Investigating Undergraduate Student Perceptions of Classroom Inclusion—Emergence of the Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework

Mallory M. Rice,[†#] Lorenzo Lones,[‡*#] Lucy M. C. Luong,[§#] Maurina L. Aranda,[‖] Katherine M. Farrar,[¶] and Kimberly D. Tanner[§]

[†]Department of Biological Sciences, California State University San Marcos, San Marcos, CA 92096; [‡]Department of Molecular and Cell Biology, University of California, Berkeley, Berkeley, California 94720; [§]Department of Biology, San Francisco State University, San Francisco, CA 94132; [‖]Department of Biological Sciences, Southern Illinois University Edwardsville, Edwardsville, IL 62026; [¶]Teaching and Learning Lab, Harvard Graduate School Of Education, Cambridge, MA 02138

ABSTRACT

While assertions are common about what fosters inclusive undergraduate STEM classrooms, few studies have systematically investigated student perspectives. Additionally, it is unclear how students broadly perceive active learning practices in relation to inclusion. As such, we purposefully investigated student perceptions of classroom inclusion across courses in a biology department enriched with evidence-based teaching and situated in an urban, public institution. Student perceptions were investigated using open-ended prompts on a department-wide, end-of-term assessment. Results revealed that students, across social identities, do indeed report active learning strategies—as well as instructor interactions and collaborative classroom culture—as fostering inclusion. Student reports about instructor practices associated with their inclusion or exclusion clustered into four mirrored categories: *Building/Dismantling the Instructor/Student Relationship, Making/Compromising Student-Centered Pedagogical Choices, Establishing Collaborative/Non-Collaborative Classroom Culture,* and *Portraying Science as Inclusive/Exclusive*. These categories comprise a new analytical framework, the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*, for investigating student perspectives on inclusion. Intriguingly, student reports about inclusion consistently alluded to instructor language, and the emergent *SPIP-I/E Framework* aligns with existing Instructor Talk frameworks. We hypothesize that modest differences in instructor language—surrounding any teaching strategy—may mediate and be a predictive, explanatory variable for student perceptions of inclusion.

INTRODUCTION

In attempts to address high attrition rates in undergraduate STEM education and promote student success, there has been increased focus on the role of creating inclusive classrooms that attend to affective aspects of learning. Researchers and instructors endorse students' sense of inclusion in undergraduate classrooms as likely key to undergraduate biology and STEM education reform. Yet, what specifically constitutes classroom inclusion has been elusive and is variably associated with a

Elisabeth Schussler, *Monitoring Editor*

Submitted Jun 30, 2025; Revised Jun 9, 2026; Accepted Jun 16, 2026

CBE Life Sci Educ September 1, 2026 25:ar30

DOI:10.1187/cbe.25-06-0124

[#]These authors contributed equally to this work and should be considered co–first authors.

Author contributions: Conception and Design: Katherine M. Farrar and Kimberly D. Tanner. Data Collection: Maurina L. Aranda, Katherine M. Farrar, and Kimberly D. Tanner. Data Analysis: Mallory M. Rice, Lorenzo Lones, Lucy M. C. Luong, Maurina L. Aranda, and Kimberly D. Tanner. Drafting & Revising: Mallory M. Rice, Lorenzo Lones, Lucy M. C. Luong, Maurina L. Aranda, Katherine M. Farrar, and Kimberly D. Tanner.

Conflict of interest: The authors declare no competing financial interest.

*Address correspondence to: Lorenzo Lones (llones@berkeley.edu).

wide range of interrelated factors that are challenging to measure, including sense of belonging, science identity, and self-efficacy (Trujillo and Tanner, 2014; Dewsbury, 2017; Dewsbury and Brame, 2019). Importantly, these aspects of students' affective experiences of undergraduate STEM classrooms are likely strongly influenced by instructors' pedagogical decisions, including the use of active learning and other classroom strategies, as well as the resulting instructor and student relations and the overall classroom climate. Further, much of what has been asserted about inclusive teaching has been largely defined by instructors and researchers at specific institution types, without systematic investigation of student perceptions of classroom inclusion, especially from diverse populations of undergraduate students at broad access institutions.

While research related to classroom inclusion among undergraduates is connected to a myriad of scholarly fields, there have been multiple recent studies in undergraduate biology and STEM education research that contribute knowledge about classroom inclusion and that also reveal gaps in the literature. For example, recent studies that investigate undergraduate STEM student perceptions about inclusive teaching and classroom climate employed methodologies that appear to center researcher perspectives on undergraduate STEM classroom inclusion and rely on researcher-centered framing in assessment tools and data collection approaches (e.g., Jantzer *et al.*, 2021; Valdez and Kelp, 2023). Additionally, some studies were specifically designed to center student perspectives on undergraduate STEM classroom inclusion, using open-ended assessment methodologies and eliciting student language and reflections on classroom inclusion; however, these studies have been primarily conducted in the context of Research-1 institutions and with student populations that appear to be majority White and continuing-generation college-going, with some of these studies conducted during the COVID-19 pandemic (Bustamante *et al.*, 2024; Walker *et al.*, 2024; York *et al.*, 2024). Further, there are research findings that have emerged from studies of adjacent undergraduate student experiences (e.g., student anxiety) that may contribute important insights into student perspectives of undergraduate classroom inclusion (Schussler *et al.*, 2021). Below, we explore findings from each of these types of studies and clarify gaps in the literature about undergraduate student perspectives of classroom inclusion in biology courses that are yet to be addressed.

There has been increasing interest in understanding student perspectives on STEM instruction that has prompted a variety of studies, some of which have included probes related to students' sense of belonging or inclusion. Such studies are important as they often attempt to gather insights across broad student populations; however, as a result, these studies often employ closed-ended research methodologies that inadvertently center researcher perspectives, especially in the design of data collection tools. For example, one study aimed at understanding student perspectives within an introductory biology course at a small liberal arts institution probed a variety of student perspectives, not just classroom inclusion, across hundreds of students (Jantzer *et al.*, 2021). Studies like this can be pivotal for inspiring local reform efforts and supporting departments in developing regular program assessment methods and efforts. However, the study—and often other efforts with similar goals—employed a locally developed survey composed of closed-ended questions written by the researchers or adapted from published surveys by other researchers. It is unclear if the student's interpretation of question language was evaluated during development of the survey tools, such as through think-aloud interviews or other methods for optimizing the face validity of assessment questions. Moreover, it is unclear what student perspectives on biology course experiences may have been missed without using open-ended methodologies that could allow students to share perspectives not specifically prompted by researchers. Another recent study aimed to investigate undergraduate students' perspectives about STEM instructor practices across an institution, specifically with respect to inclusive teaching and other practices related to diversity, equity, and inclusion (Valdez and Kelp, 2023). Again, such studies can be key in locally impacting undergraduate STEM education reform efforts in positive ways. The research methodologies of the study, however, again appear to limit what students are able to express about their perceptions of inclusion in STEM courses. A strength of this study was its attention to the face validity of the assessment questions and the connection of the data collection questions to specific concepts. Yet, the specificity of the closed-ended methodological approach was also a weakness, as the researchers focused on a particular set of inclusive pedagogies and diversity, equity, and inclusion-related practices that may or may not have been most salient for that student population at that time. These studies represent important efforts to examine undergraduate students' perceptions. Yet, they are not unusual in their reliance on closed-ended assessment methodologies that may unintentionally center researcher perspectives and limit student expression of perspectives not anticipated by researchers. It remains unclear what additional insights could have emerged if students had been allowed to articulate their experiences and perspectives without the constraints of pre-determined categories and closed-ended prompts. As such, more research is needed that centers on student perspectives and broadens opportunities for students to share unexpected experiences and insights with researchers through the use of more open-ended data collection methodologies.

Additionally, more recent studies of student perspectives about undergraduate STEM inclusion have addressed these limitations of closed-ended methodological approaches and designed data collection approaches that allow students to more broadly share their perspectives. Specifically, multiple studies have used open-ended methodologies to intentionally center student voices to examine perceptions of inclusion in STEM classrooms, including in physics (Bustamante *et al.*, 2024), chemistry (Walker *et al.*, 2024), and across introductory STEM courses (York *et al.*, 2024). In the largest of these studies (York *et al.*, 2024), undergraduate students enrolled in introductory Biology, Chemistry, and Physics courses responded to an open-ended prompt asking them to share how inclusive they felt their course was and why. Analysis showed that the vast majority of student responses most frequently cited instructor teaching practices, student-instructor interactions, course structure, and course policies, which the researchers coded as "Academic" (York *et al.*, 2024). When

further subdivided into subcategories of "Academic," the highest proportion of student responses related to "Student-Instructor Interactions," which appeared to reference in-class instructor facilitation approaches. This was closely followed by a subcategory of "Course Structure," which appeared to include teaching strategies, as well as course design and policies. The extent to which instructors for these courses had been trained to use evidence-based or inclusive teaching strategies was unclear. While a strength of these studies was their use of open-ended data collection methodologies, it is also notable that all these studies appear to have been conducted in the context of Research-1 institutions. Further, the undergraduate student populations in each of these study contexts appeared to be majority White and continuing-generation college-going, which was noted by authors in the *Limitations* sections of the publications. Additionally, some of the studies were conducted during the COVID-19 pandemic, which may have captured student perspectives with limited relevance to non-COVID-19 era classrooms (Bustamante *et al.*, 2024; Walker *et al.*, 2024). Given evidence across a variety of disciplines that students' perceptions and experiences are often shaped by personal identity as well as surrounding context, it is unclear how representative these findings would be beyond Research-1 institutions. As such, there is a gap in the literature about perspectives of undergraduate biology and STEM classroom inclusion from students who are more racially diverse, who are more likely to be first-generation college-going, and who are attending broad-access institutions without institutional cultures that may differ from those at research-focused universities.

Finally, there are findings from the biology education research literature that suggest types of instructor behaviors that may influence students' classroom experiences, discovered in studies not focused on inclusion per se, but rather in studies about adjacent constructs and student experiences. As one example, Schussler and colleagues aimed to understand how student anxiety may be related to student perceptions of instructor supportiveness in introductory biology courses (Schussler *et al.*, 2021). While the study used multiple assessment approaches, it importantly included open-ended opportunities for students themselves to evaluate their instructor's supportiveness and explain their reasoning for their evaluation. Interestingly, the most prevalent categories of student reports about instructor supportiveness—reported by over half of students in each category—related to instructor behaviors that were either "relational" or "pedagogical." The "relational" instructor behaviors that were reported by students as supportive included positive communications with students, exhibitions of care for students, and general helpfulness toward student success. The "pedagogical' instructor behaviors that were reported as supportive by students included specific teaching practices, effectiveness in answering questions, and care that students were learning. Interestingly, the authors note that active learning practices were rarely mentioned by students in the "pedagogical" category evidence, and one wonders the extent to which active learning practices were being used by instructors in these courses. Importantly, even though this study was not explicitly focused on students' perceptions of undergraduate biology classroom inclusion, its findings make clear that students perceive, remember, and report specific instructor behaviors and practices as supportive and potentially anxiety-reducing. While these findings are intriguing, there continues to be a gap in the literature about how students themselves would frame instructor behaviors related to their own sense of classroom inclusion or exclusion more broadly, not just in the context of anxiety. Further, there is a persistent gap in centering the voices of students from diverse backgrounds at colleges and universities that are not Research-1 institutional contexts in both this study and the other studies described above.

Given the current state of knowledge about students' perceptions of inclusion in undergraduate biology courses, more research is needed to address gaps in the literature and specifically investigate how demographically diverse populations of undergraduate biology students at broad-access, public institutions frame and perceive classroom inclusion and exclusion. While there are multiple recent studies of undergraduate STEM classroom inclusion, these studies have often centered on researcher and instructor perspectives about classroom inclusion, have primarily been conducted in the context of Research-1 institutions, and appear to have been situated among student populations that are primarily White and continuing-generation college-going. Additionally, while student experiences in undergraduate classrooms are no doubt influenced by their unique personal background and prior educational experiences, instructor decisions and pedagogical practices are also likely key to understanding student classroom experiences. For example, while active learning is an instructor practice often asserted as promoting student inclusion, it remains unclear whether students themselves perceive such strategies as making them feel included in the classroom. Further, it is unclear whether undergraduate STEM students in previous studies about classroom inclusion had opportunities to experience a wide range of evidence-based pedagogical strategies.

As such, we designed an investigation of student perceptions of instructor practices that promote inclusion or exclusion in the context of undergraduate biology courses across an entire department at a large, diverse, broad access, public, minority-serving, Master of Science-granting state university. The departmental context of the study is of particular interest because it has been previously shown to be enriched in instructor use of evidence-based teaching practices, increasing the likelihood that students may have experienced a range of instructor practices—active learning and other teaching practices—that students could evaluate as inclusive or exclusive in biology courses (Owens *et al.*, 2018). To investigate undergraduate students' perceptions of classroom inclusion and exclusion in biology courses, we addressed the following research questions: 1) What do undergraduate students report their instructor doing that causes them to feel included in their biology course? 2) What do undergraduate students report their instructor doing that causes them to feel excluded in their biology course? 3) To what extent do student perceptions of instructor practices vary by student demographic characteristics?

METHODS

This study aimed to evaluate student perceptions of instructor practices that are associated with student feelings of

inclusion or exclusion in biology courses. This study was approved by the Institutional Review Board at San Francisco State University (#X16-28R2). Below, we describe the context of the institution and biology department, study participants, the department-wide data collection to assess student perceptions of biology courses, and data analyses.

Context of the Institution and the Biology Department

This study took place at a public, Minority-Serving (MSI), Hispanic-Serving (HSI), and Asian American and Native American Pacific Islander-Serving (AANAPISI) institution on the West Coast in Spring 2018. At the time of study, the undergraduate student body was composed of 52% first-generation college students, 56% female, 44% Pell-grant recipients, and 81% students of color (Black or African American, American Indian or Alaskan Native, Asian, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, or two or more races). In this study, participants were enrolled in both majors and non-majors courses offered by the biology department.

Nearly 85% of instructors in the department context for the study have engaged in extensive professional development in scientific teaching (Owens *et al.*, 2018), and this study context was purposefully chosen as it provides a unique context to evaluate student perceptions of biology courses. The context of the biology department is described in detail in Supplemental Material. As most of the instructors in the department of study had received training on inclusive, evidence-based teaching practices, we wanted to leverage this unique departmental context to investigate students' perceptions of instructor practices.

Study Participants

A total of 3425 undergraduate students enrolled in a biology course in Spring 2018 were invited to participate in the department-wide assessment. To investigate student perceptions, we asked all instructors teaching a course in the biology department for their permission to assess student perceptions and experiences in their classrooms. After receiving permission from their biology instructor, 3425 undergraduate students were invited to participate in each biology course they were enrolled in during that semester. From this population, 1173 student responses from 53 majors and non-majors biology courses were recorded. Students who completed the assessment were entered into a raffle for prizes.

Data Collection

Assessing Student Perceptions of Instructor Practices Associated with Feelings of Inclusion or Exclusion in Biology Courses. To investigate instructor practices that might foster inclusion or exclusion in biology courses, we invited undergraduate students to write about what their instructor(s) in the course did to make them feel included or excluded. Students were invited to share up to three open-ended responses for both the inclusion prompt and exclusion prompt, which were as follows:

> "What, if anything, does the instructor for this course do that helps you to feel INCLUDED? Please respond in complete sentences."

> "What, if anything, does the instructor for this course do that causes you to feel EXCLUDED? Please respond in complete sentences."

To check the clarity and face validity of these two open-ended prompts, we conducted a series of think-aloud discussions with undergraduate students from a range of backgrounds before data collection. The wording of the prompts appeared clear to students, and the inclusion of the phrase "if anything" in both prompts appeared to be interpreted by all students as meaning that "nothing" was a possible answer in each case.

These two open-ended questions were implemented as part of an annual department-wide survey, previously developed to assess students' experiences of teaching strategies in their biology courses within the department of study (Owens *et al.*, 2018). The department-wide survey was sent to students during the last few weeks of the Spring 2018 semester, which ensured that their experiences in the biology course were recent. While the department-wide survey asked students to respond to a variety of prompts, the two open-ended questions about instructor practices that students considered inclusive or exclusive appeared near the end of the survey, just before students were invited to self-identify their gender, first-generation college status, race and ethnicity, and transfer student status. Perhaps due to its placement towards the end of the survey, fewer students completed the open-ended questions than the closed-ended questions in the earlier sections of the survey. Although fewer students responded to the open-ended questions, the demographic composition of those who did respond reflected the diversity of the institution and the overall participant pool (refer to Table 1).

Exclusion Criteria for Collected Student Data. Some student responses were excluded from the analysis under the following conditions: (1) the response was incomplete, (2) the same student submitted multiple assessments for the same course, in which case only the most recent response was used, (3) the instructor did not complete the corresponding assessment for their course, which was required for student data to be included, (4) the instructor did not grant permission for us to contact their students, or (5) the student's enrollment in the course could not be verified by the university. A survey response was considered incomplete if the student did not identify the specific course they were evaluating, did not indicate whether it was a lecture course, or did not answer the first question, which asked about their professional identity. Additionally, as a reminder, all instructors teaching a course in the department were asked for permission to distribute the department-wide assessment to their students. If an instructor chose not to participate, their students' responses were excluded from the data analysis.

Data Analysis

We used a multi-prong approach to qualitatively and quantitatively evaluate student perceptions of instructor practices associated with feelings of inclusion or exclusion and statistically analyze student perceptions of instructor practices across demographics. We describe these approaches in detail below. All data analyses and figure production were done in

TABLE 1. Self-identified demographics of students who completed the entire demographics form (gender, race/ethnicity, first-generation college-going status, and transfer student status) who responded to the department-wide survey, the inclusion prompt, and the exclusion prompt. Please note that not all students completed all demographic questions. So, sample sizes may vary across categories, not reflecting the total in the column header

Demographic categories	Percent students who responded to departmental survey ($n = 593$)	Percent students who responded to INCLUSION prompt ($n = 375$)	Percent students who responded to EXCLUSION prompt ($n = 183$)
Women or gender non-conforming	61.7% (366)	69.8% (256)	71.1% (128)
Men	22.8% (135)	26.2% (96)	24.4% (44)
Decline to state	15.5% (92)	4.1% (15)	4.4% (8)
People of Color	69.3% (411)	76.9% (283)	77.2% (139)
Non-people of Color	17.4% (103)	20.7% (76)	19.4% (35)
Decline to state	13.3% (16)	2.4% (9)	3.3% (6)
First-generation college student	46.5% (276)	53.3% (196)	55.3% (99)
Continuing-generation college student	43.0% (255)	46.7% (172)	44.7% (80)
Transfer student	29.7% (176)	34.2% (126)	31.8% (57)
Non-transfer student	59.5% (353)	65.8% (242)	68.2% (122)

Notes: Responses that were left blank were removed from the dataset and not included for the above calculations. Women or gender non-conforming includes individuals who identified as a woman, trans woman, non-binary, gender queer, or gender non-conforming. Men includes individuals who identified as a man or trans man. People of color (POC) includes individuals who identified as African American/Black, Asian, Filipino/Pacific Islander, Native American, Latino/Chicano/Hispanic, Samoan, Middle Eastern, and individuals who included any of these identities.

R (R Development Core Team, 2017) using the *ggplot* and *ggtheme* packages (Wickham and Wickham, 2009; Arnold, 2017).

We assessed undergraduate student perceptions of instructor practices they associated with feelings of inclusion and exclusion in biology courses using qualitative analysis of student writing. Below, we describe our approach to qualitatively code student responses, which led to the emergence of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*, the quantitative summary of student responses across categories of this framework, and the statistical analyses of student responses across demographics.

Emergence of the Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework. To evaluate which instructor practices students perceived as making them feel included, we began our qualitative analyses with an inductive coding approach, seeking common themes offered by students. However, the emerging categories using this coding approach were unsatisfyingly broad and general, resulting in few insights beyond the need for instructors to be kind and to use teaching approaches beyond lecture. As such, we attempted a second inductive analysis approach with additional colleagues reviewing the evidence in search of more specific and insightful coding categories. What emerged to our surprise was that our second set of inductive categories was similar in kind to some of the categories that had emerged in the previous development of published Instructor Talk frameworks from our laboratory. This was interesting because the data for the current study were based on students' written perceptions of instructor practices that made them feel included or excluded, whereas the data used to develop the Instructor Talk frameworks were squarely grounded in analyses of recorded classroom language used by instructors. Thus, we proceeded with the second inductive process, but the names of these codes were aligned with the names of relevant Instructor Talk categories.

Two coders (M.M.R. and K.D.T.) coded a 10% sample of student responses into proposed categories and discussed discrepancies to reach consensus. After several rounds of this process, we evaluated the clarity of the categories by coding a random 10% sample of the students' open-ended responses and calculated interrater reliability. At the category level, the two coders (M.M.R and K.D.T.) were in 85% agreement for the inclusion categories. Given the high interrater reliability, one coder (M.M.R.) finished classifying the remaining student responses into inclusion categories.

To assess which instructor practices students perceived as fostering exclusion in biology courses, students were invited to share up to three open-ended responses about what the instructor of their course did to make them feel excluded. These open-ended responses were coded using the same methods as the included open-ended responses, described in detail above. At the category level, the two coders (M.M.R and K.D.T.) were in 85% agreement for the exclusion categories.

Quantifying Student Perceptions of Instructor Practices Associated with Student Feelings of Inclusion or Exclusion in Biology Courses. We analyzed student perceptions of inclusion in biology courses by quantifying the proportion of students who shared one or more instructor practices that were associated with student feelings of inclusion in each category of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*. We analyzed student perceptions of exclusion in biology courses using the same methods for the included open-ended responses. This approach allowed us to consider the proportion of students who perceived instructor practices as inclusive or exclusive by category.

Disaggregating Perceptions of Inclusion or Exclusion for Students from Marginalized Populations and Their Peers. To evaluate how student perceptions of inclusion or exclusion may have varied between students from marginalized groups

and their peers, we applied the following two criteria: (1) students had to complete the entire demographics form, and (2) students had to report at least one inclusive or one exclusive practice. We then calculated the proportion of students across self-identified demographic characteristics that shared one or more instructor practices associated with feelings of inclusion or exclusion in their biology courses. We disaggregated student data by self-identified gender, first-generation college status, transfer student status, and persons of color (i.e., non-white students). For comparisons across gender, we disaggregated data by gender, where women and gender nonconforming consisted of individuals who self-identified as cis women, trans women, nonbinary, and gender queer, and men consisted of individuals who self-identified as cis men and trans men. For comparisons across race and ethnicity, we disaggregated data by students of color, which consisted of individuals who self-identified as African American/Black, Asian, Filipinx/Pacific Islander, Latinx/Chicanx/Hispanic, Middle Eastern, Native American, and persons of mixed race who included any of these designations. Statistical comparisons were conducted using Pearson chi-square tests with Bonferroni corrections for multiple comparisons (level of significance was 0.0125 due to four multiple comparisons). The four pairwise comparisons included: (1) women and gender non-conforming versus men, (2) first-generation college versus continuing-generation, (3) students of color versus non-students of color (i.e., white students), and (4) transfer students versus non-transfer students.

RESULTS

Below, we detail the study participant demographics, describe the mirrored categories that emerged for the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*, provide a quantitative summary and example student responses for each category, and explore how student perceptions varied across self-identified demographics.

Study Participant Demographics

A total of 1173 undergraduate students enrolled in biology courses during the Spring 2018 semester participated in the department-wide assessment (34% response rate, n = 1173/3425 students). After applying the exclusion criteria (refer to *Methods* section), 593 students remained in the overall department-wide dataset (refer to Table 1 for participant demographics). As a reminder, the open-ended questions about students' perceptions of instructor practices that foster feelings of inclusion and exclusion in biology courses appeared later in the survey. Consequently, only a subset of participants from that larger dataset completed these questions. Specifically, 375 students provided responses about inclusive practices, and 183 students provided responses about exclusive practices. Despite the smaller sample sizes, the demographic composition of students who responded to the open-ended questions closely mirrors the demographics of the full data set (refer to Table 1) and the institution's overall demographics at the time of the study (refer to *Methods* section). The consistency of the demographic makeup suggests that the results, even with the reduced sample size, remain reflective of the broader student population.

Emergence of the Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework—INCLUSION categories

In response to a department-wide assessment, students shared up to three responses of instructor practices that they perceived as promoting feelings of inclusion. Most students shared that their instructors engaged in instructor practices that made them feel included (97% of students, n = 362/375).

From student responses, four inclusion categories of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* emerged that captured instructor practices that students associated with feelings of inclusion in biology courses (Table 2; Figure 1). In these analyses, 375 students shared 704 responses that were coded into either a single category (616 responses) or two categories (88 responses) of the *SPIP-I/E Framework* or "Nothing was Inclusive" (refer to Figure 1). Only 3% of students (n = 11/375) shared a single response that their instructor did nothing inclusive, and less than 1% of students (n = 2/375) shared a single response that appeared better aligned with a category in the exclusion part of the framework. Below, we detail the four *SPIP-I/E Framework* inclusion categories and provide a quantitative summary and student example responses of each category.

Building the Instructor/Student Relationship

Many students shared instructor practices associated with feelings of inclusion that we classified as "Building the Instructor/Student Relationship." In total, over half of students (52%, n = 197/375) shared responses that were classified within this category (Figure 1). Student responses from this category included instructors learning about students as individuals (e.g., learning names), encouraging student questions, accommodating students' schedules (e.g., flexibility with office hours and deadlines), being a supportive and collegial instructor, and sharing personal experiences with students. We chose to put instructors knowing student names in this category because names are affiliated with individual students. Further, we included responses where instructors welcomed, encouraged, and responded to questions from individual students in this category, as this promotes an individualized relationship between the instructor and the student. Below are examples of student responses (Table 3):

> "The professor welcomes everyone to ask questions about course content, homework, exams etc. and answers to the best of his ability with respect and kindness." – student

> "My instructor was very mindful and nonjudgmental with how he discussed human sexuality in class and how he spoke about sexual orientation, sex, gender identity etc." – student

Establishing Collaborative Classroom Culture

Students shared instructor practices associated with feelings of inclusion that we categorized as "Establishing Collaborative Classroom Culture." In total, 39% of students (n = 145/375) shared responses that were categorized as "Establishing Collaborative Classroom Culture" (Figure 1). While "Building the

TABLE 2. ***Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*****: four emergent categories of instructor practices associated with feelings of INCLUSION in biology courses that emerged from student perceptions**

Category	Characteristics
Building the Instructor/Student Relationship	• Interacting with and learning about students individually (e.g., knowing names, using name cards, personal checks-in) • Welcoming and responding to questions from students • Accommodating and being flexible with respect to students' time • Using inclusive language generally (i.e., about identities and/or culture) • Being a kind, open-minded, accessible, and collegial instructor • Sharing personal experiences and/or stories with students
Establishing Collaborative Classroom Culture	• Promoting collaborative learning and peer relationships • Encouraging all students to share ideas and opinions with peers and the class • Acknowledging students with raised hands • Interacting with students during group work or class activities • Avoiding favoritism and teaching all students
Making Student-Centered Pedagogical Choices	• Engaging students in activities within lecture courses (e.g., in-class activities, clicker questions, projects, etc.) • Using student evidence and ideas to guide teaching choices • Asking questions to students and/or the class to check for understanding and clarify concepts • Making course accessible and organized for students • Soliciting and providing feedback • Discussing many ideas in class, not just "correct" answers • Connecting content to the real world and career
Portraying Science as Inclusive	• Revealing science as collaborative and inclusive of individuals from all identities (e.g., curriculum, case studies, etc.) • Demonstrating connections between science and communities/cultures • Using inclusive language as it relates to science • Showcasing the stories and/or research of scientists from diverse backgrounds and cultures

Instructor/Student Relationship" focused on close social distance between individual students and their instructors, the "Establishing Collaborative Classroom Culture" category focuses on the instructor facilitating relationships among students. Responses within this category pertained to instructors promoting peer relationships, treating students without favoritism, and facilitating collaborative active learning strategies like think-pair-shares and class discussions. Below are samples from student responses that were classified within this category (Table 3):

> "She has think-pair-share activities that help me feel included." – student

> "The professor allows everyone's idea to be heard." – student

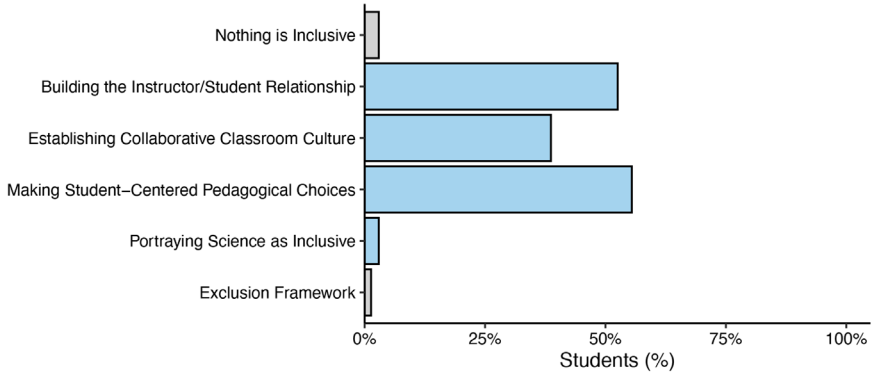

FIGURE 1. Student-reported instructor practices associated with feelings of inclusion in undergraduate biology courses. Bars show the proportion of students whose open-ended responses to the inclusion prompt (refer to *Methods* section) referenced specific instructor practices, grouped into emergent inclusion categories from the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*. Percentages represent the fraction of the total student sample ($n = 375$) whose responses were coded in each category. Since students could share up to three responses, individual responses could be coded into more than one category.

TABLE 3. Example student responses for each INCLUSION category of the *Student Perceptions of Instructor Practices – Inclusion/Exclusion (SPIP-I/E) Framework* (n = 375 students who responded to the inclusion prompt)

	Example student responses
Building the Instructor/Student Relationship	"The professor welcomes everyone to ask questions about course content, homework, exams, etc. and answers to the best of his ability with respect and kindness."
	"The instructor has remembered almost all of our names, makes me feel more like a student than a face in the crowd."
	"Professor is approachable and helpful during class and office hours."
	"Genuinely cares about what I'm asking and tries to help."
	"He responds to my emails promptly and is thorough in his explanations."
	"He adjusts his office hours to accommodate to my schedule."
	"Very understanding when we struggle with deadlines."
	"My instructor was very mindful and nonjudgmental with how he discussed human sexuality in class and how he spoke about sexual orientation, sex, gender identity, etc."
	"Our instructor shares stories of her own difficulties being a woman in the field of science."
Establishing Collaborative Classroom Culture	"She always walks around while working in groups and ask students how they are doing."
	"Has encouraged us strongly to get to know each other and network."
	"The instructor makes me feel included by going around class asking if people feel comfortable with the material."
	"Our instructors for this class help to set up tables that are randomly seated so that way everyone has a chance to get to know different people."
	"She has think-pair-share activities that help me feel included."
	"There does not appear to be any favoritism."
	"The instructor asks for volunteers to share ideas with the class."
	"Asks others to participate when they haven't been able to."
	"The professor allows everyone's idea to be heard."
Making Student-Centered Pedagogical Choices	"She purposely uses anonymous iClickers to gather data on class understanding."
	"He constantly checks in if we have any questions."
	"Will work with any answer given to him by a student, even if it is wrong."
	"Values opinions and different answers to questions."
	"Do case studies to connect to the real world."
	"Questions and answers in lecture similar to those on the test."
	"He made sure that everything was available to all types of people."
	"He makes sure all lectures are recorded for online students."
Portraying Science as Inclusive	"The instructor brings in female professionals in the areas of pharmacology."
	"Uses inclusive language or acknowledges when data is exclusive."
	"He talks about molecular biology issues and ties it into other groups, which to me seems inclusive."
	"He covers experiments or observations that explore every sexuality."

Making Student-Centered Pedagogical Choices

Students shared a wide range of instructor practices associated with feelings of inclusion that we coded as "Making Student Centered Pedagogical Choices." Over half of students (56%, n = 208/375) shared responses that were classified within this category (Figure 1). While "Building the Instructor/Student Relationship" involves instructors welcoming, encouraging, and responding to questions from individual students, "Making Student Centered Pedagogical Choices" involves instructors asking questions to check students' understanding of course concepts. Responses from this category included instructors integrating activities in lecture courses (e.g., iClicker questions and projects), connecting content to the real world, ensuring student understanding of concepts (e.g., asking questions), making the course material accessible for all students (e.g., recorded lectures and an organized course website), and discussing ideas beyond just the "correct" answer in class. Below are examples of student responses (Table 3):

> "He constantly checks in if we have any questions." – student

> "Practical homework that integrates what we learned." – student

Portraying Science as Inclusive

Few students shared instructor practices associated with feelings of inclusion that we identified as "Portraying Science as Inclusive." Only 3% of students (n = 11/375) shared responses that were identified within this category (Figure 1). Responses from this category included instructors featuring the stories and research of diverse scientists and cultures, making the connections between science and communities clear to students, and revealing that science is a collaborative process that involves individuals from all identities (e.g., Aranda *et al.*, 2021; Costello, Driessen *et al.*, 2025; Costello, Ewell et al., 2025; Ovid *et al.*, 2023; Ovid, Rice *et al.*, 2024; Schinske *et al.*, 2015; Schinske *et al.*, 2016; Yonas *et al.*, 2020).

TABLE 4. *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*: four emergent categories of instructor practices associated with feelings of EXCLUSION in biology courses that emerged from student perceptions

Category	Characteristics
Dismantling the Instructor/Student Relationship	• Disengaging from interactions with and not getting to know students individually • Deflecting or not allowing student questions and/or responding rudely to student questions • Disregarding students' time and being inflexible • Using exclusive language generally (i.e., about identities and/or culture) • Being a rude, judgmental, and inaccessible instructor
Establishing Non-collaborative Classroom Culture	• Lecturing primarily with little or no in-class student interaction and collaboration • Discouraging students from sharing ideas and opinions with peers and the class • Maintaining static seat assignments or room arrangements that limit student interactions • Categorizing and interacting with students based on their performance or grades • Showing favoritism and teaching to a subset of students • Creating an unsupportive environment by calling on students (e.g., random call, picks on)
Compromising Student-Centered Pedagogical Choices	• Minimizing evidence-based teaching approaches within the course • Isolating content from connections to real world and career • Delivering information without soliciting student involvement or checking for understanding • Making assumptions about students' prior knowledge • Making course inaccessible and unorganized for students • Giving limited or untimely feedback • Speaking quickly, too much, or off topic • Dishonoring divergent ideas and valuing only the "correct" answer
Portraying Science as Exclusive	• Portraying science as competitive and exclusive • Ignoring connections between science and communities/cultures • Using exclusive language as it relates to science • Showcasing stories and research of only stereotypical scientists

The "Making Student Centered Pedagogical Choices" category involves instructors connecting concepts to the real world, whereas the "Portraying Science as Inclusive" category involves instructors making explicit connections between concepts and various communities. Below are samples from the student responses within this category (Table 3):

> "The instructor brings in female professionals in the areas of pharmacology." – student

> "Uses inclusive language or acknowledges when data is exclusive." – student

Emergence of the Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework—EXCLUSION categories

Undergraduate students shared up to three responses of instructor practices that they perceived as promoting feelings of exclusion in biology courses. Just over half of students shared that their instructors engaged in practices that made them feel excluded (52%, $n = 96/183$).

From student responses, four exclusion categories of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* emerged of instructor practices that were associated with student feelings of exclusion (Table 4). A total of 188 students provided at least one response to what their instructor does to make them feel excluded. Out of the 188 students, 5 students provided responses that were unclear (e.g., "very large class" or "show video") and were excluded from analysis. This reduced the sample size to 183 students who shared 240 responses that were coded into either a single category (230 responses) or two categories (10 responses) of the *SPIP-I/E Framework* or "Nothing was Exclusive" (refer to Figure 2). Importantly, 42.1% of students ($n = 77/183$) reported that their instructor did not engage in any exclusive practices (e.g., "nothing is exclusive" or "nothing"). Further, 5.5% of students ($n = 10/183$) only shared a single response, which appeared better aligned with categories in the inclusion part of the SPIP-I/E framework, such as "Post grades on iLearn after each exam is done." Below, we detail the four *SPIP-I/E Framework* exclusion categories and provide a quantitative summary and student example responses of each category.

Dismantling the Instructor/Student Relationship

Many students shared instructor practices associated with feelings of exclusion that we categorized as "Dismantling the Instructor/Student Relationship." Nearly a quarter of students (24%, $n = 44/183$) shared responses that were classified within this category (Figure 2). Student responses from this category included instructors withdrawing from getting to know students (e.g., not learning names), averting student questions and/or responding condescendingly to student questions, ignoring students' time and not being flexible (e.g., not accommodating appointments and not responding to emails), and using exclusive language. We chose to put instructors ignoring student emails and not accommodating student lives, such as making office hours inaccessible, in this category because these interactions are affiliated with individual students rather than the collective class. Below are example student responses that were identified

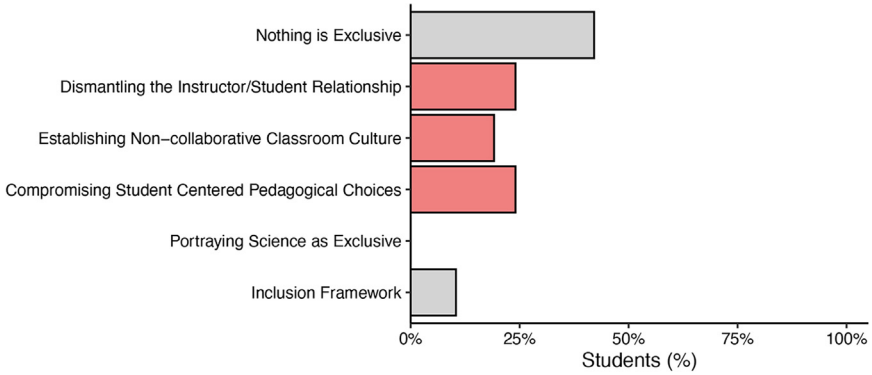

FIGURE 2. Student-reported instructor practices associated with feelings of exclusion in undergraduate biology courses. Bars show the proportion of students whose open-ended responses to the exclusion prompt (refer to *Methods* section) referenced specific instructor practices, grouped into emergent exclusion categories from the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*. Percentages represent the fraction of the total student sample ($n = 183$) whose responses were coded in each category. Since students could share up to three responses, individual responses could be coded into more than one category.

TABLE 5. Example student responses for each exclusion category of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* ($n = 183$ students who responded to the exclusion prompt)

	Example student responses
Dismantling the Instructor/Student Relationship	"Embarrasses students that walk in a few minutes late."
	"Professor doesn't remember my name."
	"Not personally providing enough time to really get to know the students."
	"My teacher tends to use very outdated language when referring to trans people (ex. 'transsexual' instead of 'trans people'), and in turn, I sometimes feel uncomfortable despite knowing he isn't being malicious…"
	"She yells a lot."
	"Responds to questions in a snarky manner, possibly making the student asking the question feel dumb or embarrassed."
	"She doesn't let the student full complete their thought because she often interrupts the student mid-sentence."
	"Forgets about appointments for advising or office hours."
	"He doesn't respond to emails."
Establishing Non-collaborative Classroom Culture	"Only one group project, no other times to talk with the people around us to share ideas or knowledge."
	"It is very boring to hear someone talking for a whole hour and not do much as a student other than sit there. Class should be way more interactive instead of sit and doze off."
	"The professor constantly teaches off PowerPoints and rarely has any real discussions that aids learning."
	"Prioritizes some students."
	"She will call on students that do not want to be called on."
	"Puts students on the spot and makes you answer questions."
Compromising Student-Centered Pedagogical Choices	"She teaches in a way that only people that have studied biology can understand."
	"I feel excluded when my instructor goes through the lectures quickly because I get left behind."
	"My instructor constantly goes off topic & our discussions often have nothing to do with biology."
	"He expects us to memorize a long list of terms for tests and quizzes."
Portraying Science as Exclusive	*No observations*

as "Dismantling the Instructor/Student Relationship" (Table 5):

> "Responds to questions in a snarky manner, possibly making the student asking the question feel dumb or embarrassed." – student

> "He doesn't respond to emails." – student

Establishing a Non-Collaborative Classroom Culture

Students shared instructor practices associated with feelings of exclusion that we categorized as "Establishing Non-collaborative Classroom Culture." Approximately 19% of students ($n = 35/183$) shared responses that were identified within this category (Figure 2). Student responses within this category pertained to instructors primarily using traditional lecture rather than having students collaborate with peers

and discuss ideas, showing favoritism, and randomly calling on students. While "Dismantling the Instructor/Student Relationship" pertains to the instructor undermining their relationship with individual students, the "Establishing Non-collaborative Classroom Culture" involves undermining relationships amongst students. Below are student responses that were classified within this category (Table 5):

> "I feel excluded when my instructor spends the whole class period talking." – student

> "Puts students on the spot and makes you answer questions." – student

Compromising Student-Centered Pedagogical Choices

Many students shared instructor practices associated with feelings of exclusion that we categorized as "Compromising Student Centered Pedagogical Choices." Nearly a quarter of students (24%, $n = 44/183$) shared responses that were coded within this category (Figure 2). Responses within this category included instructors limiting the use of active learning, not checking for student understanding of concepts, making assumptions about students' previous knowledge, creating an inaccessible course (e.g., not recording lectures), not giving feedback on student work, and valuing only the "correct" answer. Below are samples of student responses within this category (Table 5):

> "He doesn't give homework so there isn't a good way of learning on our own time other than reading notes." – student

> "My instructor constantly goes off topic and our discussions often have nothing to do with biology." – student

Portraying Science as Exclusive

While we did not observe student responses in this data collection that would be categorized as "Portraying Science as Exclusive" (Figure 2), we elected to include a parallel exclusion category in the *SPIP-I/E Framework* since evidence was observed for the "Portraying Science as Inclusive" category. We anticipate that future studies in other contexts may reveal student perceptions related to how instructor practices may indeed portray science as exclusive (personal communication, L. Lones), and multiple researchers have described how well-intentioned instructors could inadvertently make students feel excluded by poor implementation of curricular interventions such as Scientist Spotlights and Data Nuggets that are intended to portray science as inclusive (Costello *et al.*, 2025).

Disaggregation of Student Perceptions of INCLUSIVE or EXCLUSIVE Instructor Practices Across Student Demographic Characteristics

We investigated how student perceptions of inclusion or exclusion might vary between students from marginalized groups and their peers; however, we observed no differences in the proportion of students across demographic characteristics who shared at least one instructor practice associated with feelings of inclusion or exclusion. Overall, students from marginalized populations appeared similar to their peers in sharing instructor practices that made them feel included or excluded in their biology course in this study context (Figure 3). We have included these analyses to address our third research question, even though there do not appear to be statistically significant differences.

For the inclusion prompt disaggregation analysis, students had to complete the entire demographics form and report at least one instructor practice associated with feelings of inclusion ($n = 346/375$). For the exclusion prompt disaggregation analysis, students also had to complete the entire demographics form and report at least one instructor practice associated with feelings of exclusion ($n = 167/183$). Importantly, as a reminder, 77 students reported that their instructor did not engage in any exclusive practices (e.g., "nothing is exclusive" or "nothing"). The statistical information on the disaggregation analyses is shared in detail in Supplemental Material.

DISCUSSION

While many have speculated about what constitutes inclusive undergraduate STEM classrooms, several studies of student perspectives on inclusion have used closed-ended assessment tools that may center researcher perspectives about inclusion, and those studies that have used more open-ended methodologies have investigated undergraduate student perceptions of inclusion in biology and STEM courses among primarily White and continuing-generation college-going populations in the context of research-focused institutions (Jantzer *et al.*, 2021; Schussler *et al.*, 2021; Valdez and Kelp, 2023; Bustamante *et al.*, 2024; Walker *et al.*, 2024; York *et al.*, 2024). Additionally, there are gaps in the literature about whether students themselves might perceive Active Learning approaches as related to their feelings of classroom inclusion (Dewsbury, 2017; Dewsbury and Brame, 2019). To address these gaps in the biology education research literature, we designed an investigation that purposefully centered the voices of undergraduate students attending a public, minority-serving institution and investigated their perceptions of what instructors do to make them feel included or excluded in undergraduate biology courses. This research approach is aligned with calls to engage with current undergraduate students and leverage their perspectives and experiences in fostering meaningful reform of undergraduate STEM education environments (Cook-Sather *et al.*, 2018; Matthews *et al.*, 2018; Matthews *et al.*, 2019). Importantly, we documented that students were indeed experiencing evidence-based teaching practices in their biology courses in the study context (refer to Supplemental Figure S1). What emerged from analyses of these student perspectives were four mirrored categories of instructor practices that were associated with student perceptions of classroom inclusion/exclusion (refer to Tables 2 and 4). Taken together, these categories comprise a new analytical framework—the *Student Perceptions of Instructor Practices–Inclusion/Exclusion (SPIP-I/E) Framework*—that may be useful to others who aspire to investigate and characterize student perspectives about classroom inclusion/exclusion:

- *Building/Dismantling the Instructor/Student Relationship*
- *Establishing Collaborative/Non-Collaborative Classroom Culture*
- *Making/Compromising Student-Centered Pedagogical Choices*
- *Portraying Science as Inclusive/Exclusive*.

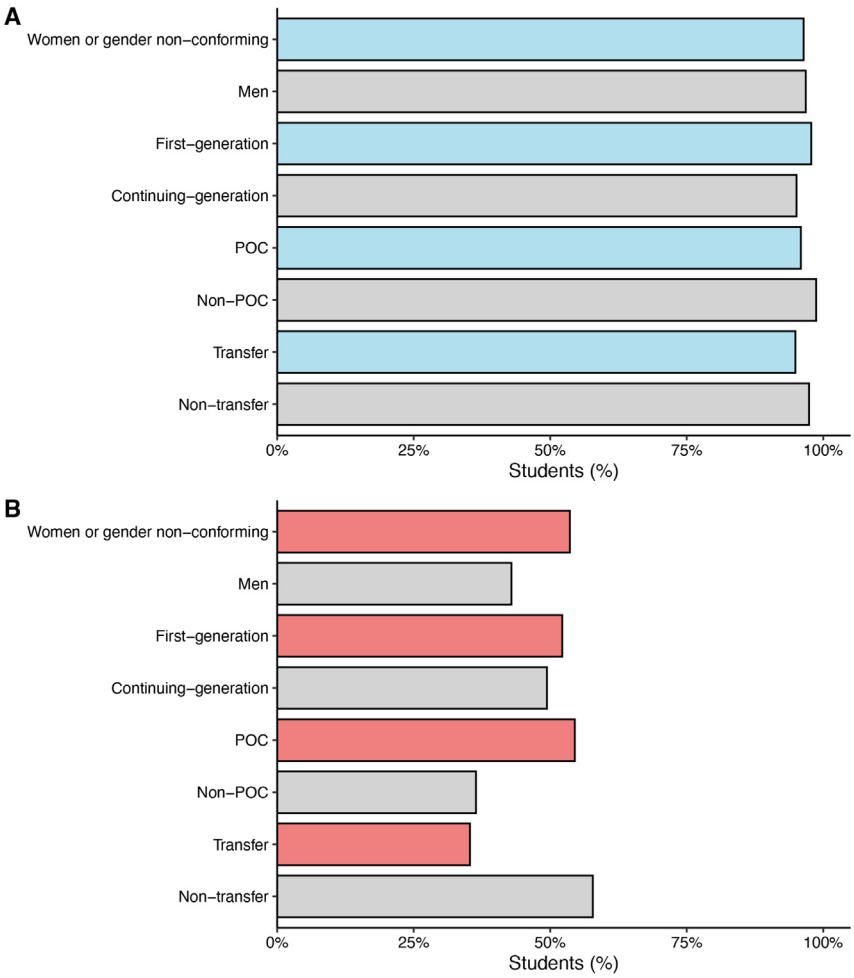

FIGURE 3. Proportion of students from marginalized populations compared with their peers who reported one or more instructor practices that made them feel included or excluded in undergraduate biology courses. (A) Proportion of students within each self-identified demographic group who reported at least one instructor practice associated with feelings of inclusion. (B) Proportion of students within each self-identified demographic group who reported at least one instructor practice associated with feelings of exclusion. Only students who completed the full demographics questionnaire were included (Panel A: $n = 346$; Panel B: $n = 167$). For each demographic group, percentages were calculated as the number of students who reported one or more inclusive (A) or exclusive (B) practices divided by the total number of students in that demographic group who completed the inclusion or exclusion prompt and the demographics questionnaire. Demographic comparisons include gender (women and gender non-conforming vs men), first-generation college status (first-generation vs continuing-generation), race and ethnicity (People of Color vs non–People of Color), and transfer status (transfer vs non-transfer).

Below, we explore the purposeful institutional and departmental context of this research, comparisons of student perceptions across social identities, and the potential utility of the *SPIP-I/E Framework* in other contexts. Then, we elaborate on relations between relevant theory and previous research that appear to underlie the instructor practices that students most often report as promoting their classroom inclusion or exclusion, specifically theory and predictions related to Active Learning, Instructor Immediacy, and Classroom Sociology. Additionally, we explore potential relations between instructor practices reported by undergraduate students as associated with their feelings of classroom inclusion/exclusion and the non-content instructor language that may or may not surround these practices—language termed Instructor Talk in previous work. Finally, we explore a hypothesis that non-content Instructor Talk may serve as a lens that mediates whether students perceive any particular teaching practice as inclusive or exclusive. Further, we predict that the presence, absence, or nature of Instructor Talk may be a key variable that could predict student perceptions of classroom inclusion/exclusion (refer to Figure 4).

The *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* Emerged as an Analytical Framework from a Diverse Population of Undergraduate Biology Students in a Public, Broad-access Institution with Demonstrated Instructor Use of Evidence-Based Teaching Practices

The analyses of student perceptions of inclusion and exclusion presented here, as well as the emergent *Student Perceptions*

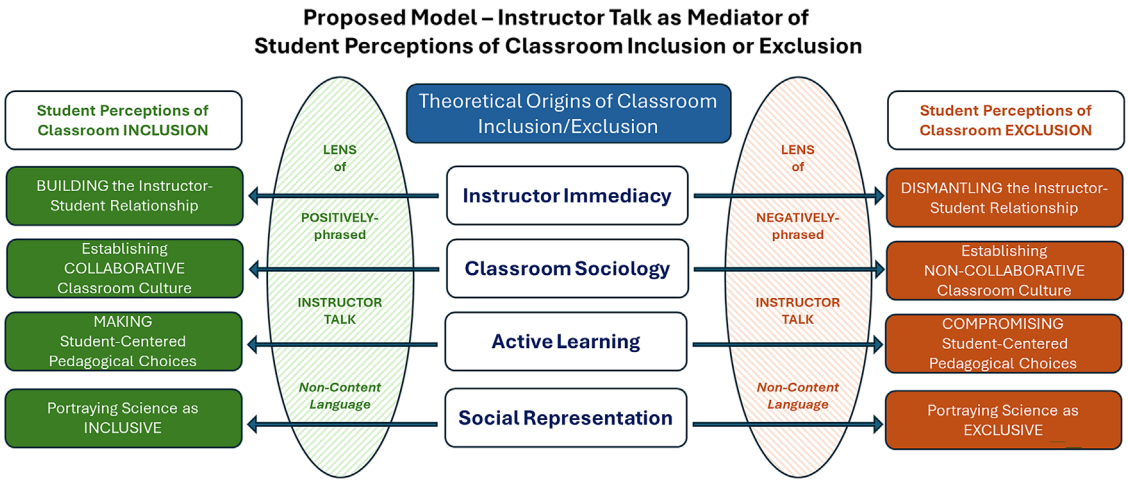

FIGURE 4. Proposed model of how Instructor Talk may be a mediating variable between theoretical origins of instructor practices that could promote student feelings of inclusion or exclusion and actual student perceptions of those practices. Commonly asserted theoretical origins of classroom inclusion/exclusion are shown in blue. The lenses of instructors' use of non-content language—namely, Positively-phrased (green) or Negatively-phrased (orange) Instructor Talk—is shown as mediating students' reported perceptions of classroom inclusion (green) or exclusion (orange) that emerged in the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework*.

of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework, appear to be broadly relevant, given the particular context in which this research was conducted. First, the institutional context for the study was an urban, public institution with MSI, HSI, and AANAPISI designations and a highly diverse student body. The rich diversity of the student population enabled us to examine whether perceptions of inclusion/exclusion differed among students with different social identities. Interestingly, student perceptions of what instructor practices fostered their feelings of inclusion or exclusion did not differ significantly between students with different social identities with respect to gender, race, first-generation college-going status, or transfer status. Future studies could further explore whether the absence of differences in students' perceptions of inclusion/exclusion across social identities could be replicated in other institutional contexts and student populations. With respect to exclusion, this may also reflect the small population of students in the sample reporting any examples of exclusionary instructor practices; however, the low proportion of students reporting exclusionary practices would seem to be a heartening finding about the overall climate of biology courses at this institution.

Additionally, it was important that this study documented that students were experiencing a variety of evidence-based teaching practices in their biology courses. This is key, as we hypothesize that a similar study conducted in a departmental context with little instructor professional development in evidence-based teaching would likely have limited breadth of student perceptions of inclusion simply because students may not have experienced a range of instructor practices. In some prior studies, researchers have noted minimal student reporting of such practices in association with student perceptions of instructor supportiveness; yet, it is unclear the extent to which students had experienced such teaching strategies (e.g., Schussler *et al.*, 2021). In the current, purposeful study context, the biology department at the institution has had more than a decade of faculty development efforts in evidence-based and inclusive teaching efforts that have introduced instructors to a range of non-traditional practices. Further, these faculty development efforts have demonstrated changes in classroom practices by instructors that have been confirmed by students' perceptions, generated new lines of pedagogical inquiry, and promoted student success and persistence in STEM across demographic groups (Seidel *et al.*, 2015; Owens *et al.*, 2017; Owens *et al.*, 2018; Harrison, Nguyen *et al.*, 2019; Ovid, Rice *et al.*, 2021; Gelinas, Ovid *et al.*, 2022; academic data not shown). Additionally, this biology department has recently undertaken centering the voices of students in curriculum development, classroom instruction, and research efforts, including this investigation (Aranda *et al.*, 2021; Ovid *et al.*, 2021; Ovid *et al.*, 2023). Taken together, these aspects of the study context provide confidence that the results reflect the perceptions of a highly diverse student population who were also experiencing some level of implementation of evidence-based teaching practices (refer to Table 1 and Supplemental Figure S1).

The potential utility of the *SPIP-I/E Framework* lies in its origins in the purposeful context of the research, the presence of evidence-based teaching practices in the department, and the rich diversity of the student population. Analyses of student perceptions of inclusion/exclusion in other contexts using the *SPIP-I/E Framework* may reveal the absence of specific categories of instructor practices with the potential to promote classroom inclusion that may not otherwise have been detected. The *SPIP-I/E Framework* could enable future research across a variety of contexts—with different student populations and varying amounts of instructor professional development efforts—precisely because it has been built from diverse student perceptions in a rich educational reform environment.

The *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* provides Evidence that Students perceive Active Learning, Instructor Immediacy, and Classroom Sociology as Key Contributors to Promoting Inclusion and Minimizing Exclusion

The *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* is novel in its centering of and grounding in student voice and its emergence from a diverse student population in a biology department in a broad-access institution. Analysis of student perspectives and the emergent categories of the framework point to three potential theoretical origins of instructor practices that may underlie student perceptions of classroom inclusion and exclusion: Active Learning, Instructor Immediacy, and Classroom Sociology. Below, we explore research literature and theory related to Active Learning, Instructor Immediacy, and Classroom Sociology, and how they may be relevant to understanding student perceptions of classroom inclusion and exclusion.

Active Learning is Reported by Students as Associated With Feelings of Inclusion, as Demonstrated by Evidence in the Category of Making/Compromising Student-Centered Pedagogical Choices. Strikingly, more than half of the students in our study reported instructor practices related to Active Learning as promoting feelings of classroom inclusion, suggesting that Active Learning can indeed contribute. The instructor practices reported by most students as influencing their sense of classroom inclusion were coded as *Making Student-Centered Pedagogical Choices*. This category of student responses was reported by over half of students and focused on instructor pedagogical choices related to engaging students in activities in class, using student evidence to make teaching choices, exploring many ideas instead of correct answers, and connecting content to real-world issues and career aspirations of students. While this category included a variety of instructor pedagogical practices, most of these reflected aspects of what many scholars would consider "Active Learning" approaches, which is in alignment with some previous studies (Schussler *et al.*, 2021; York *et al.*, 2024).

As investigated previously by many researchers, a range of Active Learning practices have been shown to have the potential to increase student performance and reduce achievement gaps in undergraduate STEM courses, even without evidence about the quality of the Active learning happening (Freeman *et al.*, 2014; Theobald *et al.*, 2020). However, despite positive academic impacts of Active Learning, previous research has also revealed varying effects on students from different social identities (Eddy and Hogan, 2014). Additionally, previous research has explored how aspects of Active Learning implementation could inadvertently be exclusionary for students of some social identities, including students with anxiety and hidden marginalized identities (Cooper and Brownell, 2016; Cooper *et al.*, 2018; Mohammed *et al.*, 2021; Pfeifer *et al.*, 2023; Weatherton *et al.*, 2024). As such, there have been questions about the relation between Active Learning and students' sense of classroom inclusion, and few studies have directly examined whether students, unprompted, would report Active Learning practices as promoting their inclusion (Dewsbury, 2017; Dewsbury and Brame, 2019).

Data from our study suggest that Active Learning has the strong potential to contribute to students' perceptions of classroom inclusion. Interestingly, we did not detect differences in reports of Active Learning practices promoting their sense of inclusion between students of different social identities—with respect to gender, race, first-generation college-going status, or transfer status. We hypothesize that this may stem from nuances and variations in instructor behaviors and practices in the implementation of Active Learning approaches in the study context. Such variations in instructor implementation of Active Learning instructor practices—*how* Active Learning is done—may produce variable outcomes in terms of students' sense of inclusion as seen in prior research (Eddy and Hogan, 2014; Cooper and Brownell, 2016; Cooper *et al.*, 2018; Mohammed *et al.*, 2021; Pfeifer *et al.*, 2023). Additionally, the details of how Active Learning may be implemented by individual instructors could differentially influence students' academic outcomes as compared with students' perceptions of inclusion (Theobald *et al.*, 2020). Future studies are needed to investigate what specific nuances and aspects of Active Learning implementation may mediate student perceptions of inclusion/exclusion, and how instructors might be coached to optimize Active Learning implementation to promote students' feelings of classroom inclusion (Seidel and Tanner, 2013).

Instructor Immediacy may Underlie Student Perceptions of Inclusion, as Shown in the Categories of Building/Dismantling the Instructor/Student Relationship. Instructor behaviors that were coded as *Building the Instructor Student Relationship* appear to be closely related to the theoretical concept of Instructor Immediacy, which is defined as increasing the perceived socio-psychological/social closeness between the instructor and students (Mehrabian, 1971; Kearney *et al.*, 1988; Kelley and Gorham, 1988). More than half of the students in this study indicated that positive social interactions between the instructor and students were key to promoting classroom inclusion, such as an instructor aspiring to know students' names, welcoming questions from students, being responsive and available, and sharing personal experiences. Additionally, students appeared to view instructor behaviors such as avoiding interactions with students, being inaccessible, deflecting or ridiculing students' questions, and ignoring students' challenges as exclusionary. While numerous studies have studied Instructor Immediacy in the context of student outcomes (Wilson and Locker, 2007; Frisby and Martin, 2010; Kim *et al.*, 2024) and motivation (Gorham and Christophel, 1992; Christophel and Gorham, 1995; Baker, 2010; Littlejohn, 2012), few appear to have studied Instructor Immediacy as it relates to students' sense of inclusion (Schussler *et al.*, 2021; York *et al.*, 2024).

Our findings in this study are particularly interesting because they appear to directly connect instructor behaviors associated with student feelings of inclusion or exclusion to the phenomenon of Instructor Immediacy. Previous research on Instructor Immediacy has demonstrated its potential to influence student learning and sense of belonging through non-verbal and verbal aspects of instructor behaviors

(Mehrabian, 1971; Kearney *et al.*, 1988; Kelley and Gorham, 1988; Witt *et al.*, 2004). For example, previous investigations of the impact of an instructor attending to knowing students' names revealed multiple positive student outcomes—students feeling valued by an instructor and being more comfortable in asking for help—that appear directly related to Instructor Immediacy and classroom inclusion (Cooper *et al.*, 2017). Our analyses of student perceptions of classroom inclusion build on this prior work and suggest that developing relationships and attempting to know students as individuals may be an important component of inclusive classrooms in addition to instructor use of Active Learning practices (Marchesani and Adams, 1992; Schwartz, 2019). Future studies are needed to investigate the potential differential impacts of nonverbal and verbal behaviors of instructors on students' perception of classroom inclusion. Additionally, more research is needed to understand the potential synergy, or other relations, between instructors using Active Learning and also purposefully building Instructor Immediacy to promote students' perceptions of classroom inclusion (Creasey *et al.*, 2009). One wonders if the extent of Instructor Immediacy may influence the impact of Active Learning practices on students, as well as whether the presence of both Instructor Immediacy practice and Active Learning practices may be necessary—and neither sufficient alone—for promoting students' perceptions of inclusion.

Classroom Sociology Appears to be key to Student Perceptions of Inclusion, as Revealed in the Categories of Establishing Collaborative/Non-Collaborative Classroom Culture. Over a third of students in our study reported that how and whether biology instructors fostered a collaborative classroom culture promoted their sense of inclusion. This was distinct from the previously explored categories, which points to the importance of the sociological dynamics of classrooms as a novel theoretical origin with which to understand undergraduate STEM inclusion. This category of student responses—*Establishing Collaborative/Non-Collaborative Classroom Culture*—reflected that students value in-class group work and discussions, the purposeful fostering of new student-student networks, and instructors moving around and interacting with students, rather than instructors primarily lecturing. Additionally, students appear to view instructor behaviors such as not attending to student groupings, discouraging student interaction, and teaching only to those students who may already understand the material as exclusionary. It is important to note that instructor practices that may be used to orchestrate Classroom Sociology appear to be perceived differently by students than Active Learning instructor practices, with a strong focus on the collaborative or non-collaborative nature of instructor practices and behaviors. Interestingly, in previous investigations of undergraduate STEM classroom inclusion, student reports about the importance of collaborative classroom culture to feelings of inclusion either did not appear to emerge or were not viewed as distinct from the influence of evidence-based teaching strategies more generally (Schussler *et al.*, 2021; York *et al.*, 2024).

Previous research in pre-college STEM education has employed sociological theory—termed "Complex Instruction"—to understand equity, inclusion, and learning in diverse, multi-ability-level classrooms, which may also be useful in understanding student perceptions of inclusion/exclusion in post-secondary classrooms (Cohen, 1998; Cohen *et al.*, 1999; Villa and Sedlacek, 2024). Research related to Complex Instruction has investigated the importance of teachers thoughtfully orchestrating student–student interactions, actively organizing group work dynamics, and attending to the impact of public instructor–student interactions with strong attention to how students gain status in these interactions. Developed by the late sociologist Elizabeth Cohen and colleagues, Complex Instruction has operationalized the importance of not only implementing student-centered, active teaching strategies but also organizing the details of how such strategies are implemented and how students interact as a classroom community (Cohen, 1998; Cohen *et al.*, 1999). Given research on Complex Instruction, it appears that using Active Learning strategies, student-centered teaching, deep teaching, and/or other named pedagogical approaches may be necessary, but not sufficient, to promote student feelings of inclusion.

Interestingly, biology education research has often focused on individual students, instructors, and instructor–student interactions. However, results from students in this study, as well as theoretical work like that in the Complex Instruction literature, point to the importance of examining Classroom Sociology and the organization and management of student-student and student-instructor interactions. Yet, the details and nuances of *how* instructors do or do not construct the sociological setting of a classroom have largely gone unexamined in undergraduate biology education research. Differences in instructor actions, decisions, and practices are likely subtle and nuanced, related to who instructors choose to interact with during class time, how student pairs and groups are constructed, who is called on to speak and how often, how instructors publicly respond to what students share, how instructors describe the students and course, and even the instructor's physical location in the room.

One variable that appears common to all approaches to building the sociology of a classroom and that can be detected in evidence across all categories of the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* is language. In particular, the non-content language instructors are using to facilitate classroom interactions—previously termed Instructor Talk—appears to be an excellent candidate for an explanatory variable underlying most of the student reports on instructor practices that promoted their feelings of classroom inclusion. Below, we explore how student perceptions of classroom inclusion and the categories of the *SPIP-I/E Framework* appear to be deeply connected to non-content instructor language and the previously developed *Positively-phrased and Negatively-phrased Instructor Talk Frameworks* (Seidel *et al.*, 2015; Harrison, Nguyen *et al.*, 2019; Ovid, Rice *et al.*, 2021; Gelinas, Ovid *et al.*, 2022).

Instructor language may be key to students feeling included/excluded, as the *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* reflects some categories of the previously published *Instructor Talk* Frameworks

Student reports about what instructors do that makes them feel included or excluded often alluded to how instructors used non-content language, namely Instructor Talk, in

classrooms. Additionally, the emergent *SPIP-I/E Framework* categories appeared to be well-aligned with a subset of the previously published *Instructor Talk* framework categories (Seidel *et al.*, 2015; Harrison; Nguyen *et al.*, 2019; Ovid, Rice *et al.*, 2021; Gelinas, Ovid *et al.*, 2022). As a reminder, the *Instructor Talk* frameworks—for both Positively-phrased and Negatively-phrased language—are tools that were developed for the purpose of analyzing recorded language used by instructors in classrooms. Instructor Talk is defined as language that is not related to course content, but rather language that is used to organize classroom culture and interactions. Given the recurring allusions to instructor language in student perceptions of inclusion and exclusion in this study, we hypothesize that purposeful instructor use of non-content language may underlie whether students perceive any teaching strategy as promoting classroom inclusion.

Interestingly, there were many allusions to instructors' non-content language offered by students in describing instructor practices that made them feel included. In the *Making Student-Centered Pedagogical Choices* category, students offered examples that alluded to non-content Instructor Talk, such as "*values opinions and different answers to questions*" and "*will work with any answer given to him by a student, even if it is wrong.*" Similarly, instructor behaviors reported by students in the *Building the Instructor-Student Relationship* category included examples that specifically referenced non-content instructor language: "*the instructor has remembered almost all of our names, makes me feel more like a student than a face in the crowd*," and "*my instructor was very mindful and nonjudgmental with how he discussed human sexuality.*" Further, students alluded to instructor language in the *Establishing Collaborative Classroom Culture* category, such as "*asks others to participate when they haven't been able to*," "*always walks around while working in groups and ask students how they are doing*," and "*encouraged us strongly to get to know each other and network.*" These examples of instructor behaviors that students report make them feel included appear likely to be mediated by non-content language and directly connected to the *Instructor Talk Frameworks,* which were originally developed to analyze non-content instructor language (Seidel *et al.*, 2015; Harrison, Nguyen *et al.*, 2019; Ovid, Rice *et al.*, 2021; Gelinas, Ovid *et al.*, 2022).

Given the implied role of instructor non-content language in student perceptions of inclusion, we hypothesize that non-content Instructor Talk may serve as a lens that mediates whether students perceive any particular teaching practice as inclusive or exclusive (refer to Figure 4). While Active Learning, Instructor Immediacy, and Classroom Sociology teaching strategies may have the potential to foster student inclusion, we hypothesize that the specific, non-content language that instructors do or do not use in their implementation of these strategies may be a critical, mediating variable in how such teaching practices are perceived by students (Dewsbury and Brame, 2019). We hypothesize that instructors' use of Positively-phrased Instructor Talk may be a necessary lens for students to perceive Active Learning, Instructor Immediacy, and Classroom Sociology teaching strategies as promoting classroom inclusion. In contrast, we hypothesize that instructors' use of Negatively-phrased Instructor Talk—or the complete absence of Instructor Talk at all in a classroom—could prompt students to perceive instructor practices as promoting their feelings of classroom exclusion, even though these strategies may have the *potential* to promote feelings of inclusion. Previous research has explored how instructor language may influence student learning and academic performance, from welcoming students on the first day, minimizing microaggressions that promote stereotype threat, and alleviating stress/anxiety in the classroom (Lane *et al.*, 2021; Kranzfelder *et al.*, 2019; Kane and Williams, 2021; Meaders *et al.*, 2021; Hsu and Goldsmith, 2021; Murray and Osterhage, 2024; Navarro *et al.*, 2025; Cen *et al.*, 2025). Our findings suggest the need for further research related to the nuances of how instructors implement evidence-based teaching strategies and the non-content language used (or not used) in this implementation. In summary, we predict that the presence, absence, and/or nature of non-content instructor language, Instructor Talk, may be a key mediating variable of student perceptions of classroom inclusion/exclusion and may be more predictive of perceptions of inclusion than the specific teaching strategies in use.

LIMITATIONS AND FUTURE DIRECTIONS

While this study centered the voices of a diverse population of undergraduate students in biology courses at a broad-access institution and their perceptions of instructor practices associated with their feelings of classroom inclusion or exclusion, there are important limitations, as with any study. Since we aimed to conduct the research in a context enriched with diversity of student social identities and instructor use of evidence-based practices, the results and the emergent *Student Perceptions of Instructor Practices—Inclusion/Exclusion (SPIP-I/E) Framework* may reflect characteristics of this study context (refer to Supplemental Material). Further, the analysis of qualitative evidence can yield a variety of emergent categories and frameworks, and other researchers could have conceptualized the evidence in different categories than those presented here. Additionally, the methodological choice to collect data using a department-wide, end-of-term study offered the advantage of inviting participation of all students enrolled in biology department courses and also the disadvantage of collecting only initial impressions from those students who participated.

Additionally, it was noteworthy that evidence for the categories of "Portraying Science as Inclusive/Exclusive" was reported by so few students. This may have reflected student perceptions about instructor practices that most significantly affected them. Alternatively, this may have been related to the order of questions in the department-wide survey used to collect student perspectives. That end-of-term survey served a variety of departmental needs, and the two questions on student perceptions of instructor practices analyzed in this study were positioned after a variety of questions about students' memory of classroom practices, own personal identity, own professional identity, comfort in the course, and interactions with learning assistants and peers, but before questions about scientists studied in their courses, as well as students' degree goal, career aspirations, and demographic information. Future studies could ask these two reflection questions in isolation to probe whether the low prevalence

of student reports of evidence in these categories would be reproduced.

A variety of future studies could leverage the emergence of the *SPIP-I/E Framework*. In particular, the *SPIP-I/E Framework* could be used to analyze and investigate student perceptions of what instructors do to make them feel included across different courses, different instructors, different institutions, and different institution types. Future comparative studies could reveal variations and nuances in what students are experiencing in different contexts and the extent to which students perceive instructor practices related to *Building the Instructor/Student Relationship, Establishing Collaborative Classroom Culture, Making Student-Centered Pedagogical Choices,* and *Portraying Science as Inclusive*. Additionally, investigations using the *SPIP-I/E Framework* could reveal the absence of particular instructor practices in other contexts that have been reported as key by students in this study to their sense of inclusion. Importantly, the *SPIP-I/E Framework* is the result of centering student voices, an under-appreciated and under-leveraged resource, in undergraduate education reform efforts (Cook-Sather *et al.*, 2018; Matthews *et al.*, 2018; Matthews *et al.*, 2019).

ACKNOWLEDGMENTS

This project was supported with funds from the Howard Hughes Medical Institute (grant number 52007556). We thank past and present members of the Science Education Partnership and Assessment Laboratory (SEPAL), as well as Professors Andrea Burton, Dax Ovid, Jeffrey N. Schinske, and Shannon B. Seidel, along with the LSE Monitoring Editor and anonymous reviewers, for helpful suggestions and comments on the draft manuscript. We also sincerely appreciate the students, staff, and faculty in the Department of Biology at San Francisco State University (SFSU) for their gracious and ongoing involvement in biology education research efforts, especially the wonderful students at SFSU who graciously shared their perspectives on classroom inclusion and exclusion.

REFERENCES

Aranda, M. L., Diaz, M., Mena, L. G., Ortiz, J. I., Rivera-Nolan, C., Sanchez, D. C., ... Tanner, K. D. (2021). Student-authored scientist spotlights: Investigating the impacts of engaging undergraduates as developers of inclusive curriculum through a service-learning course. *CBE—Life Sciences Education*, *20*(4), ar55.

Arnold, J. B. 2017. *ggthemes: Extra Themes, Scales and Geoms for 'ggplot2'. R package version 3.4.0*.

Baker, C. (2010). The impact of instructor immediacy and presence for online student affective learning, cognition, and motivation. *The Journal of Educators Online*, *7*(1). https://doi.org/10.9743/jeo.2010.1.2

Bustamante, V. P., Blomgren, H. E., Walker, D. K., Edwards, J. D., & Frey, R. F. (2024). Exploratory analysis of students' open-ended responses describing their perception of course inclusivity in an introductory physics course. *Physical Review Physics Education Research*, *20*(2), 1–18. https://doi.org/10.1103/physrevphyseducres.20.020112

Cen, X., Kight, M., Lee, R., Kranzfelder, P., Lo, S. M., Maloy, J., Owens, & M. T. (2025). Development of the Follow-Up Discourse Observation Protocol (FUDOP) for characterizing instructor active learning follow-up behaviors. *CBE—Life Sciences Education,*, *24*(2), ar20. https://doi.org/10.1187/cbe.24-08-0207

Christophel, D. M., & Gorham, J. (1995). A test-retest analysis of student motivation, teacher immediacy, and perceived sources of motivation and demotivation in college classes. *Communication Education*, *44*(4), 292–306. https://doi.org/10.1080/03634529509379020

Cohen, E. G. (1998). Complex instruction. *European Journal of Intercultural Studies*, *9*(2), 127–131.

Cohen, E. G., Lotan, R. A., Scarloss, B. A., & Arellano, A. R. (1999). Complex instruction: Equity in cooperative learning classrooms. *Theory into practice*, *38*(2), 80–86.

Cook-Sather, A., Matthews, K. E., Ntem, A., & Leathwick, S. (2018). What we talk about when we talk about students as partners. *International Journal for Students as Partners*, *2*(2), 1–9.

Cooper, K. M., & Brownell, S. E. (2016). coming out in class: Challenges and benefits of active learning in a biology classroom for lgbtqia students. *CBE—Life Sciences Education*, *15*(3), ar37. https://doi.org/10.1187/cbe.16-01-0074

Cooper, K. M., Downing, V. R., & Brownell, S. E. (2018). The influence of active learning practices on student anxiety in large-enrollment college science classrooms. *International Journal of STEM Education*, *5*(1), 1–18. https://doi.org/10.1186/s40594-018-0123-6

Cooper, K. M., Haney, B., Krieg, A., & Brownell, S. E. (2017). What's in a name? the importance of students perceiving that an instructor knows their names in a high-enrollment biology classroom. *CBE—Life Sciences Education*, *16*(1), ar8. https://doi.org/10.1187/cbe.16-08-0265

Costello, R. A., Driessen, E. P., Kjelvik, M. K., Schultheis, E. H., Youngblood, R. M., Zemenick, A. T., ... Ballen, C. J. (2025). More than a token photo: Humanizing scientists enhances student engagement. *Proceedings of the Royal Society B: Biological Sciences*, *292*(2039), 1–12. https://doi.org/10.1098/rspb.2024.0879

Costello, R. A., Ewell, S. N., Adams, P. E., Aranda, M. L., Curry, A., De Jesus, M. M., ... Ovid, D. (2025). Highlighting counterstereotypical scientists in undergraduate life science courses. *CBE—Life Sciences Education*, *24*(2), 1–21. https://doi.org/10.1187/cbe.24-02-0082

Creasey, G., Jarvis, P., & Gadke, D. (2009). Student attachment stances, instructor immediacy, and student–instructor relationships as predictors of achievement expectancies in college students. *Journal of College Student Development*, *50*(4), 353–372. https://doi.org/10.1353/csd.0.0082

Dewsbury, B. M. (2017). Context determines strategies for "activating" the inclusive classroom. *Journal of Microbiology & Biology Education*, *18*(3), 18.3.66. https://doi.org/10.1128/jmbe.v18i3.1347

Dewsbury, B., & Brame, C. J. (2019). Inclusive teaching. *CBE—Life Sciences Education,*, *18*(2), fe2. https://doi.org/10.1187/cbe.19-01-0021

Eddy, S. L., & Hogan, K. A. (2014). Getting under the hood: How and for whom does increasing course structure work? *CBE—Life Sciences Education*, *13*(3), 453–468. https://doi.org/10.1187/cbe.14-03-0050

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Frisby, B. N., & Martin, M. M. (2010). Instructor–student and student–student rapport in the classroom. *Communication Education*, *59*(2), 146–164. https://doi.org/10.1080/03634520903564362

Gelinas, K. A., Ovid, D., Amaya-Mejia, W., Ayala, R., Baek, H. E., Gasmin, E., ... Tanner, K. D. (2022). Investigating instructor talk among graduate teaching assistants in undergraduate biology laboratory classrooms. *CBE—Life Sciences Education*, *21*(2), 1–22. https://doi.org/10.1187/cbe.21-10-0302

Gorham, J., & Christophel, D. M. (1992). Students' perceptions of teacher behaviors as motivating and demotivating factors in college classes. *Communication Quarterly*, *40*(3), 239–252. https://doi.org/10.1080/01463379209369839

Harrison, T. A. Nguyen, Seidel, S. B., Escobedo, A. M., Hartman, C., Lam, K., Liang, K. S., ... Akana, S. F. (2019). Investigating instructor talk in novel contexts: Widespread use, unexpected categories, and an emergent sampling strategy. *CBE—Life Sciences Education*, *18*, ar47.

Hsu, J. L., & Goldsmith, G. R. (2021). Instructor strategies to alleviate stress and anxiety among college and university stem students. *CBE—Life Sciences Education,*, *20*(1), es1. https://doi.org/10.1187/cbe.20-08-0189

Jantzer, J., Kirkman, T., & Furniss, K. L. (2021). Understanding differences in underrepresented minorities and first-generation student perceptions in the introductory biology classroom. *Journal of Microbiology & Biology Education*, *22*(3), 1–9. https://doi.org/10.1128/jmbe.00176-21

Kane, D., & Williams, J. (2021). Emerging trends and insights on student experience. In M. Shah, J. T. E. Richardson, A. Pabel, & B. Oliver (Eds.), *Assessing and Enhancing Student Experience in Higher Education*. Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-030-80889-1_2

Kearney, P., Plax, T. G., Smith, V. R., & Sorensen, G. (1988). Effects of teacher immediacy and strategy type on college student resistance to on-task demands. *Communication Education*, *37*(1), 54–67. https://doi.org/10.1080/03634528809378703

Kelley, D. H., & Gorham, J. (1988). Effects of immediacy on recall of information. *Communication Education*, *37*(3), 198–207. https://doi.org/10.1080/03634528809378719

Kim, M. H., Han, J., Buford, K. N., Osterhage, J. L., & Usher, E. L. (2024). Undergraduate student perceptions of instructor mindset and academic performance: A motivational climate theory perspective. *Contemporary Educational Psychology*, *77*, 102280. https://doi.org/10.1016/j.cedpsych.2024.102280

Kranzfelder, P., Bankers-Fulbright, J. L., García-Ojeda, M. E., Melloy, M., Mohammed, S., & Warfa, A.-R. M. (2019). The classroom discourse observation protocol (CDOP): A quantitative method for characterizing teacher discourse moves in undergraduate STEM learning environments. *PLOS ONE*, *14*(7), e0219019. https://doi.org/10.1371/journal.pone.0219019

Lane, A. K., Meaders, C. L., Shuman, J. K., Stetzer, M. R., Vinson, E. L., Couch, B. A., … Stains, M. (2021). Making a first impression: Exploring what instructors do and say on the first day of introductory STEM courses. *CBE—Life Sciences Education,*, *20*(1), ar7. https://doi.org/10.1187/cbe.20-05-0098

Littlejohn, V. (2012). Student and teacher perceptions of teacher immediacy behaviors and the influence of teacher immediacy behaviors on student motivation to learn science. *Education Dissertations and Projects*, *62*, 1–114. Retrieved from https://digitalcommons.gardner-webb.edu/education_etd/62

Marchesani, L. S., & Adams, M. (1992). Dynamics of diversity in the teaching-learning process: A faculty development model for analysis and action. *New Directions for Teaching and Learning*, *1992*(52), 9–20. https://doi.org/10.1002/tl.37219925203

Markus, H., & Nurius, P. (1986). Possible selves. *American psychologist*, *41*(9), 954.

Matthews, K. E., Dwyer, A., Hine, L., & Turner, J. (2018). Conceptions of students as partners. *Higher Education*, *76*, 1–15. Retrieved from https://dx.doi.org/10.1007/s10734-018-0257-y

Matthews, K. E., Cook-Sather, A., Acai, A., Dvorakova, S. L., Felten, P., Marquis, E., & Mercer-Mapstone, L. (2019). Toward theories of partnership praxis: An analysis of interpretive framing in literature on students as partners in teaching and learning. *Higher Education Research and Development*, *38*(2), 280–293. https://doi.org/10.1080/07294360.2018.1530199

Meaders, C. L., Senn, L. G., Couch, B. A., Lane, A. K., Stains, M., Stetzer, M. R., … Smith, M. K. (2021). Am I getting through? Surveying students on what messages they recall from the first day of STEM classes. *International Journal of STEM Education*, *8*(1), 1–16. https://doi.org/10.1186/s40594-021-00306-y

Mehrabian, A. (1971). *Silent messages. Wadsworth*.

Mohammed, T. F., Nadile, E. M., Busch, C. A., Brister, D., Brownell, S. E., Claiborne, C. T., … Cooper, K. M. (2021). Aspects of large-enrollment online college science courses that exacerbate and alleviate student anxiety. *CBE—Life Sciences Education*, *20*(4), 1–23. https://doi.org/10.1187/cbe.21-05-0132

Murray, C., & Osterhage, J. (2024). "They helped me through the semester": Electronic instructor messages can foster the instructor-student relationship. *Journal of Microbiology & Biology Education*, *25*(1), 1–5. https://doi.org/10.1128/jmbe.00004-24

Navarro, A., Armenta, R. F., & Rice, M. M. (2025). "We are way too stressed": Balancing academic priorities with mental health and wellness among life science undergraduates. *CBE—Life Sciences Education*, *24*(2), 1–14. https://doi.org/10.1187/cbe.24-09-0226

Owens, M. T., Trujillo, G., Seidel, S. B., Harrison, C. D., Farrar, K. M., Benton, H. P., … Tanner, K. D. (2018). Collectively improving our teaching: Attempting biology department–wide professional development in scientific teaching. *CBE—Life Sciences Education*, *17*(1), ar2. https://doi.org/10.1187/cbe.17-06-0106

Owens, M. T., Seidel, S. B., Wong, M., Bejines, T. E., Lietz, S., Perez, J. R., … Tanner, K. D. (2017). Classroom sound can be used to classify teaching practices in college science courses. *Proceedings of the National Academy of Sciences*, *114*(12), 3085–3090. https://doi.org/10.1073/pnas.1618693114

Ovid, D., Abrams, L., Carlson, T., Dieter, M., Flores, P., Frischer, D., … Tanner, K. D. (2023). Scientist spotlights in secondary schools: Student shifts in multiple measures related to science identity after receiving written assignments. *CBE—Life Sciences Education*, *20*(2), ar22, 1–22.

Ovid, D., Rice, M. M., Luna, J. V., Tabayoyong, K., Lajevardi, P., & Tanner, K. D. (2021). Investigating student perceptions of instructor talk: alignment with researchers' categorizations and analysis of remembered language. *CBE—Life Sciences Education*, *20*(4), 1–24. https://doi.org/10.1187/cbe.21-06-0153

Ovid, D., Acosta-Parra, A. R., Alemayehu, A., Francisco Gomez, J., Tran, D., & Tripp, B. (2024). "All of us are capable, and all of us can be scientists." The impact of Scientist Spotlight assignments with undergraduates in physiology courses. *Advances in Physiology Education*, *48*(4), 770–783. https://doi.org/10.1152/advan.00116.2024

Pfeifer, M. A., Cordero, J. J., & Stanton, J. D. (2023). What I wish my instructor knew: How active learning influences the classroom experiences and self-advocacy of STEM majors with ADHD and specific learning disabilities. *CBE—Life Sciences Education*, *22*(1), 1–20. https://doi.org/10.1187/cbe.21-12-0329.

R Core Team. (2017). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Schinske, J., Cardenas, M., & Kaliangara, J. (2015). Uncovering scientist stereotypes and their relationships with student race and student success in a diverse, *Community College Setting. CBE-Life Sciences Education*, *14*(3), ar35.

Schinske, J., Perkins, H., Snyder, A., & Wyer., M. (2016). Scientist spotlight homework assignments shift students' stereotypes of scientists and enhance science identity in a diverse introductory science class. *CBE - Life Sciences Education*, *15*(3), ar47.

Schussler, E. E., Weatherton, M., Chen Musgrove, M. M., Brigati, J. R., & England, B. J. (2021). Student perceptions of instructor supportiveness: what characteristics make a difference? *CBE—Life Sciences Education*, *20*(2), ar29. https://doi.org/10.1187/cbe.20-10-0238

Schwartz, H. L. (2019). What is connected teaching? In *Connected Teaching*. Routledge.

Seidel, S. B., Reggi , A. L., Schinske , J. N., Burrus , L. W., & Tanner , K. D. (2015). Beyond the biology: A systematic investigation of noncontent instructor talk in an introductory biology course. *CBE—Life Sciences Education*, *14*, ar43.

Seidel, S. B., & Tanner, K. D. (2013). "What if students revolt?"—Considering student resistance: Origins, options, and opportunities for investigation. *CBE—Life Sciences Education*, *12*(4), 586–595. https://doi.org/10.1187/cbe-13-09-0190

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., … Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences*, *117*(12), 6476–6483. https://doi.org/10.1073/pnas.1916903117

Trujillo, G., & Tanner, K. D. (2014). Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity. *CBE—Life Sciences Education,*, *13*(1), 6–15. https://doi.org/10.1187/cbe.13-12-0241

Valdez, C., & Kelp, N. C. (2023). Student perceptions of inclusive pedagogy in undergraduate STEM classrooms. *Journal of Microbiology & Biology Education*, *24*(3), 1–12. https://doi.org/10.1128/jmbe.00097-23

Villa, III, A. M., & Sedlacek, Q. C. (2024). A systematic review of complex instruction in the United States. *Intercultural Education*, *36*(1), 1–16. https://doi.org/10.1080/14675986.2024.2425555

Walker, D. K., Bustamante, V. P., Blomgren, H. E., Edwards, J. D., & Frey, R. F. (2024). A mixed methods study exploring students' open-ended responses about course inclusivity in general chemistry 1. *Journal of Chemical Education*, *101*(4), 1403–1415. https://doi.org/10.1021/acs.jchemed.3c00781

Weatherton, M., Schussler, E. E., Brigati, J. R., Ferguson, H., Boyd, I., & England, B. J. (2024). Is support in the anxiety of the beholder? how anxiety interacts with perceptions of instructor support in introductory biology classes. *CBE—Life Sciences Education*, *23*(4), 1–14. https://doi.org/10.1187/cbe.24-02-0092

Wickham, H., & Wickham , H. (2009). *ggplot2 Elegant Graphics for Data Analysis Introduction*. New York: Springer.

Wilson, J. H., & Locker, L. (2007). Immediacy scale represents four factors: Nonverbal and verbal components predict student outcomes. *The Journal of Classroom Interaction*, *42*(2), 4–10. Retrieved from http://www.jstor.org/stable/23869788

Witt, P. L., Wheeless, L. R., & Allen, M. (2004). A meta-analytical review of the relationship between teacher immediacy and student learning.

Communication Monographs, *71*(2), 184–207. https://doi.org/10.1080/03645204200022805 4

Yonas, A., Sleeth, M., & Cotner, S. (2020). In a "scientist spotlight" intervention, diverse student identities matter. *Journal of Microbiology & Biology Education*, *21*(1), 1–12. https://doi.org/10.1128/jmbe.v21i1.2013

York, A. M., Miller, K. G., Cahill, M. J., Bernstein, M. A., Barber, A. M., Blomgren, H. E., & Frey, R. F. (2024). An exploratory mixed-methods analysis of factors contributing to students' perceptions of inclusion in introductory stem courses. *CBE—Life Sciences Education*, *23*(3), 1–16. https://doi.org/10.1187/cbe.23-04-0055

SUPPLEMENTAL MATERIAL

CBE—Life Sciences Education

Investigating Undergraduate Student Perceptions of Classroom Inclusion – Emergence of the Student Perceptions of Instructor Practices – Inclusion/Exclusion (SPIP-I/E) Framework

Mallory M. Rice*, Lorenzo Lones*, Lucy M. C. Luong*, Maurina L. Aranda, Katherine M. Farrar, Kimberly D. Tanner

*These authors contributed equally to this work and should be considered co–first authors.

Context of the Study: An Undergraduate Biology Department with Prevalent Evidence-based Teaching Practices

Here, we share the details of the departmental context for this study, where the vast majority of instructors (nearly 85%) have engaged in extensive professional development in scientific teaching through the Biology Faculty Explorations in Scientific Teaching (FEST) program (Owens *et al.*, 2018). We hypothesized that students may be more likely to share a wider range of perceptions of instructor practices associated with feelings of inclusion or inclusion since these students may have been exposed to a wide range of pedagogical strategies. This may make this departmental context for the study different than biology departments at other institutions without such prior professional development efforts.

As a reminder, in this study, all instructors teaching a major or non-majors biology courses in Spring 2018 were invited to have their courses participate in the department-wide assessment, NOT just instructors who had participated in professional development efforts in the past. Of the 53 biology courses represented in this study on student perspectives of classroom inclusion and exclusion, 82% of instructors had previously participated in at least one departmental professional development program on evidence-based teaching from 2014-2017, which is reflective of the broader departmental context.

In response to questions on the 2018 department-wide survey that were NOT specifically related to the study research questions, student responses provided evidence that they perceive biology instructors as regularly using multiple evidence-based teaching practices (black and light grey bars), in addition to traditional lecture. This data is shown below in comparison to annual results using the same questions that have since department-wide professional developments began in 2013 (Figure S1).

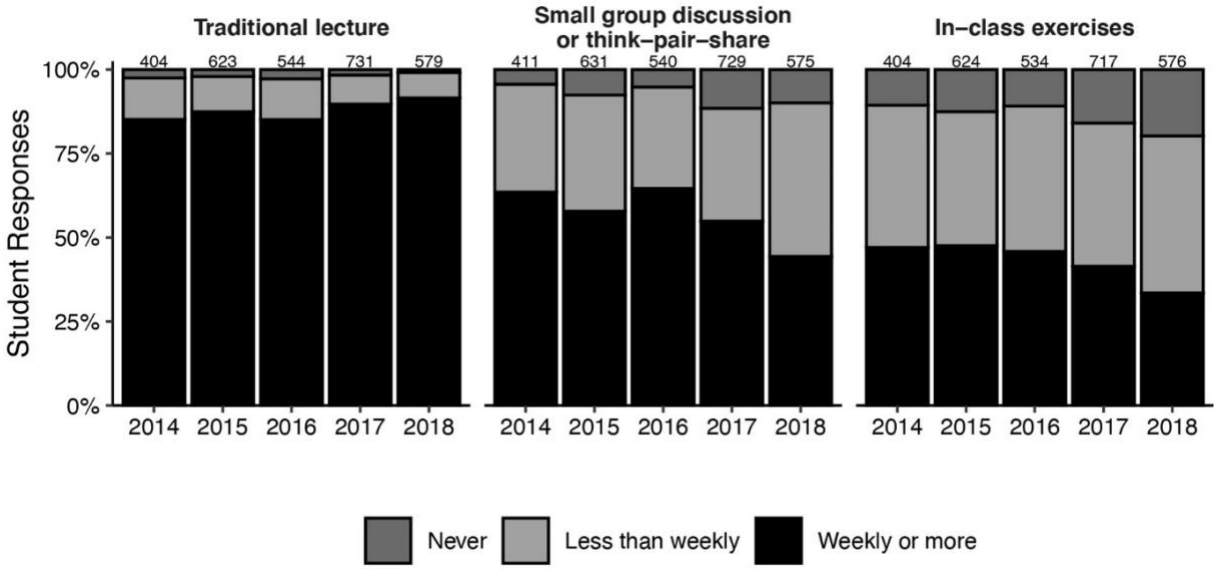

Figure S1. Student perceptions of active learning practices used in their biology courses in Spring Semesters 2014-2018) after their biology instructor(s) participated in initial professional development on evidence-based, inclusive teaching practices. *Sample sizes on top of the bars indicate the total number of student responses for that prompt during that survey year. Student respondents varied year to year. The sample size across different teaching strategies (traditional lecture, small group discussion or think-pair-share, in-class exercises) for each year varied because a small number of students left some of those questions blank. Data shown from years 2014-2017 were previously published in the Owens et al. (2018) study.*

The data analysis used to produce Figure S1 followed that described in the Owens *et al.* (2018) study. In the 2018 analyses, a total of 1,173 undergraduate students enrolled in biology courses during the Spring 2018 semester participated in the department-wide assessment (34% response rate, n = 1,173/3,425

students). After applying exclusion criteria (see Methods), 593 students remained in the overall dataset for the department-wide survey evidence. The sample size across different teaching strategies varied from the overall 593 student n-value because a small number of students left some of these questions blank. In 2018, 91.5% of students (n = 530/579) reported that their instructors used traditional lectures weekly or more, 7.6% of students (n = 44/579) reported less than weekly use, and 0.9% of students (n = 5/579) reported that traditional lectures were never used. For small group discussions, 44.3% of students (n = 255/575) reported weekly or more use, 45.7% of students (n = 263/575) reported less than weekly use, and 9.9% of students (n = 57/575) reported that these activities were never used. For in-class exercises, 33.5% of students (n = 193/576) reported weekly or more use, 46.7% of students (n = 269/576) reported less than weekly use, and 19.8% of students (n = 114/576) reported in-class activities were never used. Additional information about these data collection methods and analyses are available on request.

Statistical information on the disaggregation of student perceptions of INCLUSIVE or EXCLUSIVE instructor practices across student demographic characteristics

For the inclusion prompt disaggregation analysis, students had to complete the entire demographics form and report at least one instructor practice associated with feelings of inclusion (n = 346/375). A similar proportion of women or gender non-conforming students and men shared instructor practices that made them feel included (Pearson chi-square test; the $\chi^2 = <$ 0.001, P = 1.00). Similarly, a comparable proportion of first-generation college students and continuing-generation college students shared instructor practices that they associated with feelings of inclusion (Pearson chi-square test; χ^2 = 1.14, P = 0.29). A similar proportion of students of color reported instructor practices that made them feel included in their biology course relative to non-students of color (Pearson chi-square test; χ^2 = 0.62, P = 0.43). Lastly, a similar proportion of transfer students and non-transfer students reported feeling included (Pearson chi-square test; χ^2 = 0.80, P = 0.37). Due to multiple comparisons, we used an alpha level of P = 0.0125 for significance.

For the exclusion prompt disaggregation analysis, students also had to complete the entire demographics form and report at least one instructor practice associated with feelings of exclusion (n = 167/183). Importantly, as a reminder, 77 students reported that their instructor did not engage in any exclusive practices (e.g. “nothing is exclusive” or “nothing”). As such, these 77 students were not included in this analysis. A similar proportion of women or gender non-conforming students and men shared instructor practices that made them feel excluded (Pearson chi-square test; χ^2 = 1.1, P = 0.30). Similarly, a comparable proportion of first-generation college students and continuing-generation college students shared instructor practices that they associated with feelings of exclusion (Pearson chi-square test; χ^2 = 0.05, P = 0.83). While a higher proportion of students of color reported instructor practices that made them feel excluded in their biology course relative to non-students of color, the difference was not significant (Pearson chi-square test; χ^2 = 2.79, P = 0.095). Transfer students reported feeling excluded less often relative to non-transfer students (Pearson chi-square test; χ^2 = 6.28, P = 0.012). Due to multiple comparisons, we used an alpha level of P = 0.0125 for significance.