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# Improving sense of belonging in biomedical engineering students through student-faculty lunches

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**Introduction:** Full undergraduate experience in biomedical engineering should feature cordial interactions between students and faculty as well as a good sense of belonging. However, both factors remain elusive for many students, rendering their undergraduate experience suboptimal. We designed the organized student-faculty lunches to promote informal student-faculty interactions and the formation of belonging among the student participants.

**Methods:** During each lunch, an average of four student participants were paired with one faculty and a student assistant. Lunches were provided at no cost to all participants. Invites for students were based on matching interests during recruitment. A mixed-methods survey, including eight identical Likert-scale questions and up to three free-response questions, was distributed three times: before, immediately after, and 1 month after the lunch. We collected a total of 42 responses for the post-survey and 28 responses for the one-month survey. Four students participated in a 30-minute interview. We used paired *t*-tests to analyze the Likert-scale questions across the three surveys. We performed regression analysis to quantify the equity in the outcomes of these lunches. We obtained guidelines for conducting these lunches in the future through regression analysis and thematic coding of the surveys and the interviews.

**Results:** We found that the student-faculty lunches generated significant positive impact across all eight Likert-scale questions across three domains of belonging: academic, social, and personal space. Improvements in survey questions within the social and personal space domains tend to be longer lasting and more statistically significant. The regression analyses revealed that our interventions resulted in better parity in sense of belonging among students with different years of academic experience, ethnic identities, and gender identities. These analyses also suggest that the most effective lunch is conducted in the middle of the Winter quarter with an Assistant Professor. Coding analyses revealed that the students were highly satisfied with the lunches and the current format of facilitation, while noting the benefits of these lunches in reducing the interaction barriers between students and faculty. We intend to perform more qualitative analyses on aspects of equity and faculty demographics concerning their impact on the outcomes of these lunches.

## KEYWORDS

diversity and inclusion, belonging, student-faculty interaction, mixed methods, engineering education, biomedical engineering, lunch

## 1 Introduction

The undergraduate college experience encompasses more than just teaching and learning. To many students, college is a broadening experience for these new adults to develop their knowledge and openness in a community filled with similar-aged peers (Moffatt, 1991). However, a sense of community and belonging remains elusive to some students, which adversely affects their academic and social educational outcomes, especially in highly technical majors such as engineering. To make matters worse, lack of belonging is more common in students who identify with at-risk indicators that are often associated with minority campus groups, which may include part-time, transfer, international, Pell-grant eligible, women, underrepresented minorities, and/or first-generation status (Doran and Swenson, 2022). A 2012 longitudinal study at a large eastern U.S. institution revealed that students who left engineering regarded challenges in their sense of belonging as the most prominent factor in their decision to leave engineering. The same study found that a unit on a 5-point lack-of-belonging scale is associated with a 37.9% decrease in choosing a technical major after leaving engineering (Marra et al., 2012). With respect to the field of Biomedical Engineering (BME), a 2019 departmental survey in one U.S. BME department revealed that one-sixth of students felt uncomfortable in the major. These students were a subset of 34% of the respondents who did not belong to any undergraduate-focused group, including student chapters of professional societies (the Biomedical Engineering Society) and other engineering or non-engineering undergraduate student clubs (Chan et al., 2024). These recent findings acutely reflect the need to develop community-building interventions for engineering students to promote their sense of belonging.

Students, however, are not the only components within the educational community in colleges; “colleges would not be college, after all, without ‘academics’” (Moffatt, 1991): professors, as knowledgeable adults in the college community, play an important role in shaping students’ college experiences. The benefits and challenges associated with student-faculty interactions, including in-class experiences and out-of-class informal interactions, have been well documented in the current literature. However, current research on student-faculty interactions primarily examines the relationships of general student-faculty interactions with students’ developmental outcomes (Kim and Sax, 2017). Translational research in student-faculty interactions, especially specific interventions to promote positive student-faculty interactions, remains missing from the literature.

Shifts in post-pandemic college experiences have brought new challenges to student belonging and student-faculty interactions (Fash et al., 2021); the same challenges are acutely observed in our BME department. Inspired by findings that a single community-building event can potentially improve students’ sense of belonging (Walton and Cohen, 2007), we designed our belonging intervention of organized small-group student-faculty lunches. Our innovative intervention integrates community building among students and benefits from student-faculty interactions. This paper first documents the relevant theoretical frameworks associated with our work and then presents the protocols for conducting these student-faculty lunches. We demonstrate the quantitative and qualitative assessments around our lunches, with a special focus on the benefits, equity, and translatability aspects. Potential future work will be presented at the end of this paper.

## 2 Theoretical framework

Our work is positioned at the intersection of student-faculty interactions and sense of belonging. We first provide relevant theoretical background on these topics and then illustrate our integration of these theoretical frameworks.

### 2.1 Student-faculty interaction

Our intervention to facilitate positive student-faculty interactions originated from a careful reflection of theoretical frameworks regarding the roles of faculty in the college community from the students’ perspective. The learning environment of college students would not be complete without interactions with faculty. Astin’s Student Involvement Theory suggests that students’ personal and educational outcomes are linked to their level of involvement in the program; quality student-faculty interaction was cited as the strongest predictor associated with student satisfaction (Astin, 1984). Indeed, according to the Socialization Theory, favorable interaction between students and faculty facilitates positive socialization (Weidman, 1989), which allows students to assess and develop their aspirations, values, and aptitudes in their institution’s context (Carter et al., 2013; Weidman, 1989). In addition, the Social Capital Theory reaffirms the role of faculty as important resources in the campus community for students as agents of knowledge, advice, advocacy, and social support (Stanton-Salazar, 2011).

We then examined relevant frameworks for categories of student-faculty interactions. Komarraju et al. (2010) classified student-faculty interactions into two major categories: formal/in-class interactions and informal/out-of-class interactions. Cox and Orehovec (2007) framework of out-of-class interactions further divides these interactions into four levels by frequency of occurrence: incidental interactions such as waves and greetings; functional interactions, which are primarily academically related; personal interactions that are purposeful and out of personal interest; and mentoring. We determined that formal interactions are better addressed by pedagogical research in Scholarship of Learning and Teaching and decided to orient our intervention around informal student-faculty interaction. Within out-of-class interactions, forging a mentoring relationship from an interventional perspective typically requires significant time commitment from both students and faculty (Hayes, 2005), as well as long-term longitudinal tracking of learning outcomes (Cox and Orehovec, 2007), which is better suited for research-oriented educational programs. Personal interactions, however, can provide educational benefits to students, which is the category of student-faculty interactions we identified to establish our intervention.

Current research on formal or informal student-faculty interactions is based primarily on students’ perceived quantity and/or quality of student-faculty interactions. Perceived high-quality student-faculty interactions are linked to better academic outcomes in students, such as higher GPA (Komarraju et al., 2010; Anaya and Cole, 2001) and persistence (Loes et al., 2024); similar benefits have been reported by frequent student-faculty interactions occurring outside of the classroom (Tovar, 2015). Affective outcomes, such as better sense of belonging, have been linked to formal (Meeuwisse et al., 2010) and informal (Chan et al., 2024) student-faculty interactions. Often, beneficial student-faculty interactions are linked to descriptors such

as helpful, kind, and respect. However, certain types of student-faculty interactions, such as receiving negative feedback from professors in academic work (Chang et al., 2011), frequent informal visits of professors (Anaya and Cole, 2001), or even informal student-faculty interactions in general (Gordon et al., 2007), may be linked with negative educational outcomes. These findings led us to identify student-faculty lunches as a potential avenue for promoting student-faculty interaction with the following key features: small-group student-faculty contact to ensure quality and quantity; some levels of organization to enhance helpfulness; and positivity and respect during the event. Students' identities, such as gender, ethnic identity, and major, can potentially affect the outcomes of student-faculty interactions as well (Kim and Sax, 2014; Park et al., 2022; Goeddeke and Taschner, 2023). Therefore, we performed a demographic analysis to identify potential gaps in the outcomes experienced by students with different identities during outcome assessments.

## 2.2 Sense of belonging in college students

Improving the sense of belonging among our participants is identified as a key goal of this study. Belonging is considered a human need to feel connected with others who are concerned about each other's welfare (Baumeister and Leary, 1995). In the context of educational environments, belonging can be interpreted as students' senses of feeling accepted, valued, included, and encouraged (Goodenow, 1993). A heightened sense of belonging has been linked to multiple benefits within the student population, including improved retention, higher motivation, and better enjoyment of their academic study (Pedler et al., 2022; Marra et al., 2012). However, a sense of belonging is unequally felt among students of different identities. For example, Pedler et al. (2022) reported that first-generation students tend to feel less belonging than non-first-generation students do; Kissinger et al. (2009) found that female students' sense of belonging tend to be better in engineering majors with a higher percentage of female students, but Fink et al. (2020) indicated that the sense of belonging of female students can still be lower than that of male students, although the enrollment of the chemistry major is approximately equitable in gender. Doran and Swenson (2022) compiled a list of at-risk indicators for students' sense of belonging that are associated with academic probation and dismissal, which include part-time, transfer, international, Pell-grant eligible, women, underrepresented minority, and/or first-generation status. The reported inequities among identity groups reinforced the need for demographic analysis when we assess outcomes in sense of belonging from these lunches.

Ahn and Davis's (2020) framework categorizes college students' sense of belonging into four domains: academic, social, surroundings, and personal space. Within the framework, we did not believe that student-faculty lunches could affect the domain of surroundings, which focuses on accommodation and culture. The domains of academic (academic engagement), social (social engagement, network, solidarity), and personal space (life satisfaction, attitudes, identity, personal interest) were identified as potential outcomes for assessment from the student-faculty lunches. To translate the three domains into quantitative indicators we can evaluate, we consulted a validated survey by Leibowitz et al. (2020), which focused on the academic sense of belonging. We identified diversity, equity, and

inclusion (DEI) as relevant to solidarity as an important aspect of social belonging; therefore, we additionally considered Driscoll et al. (1996) framework, which assesses the interaction among students, faculty, and the community, to develop an item related to DEI.

## 2.3 Research questions

From the theoretical frameworks mentioned above in combination with our proposed intervention, we formulate the following research questions:

*RQ1: Will a single intervention, an organized small-group student-faculty lunch, provide benefits to students in their sense of belonging?*

*RQ2: Will the potential benefits have a lasting impact on students' sense of belonging?*

*RQ3: Will the potential benefits be equitable for campus minority groups?*

*RQ4: How can we best organize and coordinate these student-faculty lunches to provide the maximum benefit to the student participants?*

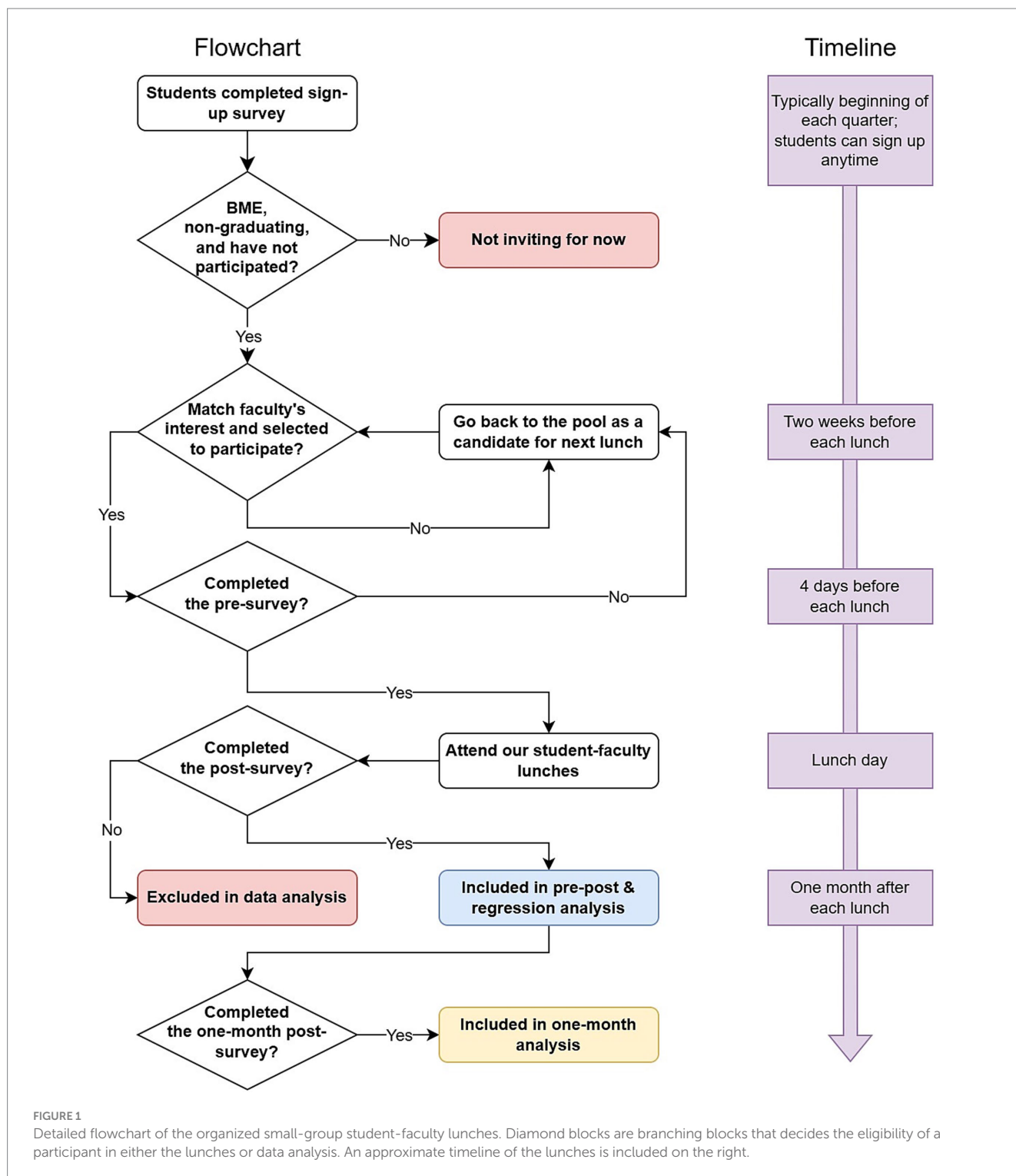
## 3 Materials and methods

The overall flow diagram of our study, including the study protocol and inclusion criteria for analyses, is shown in Figure 1. The UC Davis Institutional Review Board (IRB) designated our study as IRB exempt (#2030008–3).

### 3.1 Study protocol

Students and faculty participated in our intervention, the organized small-group student-faculty lunches, on a per-recruitment basis. UC Davis BME undergraduates with at least 1 year left in their study plan are eligible to participate in these lunches. Student participants were recruited via a sign-up survey distributed through multiple channels, including first-year orientations, presentations in major classes, social media of the authors' lab, and departmental email lists. Students can indicate their general areas of interest from one of seven (7) predefined options, including course planning, career choice, undergraduate research, master's programs, Ph.D. programs, life advice for undergraduates, life as a graduate student or postdoc, or life as a faculty. Students can further elaborate or specify their own areas of interest in a subsequent free-response question. Students are invited to write in up to three additional names of students that they want to come together with at these lunches. Due to the current high demand for these lunches, each student is only eligible to attend one lunch.

The faculty who participated in our intervention were from the BME department at UC Davis. The BME department at UC Davis consists of 35 tenure-track faculty. Since the inception of these lunches in April 2023, we have conducted 12 lunches with one faculty participating in each lunch. The undergraduate student makeup of the UC Davis BME is 56% women; therefore, a focus was placed on



engaging our female faculty in these lunches to serve as role models (Olsson and Martiny, 2018). Another focus was placed on faculty that were actively looking for undergraduate student researchers; many of these faculty were new assistant professors in the department. However, we did not reveal any intention as to why the faculty was recruited for these lunches; we simply asked the faculty whether they would like to have a free lunch with some undergraduates. The demographics of the participating faculty can be found in Table 1. Typically, 2 weeks before the lunch, faculty were asked about their

preferred topics among these seven predefined areas, as specified above.

UC Davis adopts a quarter academic system with three main academic quarters per academic year (Fall, Winter, Spring), and each quarter is approximately 11 weeks (Weeks 1–10 and finals week). Three lunches are typically conducted per quarter, with one in Weeks 1–3 (early), one in Weeks 4–8 (middle), and one in Weeks 9–11 (late). We compile the list of eligible participants every month prior to conducting the lunch and select up to 6 (six) students based on



TABLE 1 Gender and rank of the 12 participating faculty members.

Gender	Recruited	Percentage
Male	7/25	58%
Female	5/12	42%

Rank	Recruited	Percentage
Professor	2/18	17%
Associate Professor	4/10	33%
Assistant Professor	6/7	50%

The column “Recruited” shows the number of recruited faculty members over all faculty members of that identity (for example, the first row 7/25 means that 7 male faculty participated in these lunches out of 25 male faculty affiliated with UC Davis BME).

common options between students’ areas of interest and faculty’s preferred topics. A mix of lower-division and upper-division students were invited when possible. Priority was given to students who had not participated in these lunches; all invited students have been first-time participants. For each student who put down names in their sign-up survey, the whole group was invited. To participate in these lunches, invited students were required to fill out an anonymous pre-intervention survey, typically 3 days before the lunch started. The pre-survey asked for optional demographic information and an additional 10 questions, including eight Likert-scale questions (1: strongly disagree, 5: strongly agree) on sense of belonging and two free-response questions. The collected demographic information included students’ academic standing, gender, and ethnicity, as well as first-generation, low-income, international status, and English as a second language (ESL) status. The free-response questions asked the students to specify their goals of signing up for the lunch and write two questions for the faculty. The lunch was closed when five (5) submissions to the pre-survey were received. Students also receive a randomly generated 5-digit identifier to link their pre-survey responses to their post-surveys.

All lunches were conducted at on-campus restaurants, and reservations were often secured. Fifteen minutes prior to each lunch, an undergraduate student assistant checks in with the reservation and greets the arriving students and faculty. All undergraduate student assistants have received training in an engineering educational lab and have leadership experience in an undergraduate student organization. Sometimes, the principal investigator (PI) of the study greets students with the student assistant since this campus restaurant has multiple entrances, especially when the lunches consist of primarily lower-division students, who may not be too familiar with the campus.

The lunch starts after the student assistant has verified the completion of the pre-survey from each student. This campus restaurant has a pay-first policy; therefore, the PI or the student assistant (when the PI is not present) pays for the lunch costs for all participants, including the faculty, student assistant, and all student participants, through campus recharge to the associated accounts, before sitting down at the reserved table. The PI or the student assistant will then provide an overview of the follow-up activities, including the subsequent survey and interview opportunities and the associated compensation with these activities. The PI then leaves the restaurant if he is present.

Conversations were informal and could be driven by either students or faculty, with students encouraged to bring their own

questions and topics. The student assistant is allowed to participate in the discussion but is asked to play a primarily observational role. The student assistant is also instructed to lead with pre-submitted questions through the pre-survey when the conversation needs reignition or when they observe incivility from either students or faculty during certain conversation topics. The topics of discussion largely followed the pre-selected areas of interest of the students and faculty. Lunches lasted from 1 to 2 h depending on the schedules of the group. Forty-four students participated in these 12 lunches, resulting in a 3.67:1 student-faculty ratio.

At the end of the lunch, the student assistant thanks the faculty, and shows the QR code for the participating students to take the immediate post-survey (often referred to as “post-survey” below). The immediate post-survey contains the same Likert-scale questions from the pre-survey and an additional three (3) free-response questions. These free-response questions ask the students about whether they have achieved their goals and what went well/did not go well in these lunches. The same Likert-scale questions are reissued as a second post-survey 1 month (referred to as the “one-month post-survey” below) after the students participated in these lunches. Students who completed both post-surveys were issued a \$5 Amazon e-gift card. From the 11th lunch, two participating students from each lunch were invited for a semi-structured 30-min interview to discuss their lunch experience. All interviews were conducted within 45 days after the students had lunch with the faculty. Students who completed an interview were issued another \$25 Amazon e-gift card.

### 3.2 Quantitative instruments

To assess our interventions, we translated the three identified domains (academic, social, personal space) of belonging (Ahn and Davis, 2020) into assessable outcomes using Leibowitz et al.’s (2020) academic belonging survey and Driscoll’s (1996) service-learning model. The resulting eight (8) Likert-scale questions were included in all three surveys (pre, post, one-month). We developed these survey questions to cover as many identified themes as possible while attempting to minimize the number of survey questions that could cause survey fatigue or incomplete surveys, especially because our post-survey is completed immediately after the lunch and the one-month post-survey has only a small financial incentive (\$5). These questions included categories of belonging, such as participation, satisfaction, community feeling, identity (competence and persistence), curriculum, attitudes toward goals (career), and sensitivity to diversity (DEI). The specific wording of the Likert-scale questions can be found in Table 2.

### 3.3 Qualitative instruments

Our qualitative instruments include two free-response questions from the pre-survey, three free-response questions from the post-survey, and a semi-structured interview. Since one of our research questions is to develop specific guidelines for conducting sense-of-belonging interventions such as the small-group student-faculty lunches, gaining insights into central focus areas from the students will be beneficial. Therefore, two free-response questions were included in the pre-survey, with the wording of these questions as follows:

TABLE 2 Wording of Likert-scale questions and themes (A, academic, S, social, PS, personal space) that each question addresses.

Q#	Full question	Abbreviated	Theme
1	I am aware of the undergraduate-oriented events and opportunities (for example, the BME Open House) in the department of Biomedical Engineering at UC Davis.	Knowledge of events	S
2	I have participated in the events and am satisfied with the quality of such undergraduate-oriented events in the department.	Satisfaction of community events	S/PS
3	I feel that I belong in the department of BME at UC Davis.	Belonging in community	S/A
4	I am clear about my undergraduate academic study plan (the course schedules) in BME at UC Davis.	Curriculum	A
5	I know my strengths and weaknesses in my concentration of study in BME.	Academic competence	A/PS
6	I would like to complete my B.S degree in BME at UC Davis.	Persistence	A/PS
7	I am clear about my career goals in biomedical engineering.	Clarity of career goals	PS
8	I am aware of the challenges associated with the biomedical engineering industry in terms of diversity, equity, and inclusion.	Sensitivity to DEI	S

An abbreviated description of each question is also provided. Questions are presented in the original order of the survey with the question number Q#.

- 1 Describe your goals of signing up for lunch with this professor. Your results will be shared with the professor so that the professor knows about potential topics that can be brought up.
- 2 Write down two specific questions you want to ask this faculty.

Additionally, to obtain feedback from student participants and gain insight to the organization of future lunches, we chose to include three free-response questions in the post-survey:

- 3 Did you achieve your original goals for the faculty lunch?
- 4 What went well at the faculty lunch?
- 5 What did not go well at the faculty lunch?

The semi-structured interview was designed for the participating students to provide deeper insight into the efficacy and offer a better context of these lunches. A standard interview lasted 30 min and was conducted either in person or through Zoom. Verbal consent from the interviewee was obtained prior to the audio of the interview being recorded. The recordings were first automatically transcribed by Zoom or NVIVO. The transcription was then manually checked by the authors to correct potential errors. The interviews were organized into sections. The main section of the interview started with the same demographic questions we asked in the surveys, followed by general perceptions of student-faculty interaction, recalling the lunch, elaborating on the eight (8) Likert-scale questions, and feedback questions. The subsequent questions could be asked in any order depending on the organic flow of the conversation. The interviewees were welcome to elaborate on other topics if warranted. The interview script is included in the [Supplementary materials](#).

3.4 Data analysis

We received a total of 42 valid post-surveys (95.4% response rate) and 28 valid one-month post-surveys (63.6% response rate). An overview of the demographic factors, including the class standing, gender, and ethnicity of the participants is provided in [Table 3](#). The statuses, including first-generation, low-income, international, and ESL statuses, were collected beginning at the 10<sup>th</sup> lunch; thus, insufficient data were collected on these factors.

TABLE 3 Demographics of the students in the post-intervention survey (post-survey, 42 participants) and the one-month post-survey (28 participants) as percentages of the students who responded to the respective surveys.

Demographic	Range (post-survey, <i>n</i> = 42)			
Class standing	1st year 40.5%	2nd year 23.8%	3rd year 33.3%	4th year or higher 2.4%
Gender	Male 31.0%	Female 66.7%	Nonbinary/ third gender 2.4%	
Ethnicity	White: Asian/Asian American: Hispanic/Spanish Origin: Mexican/Mexican American/Chicanx: African American/African/Black: American Indian/Alaskan Native:			21.4% 76.2% 4.8% 4.8% 2.4% 2.4%

Demographic	Range (1-month post-survey, <i>n</i> = 28)			
Class standing	1st year 28.6%	2nd year 26.8%	3rd year 39.3%	4th year or higher 3.6%
Gender	Male 28.6%	Female 67.9%	Nonbinary/ third gender 3.6%	
Ethnicity	White: Asian/Asian American: Hispanic/Spanish Origin: African American/African/Black: American Indian/Alaskan Native:			25.0% 82.1% 3.6% 3.6% 3.6%

Note that the sum of all ethnicities exceeds 100% because students may identify as multiple ethnicities.

3.4.1 Pre/post comparisons

For each Likert-scale question, paired *t*-tests were performed to characterize the impact of our intervention. In the examination of RQ1 (efficacy of intervention), we included all 42 valid post-survey responses in a single set of pre-post comparisons. Additionally, Cohen's *d* was calculated to measure effect size; we chose the pooled

standard deviation during the calculation of Cohen's  $d$  (Cohen, 2013). For RQ2 (lasting impact), we performed two sets of paired  $t$ -tests, between the pre-survey and the post-survey, and between the pre-survey and the one-month post-survey. All 28 subjects who completed all three surveys were included in the analysis for RQ2. For both RQs, we selected an overall significance level of 0.05 for each Likert-scale question. For RQ2, Holm-Bonferroni corrections were applied to control the overall significance level. All statistical tests were performed in Python 3.11 using the statsmodels package (Seabold and Perktold, 2010) and visualized with seaborn (Waskom, 2021).

### 3.4.2 Regression analysis

To answer RQ3 (equity analysis) and partially RQ4 (best practice), we generated a multiple linear regression model for each Likert-scale question using recursive feature elimination (RFE) (Guyon et al., 2002) to determine the most impactful variables. RFE considers a smaller and smaller set of features by recursively eliminating the feature with the smallest coefficient in a statistical model, in this case, a linear regression model. Regression models with fewer features carry lower costs to the degrees of freedom, increasing the interpretability of these models by highlighting the most significant features.

The features we generated for these models are included in Table 4. Due to an insufficient number of non-binary students, the feature “non-binary” was excluded from all models along with the four factors mentioned above. All features were normalized between 0 and 1 to ensure that the weights were not affected by the encoding of the parameters. For each Likert-scale question, a model was fit for the pre-survey, post-survey, and improvement (post-survey minus pre-survey). Models fit on the pre-survey are used to examine existing inequities in the data; therefore, three additional features involving the faculty's demographics were excluded. We chose the adjusted  $R^2$  as the stopping criterion for RFE since for models with similar  $R^2$  values, the adjusted  $R^2$  will be lower due to the inclusion of additional features (Raju et al., 1997). For each model, we stop eliminating features when the adjusted  $R^2$  of the resulting linear regression model stops increasing. Regression analyses were performed in Python 3.11 with the scikit-learn (Pedregosa et al., 2011) and statsmodels (Seabold and Perktold, 2010) packages.

### 3.4.3 Coding and thematic analysis

Thematic analysis of the responses collected from the qualitative instruments was used to fully answer RQ4 (best practices). The initial codebook was developed by one of the authors through a deductive coding process by first employing the auto-coding process in NVIVO 14, followed by a detailed read through of the free-response questions. The codebook was further refined by the other two authors, who performed the final coding for the free-response questions and the interviews. For consistency, interviews were coded by whole sentences and responses to open-ended questions were coded to a sub-sentence level. The themes were constructed with the guidance of the research questions. From the broad objectives expressed from the research questions, we focused our coding on the three domains of academic, social, and personal space in the belonging framework, which were further divided into more specific frames. Additional themes that were more descriptive of the lunches were also included in the codebook. Student accounts were characterized into a code if a student said the words explicitly or heavily alluded to a particular code. Cohen's Kappa was computed by NVIVO for each primary code, and

TABLE 4 Possible features of the multiple linear regression models and numerical encoding.

Variable	Meaning	Encoding
Year	Academic standing of participants	0: first year; 1/3: second year; 2/3: third year; 1: 4+ year
Female	Gender: female	0: No; 1: Yes
Non-Binary	Gender: non-binary	0: No; 1: Yes
Asian	Ethnicity: Asian	0: No; 1: Yes
URM	Ethnicity: underrepresented minority	0: No; 1: Yes
Rank (Fac)	Faculty Title/Rank	0: Assistant Prof.; 0.5: Associate Prof.; 1: Professor
Female (Fac)	Faculty gender: Female	0: No; 1: Yes
Mid qtr.	2nd lunch of the quarter, around week 6	0: No; 1: Yes
Late qtr.	3rd lunch of the quarter, around week 10	0: No; 1: Yes
Winter	In Winter quarter (2nd quarter in AY)	0: No; 1: Yes
Spring	In Spring quarter (3rd quarter in AY)	0: No; 1: Yes
Gender match	The participant's gender is the same as the faculty's	0: No; 1: Yes
First gen	First-generation college student	0: No; 1: Yes
Low income	Low-income college student	0: No; 1: Yes
Intl	International student	0: No; 1: Yes
ESL	Student speaks English as a second language	0: No; 1: Yes

AY, academic year. The baseline of the model is a lunch conducted in the beginning (around Week 2 of 11) of the Fall quarter (first quarter of AY) with a participant identifying as a white male. Shaded variables were not included in the current study due to insufficient data.

the overall Cohen's Kappa was calculated in Excel. The coding frequency of each major code was extracted along with representative quotes. The codebook along with representative quotes can be seen in Table 5.

## 4 Results

### 4.1 Pre/post comparisons

Paired  $t$ -tests with 42 pre/post-surveys revealed significant temporary improvement in all areas of belonging assessed in the surveys. Detailed results of this comparison can be found in Table 6. We observed large and significant gains on *satisfaction of community events* (Cohen's  $d = 0.92$ ,  $p < 0.0001$ ), *belonging in community* ( $d = 0.81$ ,  $p < 0.0001$ ), and *knowledge of events* ( $d = 0.79$ ,  $p < 0.001$ ) in the post-survey, strongly supporting our hypothesis that these student-faculty lunches can improve the overall students' sense of belonging. Questions such as *sensitivity to DEI* ( $d = 0.64$ ,  $p = 0.001$ ), *clarity of career goals* ( $d = 0.61$ ,  $p < 0.0001$ ), *persistence* ( $d = 0.49$ ,  $p = 0.002$ ), and *academic competence* ( $d = 0.47$ ,  $p = 0.005$ ) received medium sized improvements in the post-survey. The improvement in

TABLE 5 Codebook (including the primary and selected secondary codes) used in the coding of free-response questions and the interviews.

Primary codes	Secondary codes	Sample quotes
Research	Challenges and Barriers	I've had a difficult time finding a wet lab.
	Research environment	I would also like to learn what the research environment feels like.
	Research interest (Faculty)	[W]e got to learn about his research, and he loved talking about current endeavors in the field as well.
	Research opportunities	I would appreciate discussing the ongoing research projects within the department and potential opportunities for undergraduate or graduate students to get involved.
	Research skills	I think I definitely learned from the lunch that I need to increase my experience in the lab and like practical applications of the BME courses I'm taking.
Career	Career paths	But you have there are there is more to look forward to in the future, and I think that's what makes me really excited about continuing in a major, but also for how and where I can go in this in the future.
	Expectations	I am [clearer] about my career field and emerging areas of research.
	Internships	I think I still need to get more experience in those fields to really determine which one I and most passionate about, like currently, I'm doing an internship in with tissue engineering.
	Motivation	I definitely think that I have a better feel of the major and feel more confident in pursuing it.
	Skills development	I've been trying to figure out ways to get in in field experience, and I think [professor] mentioned that it's important to try and apply for labs at Davis especially so you can get more experience that way.
Community building	Atmosphere	Everyone was very welcoming and was so nice.
	Between students	I mentioned the having the other students there, and their input helped me a lot almost equally to talking with [professor], because they every everyone being in BME we are going through similar paths in college.
	Between students and faculty	But he was also very friendly and made small talk that it seemed like I wasn't talking to a professor or someone who was like higher up than me. It seemed like I was talking to more like a friend.
	Diversity, equity, inclusion, belonging	I felt as though I have a better sense of community from the meeting.
	Mentorships	I could connect better with other undergraduates or even professors and faculty, who are part of BME and talk with undergrads who are going through the same process as me
	BME domains and department	I would definitely say that there has been [a] noticeable impact on how I really do approach this major and all it has to offer.
Academics	Graduate programs	I believe he said that master's is really important in terms of like exploring. It's a great next step, and then Ph.D. Can help you hone in on skills.
	Professional school	Is graduate school or medical school needed after completing undergraduate school?
	Undergraduate education	I mentioned the having the other students there, and their input helped me a lot almost equally to talking with [professor], because they every everyone being in BME we are going through similar paths in college.
Engineering identity	Interest	I was way more interested when he told us about his research, and biomaterials he makes it sound super interesting.
	Performance and competence	Do you have any advice for students who do not quite feel 'fit' to be engineers. Did you experience imposter syndrome throughout your career?
	Recognition	[As a struggling student in undergraduate], being able to achieve a lot in the future, that perspective always feels very good and motivated.
Professional experience	Experience prior to becoming faculty (UG, Ph.D., and postdoc)	I got to know [professor] pretty well [about] what his background, where he studied and what research he's doing, and even [his sharing] some personal items such as like stuff he cooks at home his hobbies.
	Experience as faculty	Yes, I found it nice to hear about a faculty's experience in academia.
Perceived faculty characteristics	Anxiety or intimidation	Before this lunch my view from the faculty was that they are very focused on their own work, and might be very reserved, and well are not friendly.
	Expertise or insight	[Professor] had really insightful takes on his field specifically in biomaterials, and he knew a lot of applications and extensions from that.
	Personable or kind	This helped me to genuinely interact with faculty and know that they are humans too who are trying to help me succeed.
	Disconnected	I honestly feel so disconnected from all faculty at Davis.
	Helpful	[Professor] was very engaging and helpful.
	People of power	When it comes to most classes, [it's] like a parent to kid kind of dynamic, where there is one person who is on top and a person who is on bottom, and one kind of follows the other.

(Continued)



TABLE 5 (Continued)

Primary codes	Secondary codes	Sample quotes
Biomedical engineering fields	Biomaterials	The way that he described his research was super cool and I became a little bit more interested in biomaterials.
	Cell and tissue engineering	I'm uncertain if tissue engineering is the specialization I want to pursue.
	Discovery of new fields	...It was he introduced more newer, newer fields of study in BME such as his studies with stem cells.
	Emerging fields	Are there any emerging technologies or interdisciplinary collaborations that you find particularly exciting?
	Imaging	I am interested in learning more about the medical imaging side of Biomedical Engineering, which [faculty] is highly specialized in.
	Interdisciplinary or diversity of fields	Understanding the focus areas and interdisciplinary collaborations would assist me in aligning my academic interests with the ongoing research endeavors.

One sample quote was included for each secondary code.

clarity of *curriculum* ( $d = 0.43, p = 0.007$ ) was the smallest yet still very statistically significant. Overall, gains in social sense of belonging outpaced gains in areas of academic and identity.

The results of tracking our participants from the pre-survey to the one-month post-survey, which featured a reduced sample of 28 participants, are shown in [Figure 2](#). Many improvements seen in the initial comparison were retained in the one-month analysis; however, improvements in social sense of belonging tended to be retained better after 1 month. *Satisfaction of events* ( $p_1 < 0.001$  for pre/post;  $p_2 < 0.001$  for pre/one-month), *belonging in community* ( $p_1 = 0.001$ ;  $p_2 = 0.005$ ), *clarity of career goals* ( $p_1 < 0.0001$ ,  $p_2 = 0.001$ ), and *sensitivity to DEI* ( $p_1 = 0.003$ ;  $p_2 < 0.001$ ) received significant and lasting improvement through the one-month post-survey. Two additional questions, including *academic competence* ( $p_1 = 0.020$ ,  $p_2 = 0.067$ ) and *persistence* ( $p_1 = 0.002$ ,  $p_2 = 0.134$ ) lost initial significance in the comparison between the pre-survey and the one-month post-survey. Two additional questions, including *knowledge of events* ( $p_1 = 0.057$ ,  $p_2 = 0.212$ ) and *curriculum* ( $p_1 = 0.161$ ,  $p_2 = 0.118$ ) did not achieve significance in either comparison in the one-month study.

## 4.2 Regression analysis

In [Table 7](#), we present all the features that contribute to the regression models significantly or near-significantly ( $p < 0.10$ ), with the full printout of the regression analyses included in the [Supplementary materials](#). Our current models analyzed the effects of year, gender (female), and ethnicity on parity in the outcomes from these lunches. The variable “year” is tied to the level of educational experience of our student participants. The pre-survey models showed that students with more years in their academic program demonstrated higher initial levels of belonging. The higher starting points are reflected in statistically significant positive slopes for *knowledge of events* ( $p = 0.021$ ), *academic competence* ( $p = 0.004$ ), and *persistence* ( $p = 0.023$ ) while also positively ( $p > 0.10$ ) contributing to the regression models for *belonging in community*, *curriculum*, and *sensitivity of DEI*. In the post-survey however, “year” became non-significant negative predictors ( $p > 0.10$ ) in *satisfaction of events*, *belonging in community*, *curriculum*, and *sensitivity to DEI*. Regression models on the pre/post improvements regarded “year” as a significant negative predictor for *knowledge of events*

( $p = 0.003$ ), *curriculum* ( $p = 0.009$ ), and *persistence* ( $p = 0.005$ ). These negative improvements may be associated with a ceiling effect ([Wang et al., 2008](#)) due to the higher initial responses from the upper-division students. These results suggest that having a small-group lunch with faculty brings equity in terms of belonging outcomes across students with variable years of experience but may be particularly beneficial for students early in their academic careers.

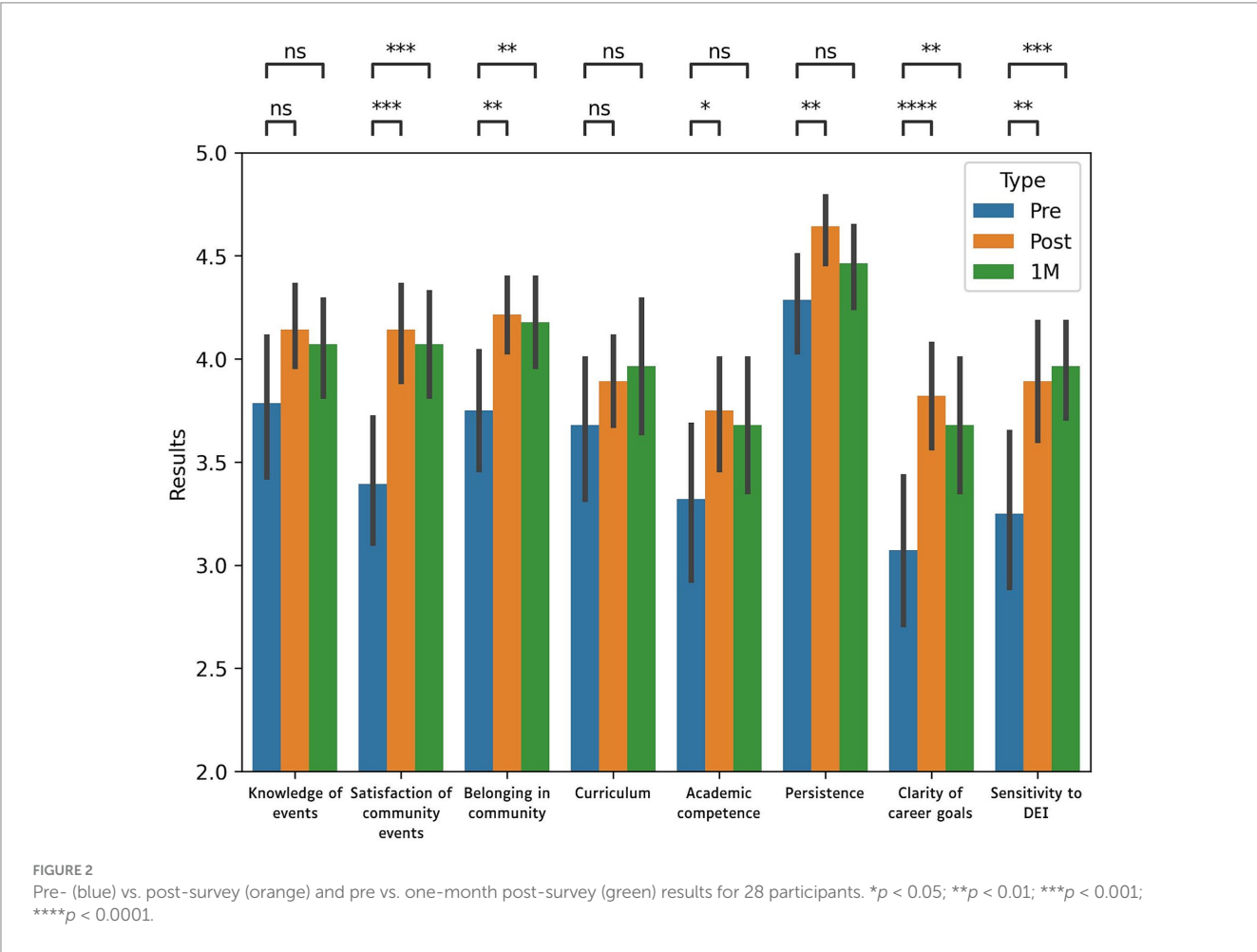
Our intervention also brought some equity in senses of belonging in terms of gender (female student) and ethnicity outcomes. The pre-survey associated the female students with a negative perception of *academic competence* ( $p = 0.042$ ), which was also seen in a 2008 national survey ([Litzler et al., 2014](#)). However, the female student participants gained significantly more *knowledge of undergraduate-oriented events* ( $p = 0.030$ ) during the lunch, positively comparing to the male participants after the lunch ( $p = 0.052$ ). However, we also observed that the gender “female” was a near-significant to significant negative predictor of the pre/post-improvement on *sensitivity of DEI* ( $p = 0.024$ ) and *belonging in community* ( $p = 0.093$ ), although the “female” variable was not present in the models for these questions in the post-survey. Examining the ethnicities of our participants, we found that Asian students were associated with higher initial levels of *knowledge of events* ( $p = 0.006$ ) and *belonging in community* ( $p = 0.051$ ). Possibly due to the ceiling effect, negative improvement outcomes in *knowledge of events* ( $p = 0.012$ ), *belonging in community* ( $p = 0.032$ ), and *curriculum* ( $p = 0.007$ ) associated with Asian students were not reflected in models for the post-survey. The underrepresented minority (URM) students fared lower in two measures, *satisfaction of community events* ( $p = 0.006$ ) and *curriculum* ( $p = 0.034$ ), in the pre-survey. The gap in these two sense-of-belonging measures did not fully close in the post-survey, but the slopes were much less negative and less statistically significant (*satisfaction of community events*  $p = 0.020$ ; *curriculum*  $p = 0.051$ ).

The regression analyses also provided valuable insights into the translatability aspects for adopting our approach to organize small-group student-faculty lunches in other schools. The identity of faculty seems to affect the outcomes of these lunches. A higher faculty rank, for example, when a student had lunch with a full professor rather than an assistant professor, was associated with multiple lower outcomes post-lunch, including *knowledge of events* ( $p = 0.072$ ), *satisfaction of community events* ( $p = 0.019$ ), and *academic competence* ( $p = 0.058$ ). The pre/post improvement models also marked all three factors as negative ( $p > 0.10$ ). Lunches involving female faculty were associated with lower

TABLE 6 Mean and standard deviation (std.) of Likert-scale questions (1: strongly disagree; 5: strongly agree) from the pre-survey (pre) and immediate post-survey (post) out of 5.00.

Theme	Description	Pre		Post		% change	<i>p</i> -value	Sig.	Cohen's <i>d</i>
		Mean	Std.	Mean	Std.				
S	Knowledge of events	3.50	1.13	4.19	0.51	19.7%	<0.001	***	0.79
S/PS	Satisfaction of community events	3.33	0.85	4.05	0.70	21.4%	<0.001	****	0.92
S/A	Belonging in community	3.71	0.77	4.24	0.48	14.1%	<0.001	****	0.81
A	Curriculum	3.62	0.88	3.95	0.66	9.2%	0.007	**	0.43
A/PS	Academic competence	3.40	0.99	3.81	0.71	11.9%	0.005	**	0.47
A/PS	Persistence	4.26	0.80	4.60	0.54	7.8%	0.002	**	0.49
PS	Clarity of career goals	3.33	1.03	3.88	0.74	16.4%	<0.001	****	0.61
S	Sensitivity to DEI	3.38	1.01	3.95	0.76	16.9%	0.001	**	0.64

% change signifies the average percentage change from the pre- to the post-survey. Possible themes include A, academic; S, social; PS, personal space. \**p* < 0.05; \*\**p* < 0.01; \*\*\**p* < 0.001; \*\*\*\**p* < 0.0001.



post-survey outcomes in *curriculum* ( $p = 0.015$ ); however, according to the memories of the student assistants, student participants in these lunches were more interested in aspects other than the BME curriculum, so the curriculum was rarely discussed as a conversational topic. An interesting phenomenon when we investigated two factors together, including the “gender of faculty” and the “gender match” variables in *satisfaction of community events* of the post-survey: going to a lunch

with a female faculty is correlated with a higher post-lunch satisfaction level ( $p = 0.049$ ); however, if the genders of the student and faculty match, a negative outcome in the same question was observed with a similar slope ( $p = 0.048$ ). This finding suggests that the satisfaction level of the students coming out of these lunches may be following this order (from better to worse): male students with female faculty, female students with any faculty, and male students with male faculty.

TABLE 7 Significant and near-significant contributors (all features with  $p < 0.1$ ) in the linear regression models for all Likert-scale questions.

Question	Type	Feature	Coef.	$p$ -value	Sig.
Knowledge of events	Pre	Asian	1.0563	0.006	**
		Year	1.2796	0.021	*
		Winter	0.7662	0.074	NS
	Post	Winter	0.3920	0.034	*
		Mid qtr.	0.5866	0.021	*
		Late qtr.	0.4164	0.067	NS
		Rank (Fac)	-0.4588	0.072	NS
		Female	0.3510	0.052	NS
	Improvement	Year	-1.9008	0.003	**
		Asian	-1.1611	0.012	*
		Female	0.8009	0.030	*
		Mid qtr.	1.2237	0.020	*
Satisfaction of community events	Pre	URM	-1.0841	0.006	**
	Post	URM	-0.7424	0.020	*
		Winter	0.5315	0.069	NS
		Rank (Fac)	-0.7988	0.019	*
		Gender match	-0.4984	0.048	*
		Female (Fac)	0.5702	0.049	*
	Improvement	Gender Match	-0.7219	0.062	NS
Belonging in community	Pre	Asian	0.5472	0.051	NS
	Post	Winter	0.3647	0.037	*
		Mid qtr.	0.3418	0.033	*
	Improvement	Female	-0.3608	0.093	NS
		Asian	-0.5221	0.032	*
Curriculum	Pre	URM	-0.8939	0.034	*
	Post	URM	-0.6039	0.051	NS
		Winter	0.5218	0.020	*
		Female (Fac)	-0.5717	0.015	*
	Improvement	Year	-1.0713	0.009	**
		Late qtr.	1.1752	0.002	**
		Asian	-0.7852	0.007	**
		Mid qtr.	0.8846	0.020	*
		Rank (Fac)	-0.6178	0.082	NS
Academic competence	Pre	Year	1.5353	0.004	**
		Female	-0.6355	0.042	*
		Winter	0.7225	0.075	NS
	Post	Winter	0.5480	0.031	*
		Rank (Fac)	-0.6610	0.058	NS
		Mid qtr.	0.7358	0.027	*
		Late qtr.	0.5740	0.055	NS

(Continued)

TABLE 7 (Continued)

Question	Type	Feature	Coef.	p-value	Sig.
Persistence	Pre	Year	0.8765	0.023	*
		Mid qtr.	0.7039	0.011	*
	Post	Late qtr.	0.5587	0.012	*
		Mid qtr.	0.4754	0.023	*
	Improvement	Year	−0.9277	0.005	NS
		URM	−0.4989	0.093	NS
Clarity of career goals	Improvement	Winter	−0.8683	0.017	*
		Spring	−0.6600	0.048	*
Sensitivity to DEI	Post	Female	−0.5613	0.024	*

Coef. is the coefficient/slope of the feature. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ . The feature names are included in Table 3.

The effects of the lunches conducted during different periods in an academic year also seem to be different. Regarding the time within a quarter, only the variable “mid-quarter” was associated with a significant positive outcome in *persistence* ( $p = 0.011$ ) in the pre-survey, meaning that students were most likely to see themselves graduate from our BME program during the time of the midterms without any intervention. However, the “mid-quarter” variable significantly and positively predicted multiple additional items in the post-survey, including *knowledge of events* ( $p = 0.021$ ), *belonging in community* ( $p = 0.029$ ), and *academic competence* ( $p = 0.027$ ), while the higher initial level of *persistence* was still preserved ( $p = 0.023$ ). The variable “late-quarter” in the post-survey also positively predicted multiple items in the post-survey, but is generally weaker than “mid-quarter,” including *knowledge of events* ( $p = 0.067$ ), *academic competence* ( $p = 0.055$ ), and *persistence* ( $p = 0.012$ ). These results suggest that the best time for students to participate in these organized lunches with faculty may be around midterm time, followed by around final exam time, with the lowest outcome being at the beginning of an academic term.

Different quarters within an academic year seem to affect the outcomes as well. Using the Fall quarter as the basis of comparison, students were near-significantly more knowledgeable in the events ( $p = 0.074$ ) and their *academic competence* ( $p = 0.075$ ) in the Winter quarter. However, we hypothesize that these findings may be school specific since a major undergraduate-oriented event, the BME Open House, occurs at the end of the Fall quarter, and many students need to meet with an academic advisor to update their study plan and clear their advising holds for course registration in early Winter. However, the post-survey for the Winter lunches showed higher levels of *knowledge of events* ( $p = 0.034$ ), *satisfaction of community events* ( $p = 0.069$ ), *belonging in community* ( $p = 0.037$ ), *curriculum* ( $p = 0.020$ ), and *academic competence* ( $p = 0.031$ ). Therefore, the Winter quarter seems to significantly boost the outcomes in almost all aspects of senses of belonging that we assessed. The Fall quarter is associated with better pre/post improvements in *clarity of career goals*, since both the models for Spring ( $p = 0.048$ ) and Winter ( $p = 0.017$ ) had significant negative slopes, although no significant impacts were found for Spring ( $p = 0.462$ ) and Winter (feature eliminated) for the regression models for the post-survey. Therefore, we suspect that the outcome from these lunches will be similar if they were conducted in the Fall or in the Spring.

## 4.3 Qualitative assessments

A quick sentiment analysis was performed on the post-survey free-response question about whether the student participants achieved their goals of signing up for the lunches. All but two (40 of 42, 95%) students wrote that they achieved their goals; one wrote “not completely” but indicated positive sentiment in interacting with faculty; only one participant did not achieve their goals because their field of interest in BME did not align with the specialty of the faculty.

The agreement of the two coders across all the major codes for our thematic analysis, as computed by Cohen’s Kappa, is 0.9037 for the surveys and 0.8313 for the interviews, indicating high levels of agreement (McHugh, 2012). The coding frequencies of our major codes are shown in Table 8, revealing consistent patterns of coding in the pre-survey and post-survey free-response questions. The coding frequencies of the interviews are further broken down in Table 9, and coherent coding can be seen within interviewees from the same lunch. To answer RQ4 (guidelines for the lunches), we organize our findings into two main themes: areas of interest and community building.

### 4.3.1 General areas of interest from lunch participants

Table 8 indicates that our lunch participants were most interested in talking about careers (11.21% code coverage). Students were the most curious about career options, opportunities in industry, and earning potential. Some students indicated preferred domains in BME when they posed the questions.

*I would like to obtain a better understanding of the various career paths that are available in BME.*

*To learn more about employment and ways to enter the industry after undergrad, particularly with an emphasis on prosthetics if possible.*

*What is the upper end in terms of salary and position for someone with only an undergraduate degree in the BME field?*

Many students also asked faculty for suggestions in skill development in preparation for their job search. The questions in this category included general questions about directions in skill



**TABLE 8** Coding frequency presented as the average percentage of text within the answer to that question for each subject.

Major code	Interviews	Pre: goals	Pre: Qs	Post: goals	Post: Plus
Academics	8.44%	8.15%	10.13%	1.21%	0.59%
Biomedical engineering fields	6.03%	8.67%	6.58%	2.67%	2.87%
Career	8.39%	9.20%	13.22%	2.95%	4.12%
Community building	8.55%	6.97%	0.99%	17.19%	17.94%
Engineering identity	3.46%	2.66%	1.52%	3.94%	5.08%
Perceived faculty characteristics	7.51%	2.85%	0.81%	12.10%	11.84%
Professional experience	3.47%	2.07%	5.89%	5.18%	0.52%
Research	4.17%	9.44%	10.87%	4.77%	7.06%

Each subject was assigned the same weight in the coding frequency and the percentages were averaged across two coders. Pre: means the pre-survey, which contains the Goals (goals of signing up for the lunch) and the Qs (questions for faculty) questions. Post: means the post survey, which contains the Goals (whether goals were achieved) and Plus (what went well) questions. The coding frequency of question “What did not go well in the lunch” was not presented because the respondents overwhelmingly talked about what went well during the lunches.

**TABLE 9** Coding frequency of the four interviews from [Table 8](#).

Major code	F1S1	F1S2	F2S1	F2S2
Academics	9.51%	7.72%	6.56%	9.97%
Biomedical engineering fields	3.66%	6.71%	6.10%	7.68%
Career	5.74%	4.37%	14.82%	8.62%
Community building	11.37%	13.41%	4.80%	4.61%
Engineering identity	2.83%	1.98%	3.31%	5.73%
Perceived faculty characteristics	8.09%	11.33%	2.17%	8.44%
Professional experience	2.24%	1.06%	8.23%	2.34%
Research	6.58%	3.45%	4.03%	2.64%

The four interviews consisted of two subjects (S1, S2) each from two student-faculty lunches (F1, F2).

development and specific questions in suggestions for courses and activities.

*What is [the] one step you recommend undergrads to take in preparing them for industry, whether it be a particular class, reaching out and building a strong industry network or joining a lab?*

*Where might one go or what might they do in order to find more opportunities for employment after graduation?*

Several students inquired about the motivation and necessary preparation to become professors.

*How did you find out that you wanted to be in academia, and how did you figure out your research interest?*

Research (10.16% code coverage) is an integral part of the undergraduate experience in BME, so seeing students using the lunches as potential opportunities for finding research labs was not surprising. Often, the first step in finding research labs is to learn about the faculty’s research interests.

*What are some of your current projects focused on and what [are] their significance?*

*What is your favorite part of the research that you conduct?*

After receiving information about the paired faculty, several students decided to investigate the faculty’s research interests on their own and brought specific questions related to the faculty’s research.

*(For a clinical imaging faculty) Could you explain how a tool to assist physicians with creating personalized medicine would look like from a physician’s perspective?*

*(For a cellular engineering faculty) Why were/are you interested in tissue and cellular engineering? Did you always want to study this?*

Several students, who may have been connected to the professor through previous contacts or courses with the professor, decided to use the lunch as an opportunity to ask for research opportunities. Through our follow-up with the faculty, one student received a research assistant position in the lunch faculty’s lab, and another secured a research assistant position in another lab through introduction by the lunch faculty.

*Do you have any entry level research spots open at your lab?*

We also observed students using the lunches as platforms to align their skills with faculty’s expectations for undergraduate research assistants for their own preparation to look for research labs.

*What do you look for when searching for new members to become a part of your research labs?*

*How do I make the jump from the general knowledge in class to the much more specific concepts involved in working in a lab or in a job?*

The student participants who mentioned topics related to academics (9.14% code coverage) used this chance to ask the faculty about their perceptions of the major, specializations, and courses that are beneficial for their educational development.

*Why study biomedical engineering?*

*How should we go about finding a specialization in BME?*

*What do you recommend to students who are interested in two specialties and are conflicted about their engineering electives?*

The students also took faculty as experts in maneuvering graduate school, knowing that all faculty in BME at UC Davis have a Ph.D. degree.

*Is it worth getting masters?*

*How did you know that graduate school was right for you?*

*What are the advantages/disadvantages of pursuing a master's or a Ph.D.?*

The interviewees commented on the helpfulness of the faculty on the topics brought to the lunch, as summarized by the following quote from one interviewee:

*I really just wanted to ask more about career and stuff I wasn't sure about, [which is] going [to] master's or PhD or industry. Honestly, [about] all the possibilities I wasn't sure of. But after hearing [faculty] talk, I learned more [about] just how many pathways there are when you go for those higher degrees. Also, what opportunities there are [in] industry versus academia ...*

### 4.3.2 Reducing barriers for student-faculty interaction and building community

Reaching out to faculty has been an elusive target for undergraduate students, especially for lower-division students (Hurtado et al., 2011). Most lower-division engineering coursework tends to involve general science education (chemistry, physics, math) in large classroom settings, which makes these instructors feel less approachable (Beattie and Thiele, 2016). A third-year student wrote the following in the pre-survey:

*I honestly feel so disconnected from all faculty at Davis. I've met one professor who was available enough to help me and actually learn my name. I want to interact on a more personal level with the faculty and I think that this is a great way to get that experience.*

Similar to phenomena reported by Hurtado et al. (2011), our students also signaled anxiety and sensed inaccessibility from faculty, especially knowing that faculty were performing research and being evaluated in their research. This sentiment was well reflected in one post-survey response to what went well in the lunches:

*Being able to ask questions I'm scared to ask.*

Hurtado et al. (2011) also found that when students know that faculty are busy at research, students are less likely to be engaged with the faculty. When asked about the general perception of interacting with faculty, our second-year interviewees noted the following sentiments:

*Before this lunch, my view from the faculty was that they're very focused on their own work, and they might be very reserved, and well are not friendly.*

*And I don't mean to impede on them or I don't mean to like almost insult them in a kind of way, like I do when I like say, hey, like I respect the time that you put into the cause.*

The lunches, however, provided an opportunity to see faculty as humans instead of experts in their fields of research. The differences in the coding frequencies between the pre-survey and the post-survey demonstrated this point. In the post-survey, many students chose to

write positively about the community-building aspects of the lunch (17.57% code coverage).

*I enjoyed the lunch and getting to speak to the professor.*

*It was nice to get to know [the] faculty better.*

*I [feel] as though I have a better sense of community from the meeting.*

*Everyone was very welcoming and was so nice.*

*It was better than I could imagine.*

The students wrote about the rarity of having such out-of-class events and the benefit of interacting with faculty without the baggage of being evaluated in an academic context:

*I was able to interact with faculty, and personally, I haven't had the opportunity to do so in a more informal setting.*

*This relieved me of ties to academic endeavors (i.e. asking professors for information about their labs or classes they conduct).*

*I think when it came to talking about faculty, it was really nice to first of all meet [faculty], but it was also very like, interesting, right? Like, oftentimes you don't get that opportunity to sit down with a professor and have those kinds of one-on-one conversations...*

Many students commented on their appreciation for the organization of the lunches, first about the presence of the student assistant for their facilitation and friendliness:

*The other students, especially [student assistant], [were] very nice and welcoming.*

*I think the conversation went well and the questions were [led] when needed.*

The students also appreciated the small group setting that involves both peers and professors, which helped with building a sense of community while providing the potential additional benefit of mentoring from the more senior peers from the group.

*Everything went perfectly fine, including conversations and interactions with peers and professors.*

*I think the lunch went really well in that sense, but I also gained an additional benefit when talking with the other students who took part [in] the lunch. I got to know more about their life at UC Davis, and what they've been doing in BME.*

*I really enjoyed getting to know [faculty], [student assistant] and [student participant], and it was great because I feel like we are all at different points in our life. [We] had a freshman, [a] sophomore, a junior, and then we had a professor.*

The students also commented on how personable, helpful, and/or insightful faculty were (11.97% code coverage in post-survey). Several students commented that they could finally see faculty as human, instead of an inapproachable higher-up figure.

*[Faculty] was very engaging and helpful.*

*But he was also very friendly and made small talk, that it seemed like I wasn't talking to a professor or someone who was higher up than me. It seemed like I was talking to more like a friend.*

*They are definitely, really informative [and] helpful. I think just having that time with the professor to learn more about them is really helpful.*

Apart from the interactions during the lunch, the lunch seems to have encouraged one interviewee to continue engaging with the faculty after the lunch.

*I went to a few office hours afterwards once I understood [that] he was always very open and friendly, but I was just more inclined to go and ask him for feedback about the Journal Club presentation. So, I felt a little bit more inclined to go and receive feedback from him directly and I think it really enhanced the end results of our project.*

## 5 Discussion

In these organized small-group student-faculty lunches, we discovered a cost-effective and highly translatable way of promoting informal student-faculty interaction, which in turn boosted students' sense of belonging in areas of academic, social, and personal space based [Ahn and Davis \(2020\)](#) belonging framework, with benefits in domains of social and personal space being stronger and more long-lasting than the effects on academic belonging. The 12 lunches conducted thus far have benefited 44 students in total; we plan to conduct more of these lunches both within and outside of our department to promote sense of belonging in the community of our university.

These lunches are organized yet still highly flexible; students can discuss almost any topic that they would like to bring up to the faculty, although in our case the most popular topics were careers, research, and academic opportunities in BME. The regression analyses revealed that career-oriented lunches tend to benefit all students almost equally; however, for lunches oriented around academics, particularly those around course selection and specializations, having primarily lower-division students can be more impactful. Our current survey did not include a question about undergraduate research; we plan to add this question in the future to investigate the best practices for lunches oriented around undergraduate research.

The regression analyses revealed that our intervention brought more parity in sense of belonging to students of different class standings, ethnic identities, and gender identities. However, we were not able to completely neutralize pre-existing levels of lower satisfaction and clarity in their academic plans of the URM student participants. Although our sample representation of URM participants aligns with the demographics of our department (approximately 15%), we plan to enroll more URM participants and interview these participants to obtain a better understanding of their challenges in these aspects.

The quantitative and qualitative analyses from our surveys and interviews revealed several best practices for implementing these student-faculty lunches. Our qualitative analyses reaffirmed the necessity of our matching process for ensuring maximum benefit to

the students – that the interests of students and faculty must align, especially if the students and faculty do not know each other, which is the case for lunches involving lower-division students. The student assistants present at the lunches were also beneficial to the participants by providing moderation when needed and ensuring a respectful flow of the conversation. The small group setting was also positively mentioned by the student participants. We hypothesize that having peers at the lunch, especially an experienced student assistant that is comfortable with interacting with the faculty, is beneficial in helping reduce anxiety in interacting with the faculty. Multiple participants commented on the benefits of having a mix of lower-division and upper-division students to achieve peer mentoring in these lunches; therefore, we recommend that a student assistant be included in these lunches and that the assistant be an upper-division student familiar with departmental faculty.

Timing seems to affect the outcomes from the lunches as well. The Winter quarter seems to be the most beneficial time to perform these lunches, as the lunches conducted in that quarter showed significant benefits in multiple domains in sense of belonging. The UC Davis quarter system only has 1 week of break between the Winter and Spring quarters, so the beginning of the Spring quarter often seems like a continuation toward the 12th week of the semester. Based on a study at Stanford University ([Goldring, 2012](#)), which found significantly higher stress levels for students in the Spring quarter compared to the national average level, we hypothesize that stress and burnout from these extended study periods may negatively affect the outcomes in the Spring lunches. The lower outcomes from the Fall lunches warrant further qualitative study by interviewing our future participants, but we suspect that a long layoff period of school during the summer break may be a potential contributor. We also found mid-quarter to be the best time to perform these lunches, followed by late in the quarter and early in the quarter. The same Stanford study ([Goldring, 2012](#)) found higher depression levels among students around the middle of the quarter; we hypothesize that breaking down the barrier of student-faculty communication around this time may be the most beneficial way to minimize academic stressors. Toward the end of the quarter, a heavy academic workload, including final projects and exams, can contribute to higher stress levels in students ([Barker et al., 2018](#)), potentially negatively impacting the outcome of these lunches. We intend to verify these findings through the lunches carried out in the near future.

The timing guidelines we developed are most suitable for universities in the U.S. using a quarter system. Therefore, some of our findings may not be directly translatable to semester-based schools. Although, the beginning of the Winter quarter at UC Davis corresponds to the start time of the second semester in most U.S. semester-based universities; we believe that for semester-based schools to adopt our approach, these student-faculty lunches may be the most effective during the second semester in an academic year, carried out in the middle of a semester. We are actively collaborating with BME/bioengineering programs to develop a protocol to translate and assess these student-faculty lunches in semester-based schools.

Our findings on faculty characteristics were interesting. We first observed a negative effect on the outcomes from lunches with higher faculty ranks. We think that two factors may have played a role. As discussed by [Hurtado et al. \(2011\)](#), students tend to be less likely to interact with faculty if they think that the faculty has more important

tasks, such as research, to do. Students have been proven to be quite capable to guess faculty ranks (Woodman, 1980), so they may recognize that higher professor ranks are typically associated with greater academic achievements and become less inclined to comfortably interact with faculty. Another factor may be the perceived age of the faculty by the students. Our interviewees, who had lunches with assistant professors, heavily commented on how young they thought the faculty were; therefore, students may have assigned the faculty to be “within their generation” or “outside their generation” based on the perceived age of the faculty. One aspect that needs additional investigation is the significant negative impact on the satisfaction level when the students and the faculty are of the same gender, which we will study further using qualitative analysis to determine whether the effect is real or due to a statistical blip.

Although these lunches have been proven to greatly benefit our students, we would like to comment on the opportunity costs of these lunches to the faculty. Our lunches heavily recruited from women faculty (5/12 lunches), a group that participates in more service activities across the U.S., and assistant professors (6/12 lunches), who tend to perform less service (Guarino and Borden, 2017) but are in the early stages of establishing their academic career. At UC Davis, informal activities such as participating in these student-faculty lunches can count as academic service toward their merit and promotion packages; outstanding service can be awarded with additional financial incentives during the review periods. Some faculty regarded these informal student-faculty interactions as a needed break from their daily routine by saying the following:

*I'd rather talk to a student rather than sit in front of my computer and respond to my endless emails.*

However, if the school or department does not have these academic support initiatives in place, justifying faculty participation, especially the time cost, would be significantly more difficult (Hurtado et al., 2011). We have recently developed a separate interview protocol to gain the faculty's perspective on these lunches and will deploy them in our next lunch.

We would like to highlight one aspect of the matching process; since our student-faculty lunches are designed to be small-group informal interactions, a round of randomized selection was involved in selecting the students who would be having lunch with our faculty participant. This degree of randomization helps break down the homophily barrier commonly reported in academic mentor-mentee relationships (Cole and Griffin, 2013) and in our case, strongly discourages students using these lunches as auditions for research placements. Although, three student participants asked about potentially joining the faculty guest's lab. Since all three asked at the end of the lunch and no immediate acceptance was given, the flow of the conversation was still genuine and relatively unimpacted. Our student assistants participating in these lunches received directives that they should consider changing topics when the conversation becomes too centered on one student. The recruitment of assistant professors is a strategic choice, since many of our new assistant professors were looking for undergraduate research assistants to help them set up their lab. Both the new assistant professors and the students tended to use this opportunity as a chance to familiarize themselves with the mode of interaction between the student/faculty counterparts; these lunches can be beneficial to these assistant

professors by providing an extra data point in calibrating their expectations and interactions with their future undergraduate research assistants.

A scene of students and faculty sitting in a room and having lunch or coffee is not new; for example, our own department has a separate branch that organizes student-faculty luncheons centered around women's challenges in BME (Alfonso-Garcia et al., 2024) and graduate student-faculty lunches. However, this type of informal undergraduate student-faculty interactions are considered rare (Kuh and Hu, 2001), and the benefits associated with these lunches have never been reported outside of our group. The authors hereby recommend all potential adopters of the student-faculty lunches to narrow the guidelines developed in this paper to undergraduate student-faculty lunches; we project the best practices for graduate-level, or lab-level student-faculty lunches to be very different based on the characteristics of the student population, especially students' identity and motivation toward their academic programs.

Our implementation is not without its limitations. Our current analysis, which includes 42 students in BME, did not have enough representation of non-binary students at these lunches for a meaningful regression analysis. We also did not collect certain demographic data until the 10<sup>th</sup> lunch, resulting in insufficient data for the first-gen, low-income, international, and ESL variables. Our interviews did not commence until the 11<sup>th</sup> lunch; we would like to perform more interviews, especially with students possessing at-risk indicators of belonging (Doran and Swenson, 2022), for a better qualitative understanding of the inclusiveness and equitability of these lunches. We also aim to use these interviews to guide us in developing the next iteration of quantitative survey questions to better assess the sense of belonging in BME students. Additionally, all participants were from a single department from an R1 quarter-based university, so we recommend caution in other departments or universities to account for their departmental culture and student/faculty demographics if our interventions were to be adopted.

## 6 Conclusion

The organized small-group student-faculty lunches are a low-cost and highly translatable way to promote a sense of belonging in BME undergraduate students. With their lasting effectiveness and equitable outcomes, these lunches can become signature events for community building within academic departments.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by University of California, Davis Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from



the participants or the participants' legal guardians/next of kin because study is considered minimal risk, and informed consent is presented electronically with a clickwrap agreement as well as verbally.

## Author contributions

TC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. AT: Data curation, Formal analysis, Investigation, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. XW: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2025.1510872/full#supplementary-material>

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