilitator-to-student ratio was three facilitators to five students. This is not typical in engineering classrooms. As a result, readers should carefully consider the transferability of findings to other settings.

4. Discussion

As researchers and scholars continue to explore successful interventions and support to engage more students in engineering, further investigation into classroom discourse methods is encouraged. This work supports the idea, similar to previous studies, that different discourse methods are needed to engage students within classroom settings. Our findings demonstrate that peer facilitators in this summer bridge program use a variety of discourse methods during sessions, but they still cling to a more traditional teaching style. This is interesting because the literature on discourse analysis found that instructors of all kinds (school teachers and college professors, tenure track or otherwise) rely on the IRE method [19], which is similar to the conservative discourse methods category. Despite using similar discourse methods to those found by professors, students seemed to be more engaged with facilitators who could relate more easily to their current experiences in this way. Accordingly, facilitators appeared to serve as a type of near-peer mentor. Students related to the facilitators as fellow peers studying chemical engineering, and this may have made them more open to engaging and asking questions when working with peer facilitators than with professors.

For future questions related to classroom discourse and peer facilitators, research should explore how successful peer facilitators in environments outside of bridge programs could impact student engagement and student mastery of engineering course materials. Understanding the challenge that the first two years of college present to engineering majors and developing situations where part of the learning for upper-class students is to work with students in early coursework could benefit retention for both facilitators and students.

Implications for Practice

Our findings point to several implications for implementers of peer-facilitated summer bridge programs that focus on the first-to-sophomore-year transition. The first is that peer facilitators need training at the beginning of the program and throughout the summer through regular check-ins. The integration of Miel and colleagues' [19] preliminary framework into training is an approachable tool for these trainings. We recommend that training also engage facilitators in role playing to see what their facilitation looks like, either in videos or through observations.

The next, summer bridge program implementers should work to retain peer facilitators over multiple summers. For example, one way to address peer facilitator retention is through purposeful recruitment—finding mentors who have a strong sense of belonging to the discipline and who can commit to at least two summers. Having experienced facilitators would only strengthen the community. The challenge is that undergraduate engineering students are likely busy securing internships over the summer. Providing financial compensation to facilitators could help increase peer facilitators' incentive to participate in multiple years.

5. Conclusions

This summer bridge program served as an active learning space that promoted several discourse methods and manifestations of those methods. Ref. [19]'s preliminary framework proved to be a useful tool to help characterize and understand the discourse in this environment. Conservative methods took the shape of peer facilitators eliciting participants to recite specific correct answers, mini-lectures, and display questions. Though facilitators reverted more often to conservative discourse methods, a little fewer than half of the methods they used were ambitious and inclusive methods combined. For example, they manifested as check-ins, probing questions, and attempts to obtain participation from everyone. These are strategies for which peer facilitators (i.e., novice instructors) could be trained. This summer bridge program also points to the relatability of peer facilitators to their peers. They often called their peers by name during all forms of discourse methods. Participants cited the relatability of peers as enhancing their learning.

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Appendix A. Code Book

Table A1. Discourse method observation protocol: method and descriptions **.

Talk Move	Description
Ambitious	Elicit and encourage student reasoning about the problem
Check-in	An open-ended question or statement that does not specifically reference a group's solution but offers students the opportunity to talk about or explain their solution
Probing question	An open-ended question that focuses on a student's solution ideas or thinking (and serves to surface student ideas about the problem)
Press for explanation	Press for student reasoning about a solution
Revoice or reflect	Paraphrase or highlight a selection of a student solution-related comment, or voice what the educator notices the student is doing with their solution.
Conservative	Elicit an anticipated answer or deliver information
Display question	Request for simple facts, procedures, or identification of students' stats in the activity, prompts for a report or single correct answer
Evaluate correctness	Categorize students' responses, products, or processes as normative, useful, or productive (or not)
Mini-lecture or suggestion	Respond to student contribution by delivering content in the form of a solution-related suggestion, content about the activity, or problem-solving tips/norms
Process management	Remind students about the activity instructions, materials, or time
Inclusive	Give multiple students a voice in the discussion

Table A1. *Cont.*

Talk Move	Description
Distribute participation	Provide an opportunity for additional students to contribute, respond, or add to the discussion
Acknowledge contribution	Indicate that a student's contribution is valuable without indicating correctness or indicate listening and encouragement
Repeat	Repeat a student's contribution to ask for clarification or to acknowledge a student's idea
Other	Emergent codes

** Information taken from [19] p. 343.

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