Investigating Instructor Talk among Graduate Teaching Assistants in Undergraduate Biology Laboratory Classrooms

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ABSTRACT

Instructor Talk—noncontent and nonlogistical language that is focused on shaping the classroom learning environment—is a recently defined variable that may play an important role in how undergraduates experience courses. Previous research characterized Instructor Talk used by faculty teaching in biology lecture classrooms. However, graduate teaching assistants (GTAs) and laboratory classrooms represent critical factors in undergraduate education, and Instructor Talk in this context has yet to be explored. Here, we present findings analyzing Instructor Talk used by GTAs teaching in undergraduate biology laboratory classrooms. We characterized the Instructor Talk used by 22 GTA instructors across 24 undergraduate biology laboratory courses in the context of a single, urban, Hispanic-serving and Asian American and Pacific Islander–serving Institution. We found that Instructor Talk was present in every course studied, GTAs with pedagogical training and prior teaching experience used more Instructor Talk than those without, and GTAs teaching laboratory courses used more Instructor Talk than previous observations of faculty teaching lecture courses. Given the widespread use of Instructor Talk and its varying use across contexts, we predict that Instructor Talk may be a critical variable in teaching, specifically in promoting equity and inclusion, which merits continued study in undergraduate science education.

INTRODUCTION

Diverse groups of people are more effective at solving complex problems than homogenous groups of high-achieving individuals (Hong and Page, 2004). As such, if we want to address our most complex biological problems, we need diverse groups of scientists working together. Unfortunately, the sciences are particularly exclusive disciplines. Undergraduate students leave the sciences at higher rates than other disciplines, and who leaves can be predicted based on personal characteristics such as race, ethnicity, gender, and sexual orientation (Seymour and Hewitt, 1997; Hughes, 2018; Seymour and Hunter, 2019). The findings of student-centered research suggest turning our focus to the choices, behaviors, and approaches of instructors to improve undergraduate science education and increase diversity and inclusion in the sciences.

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Instructors shape the classroom environment through what they say and do. Instructor Talk, referred to as noncontent language, is "any language used by an instructor that is not directly related to the concepts under study but instead focuses on creating the learning environment" (Seidel *et al.*, 2015; Harrison *et al.*, 2019). Here are two examples of previously recorded instances of Instructor Talk (Harrison *et al.*, 2019) that directly reference student learning in contrasting ways:

1. "If you couldn't remember at the end of the class what you learned in the beginning, then the learning is really quite useless, right? Because we really hope that you'll remember 5 years from now."
2. "So make sure you understand this. It's going to be very, very valuable for scoring high points there."

The first example of Instructor Talk encourages students to learn for the long-term, while the second example encourages students to learn for points. Such contrasting examples illustrate how aspects of noncontent instructor language can shape the classroom learning environment.

Based on these characteristics of noncontent language, we hypothesize that Instructor Talk may have a profound impact on student learning, inclusion, and success in biology. Instructor Talk research thus far has been informed by the theoretical and phenomenological frameworks of instructor immediacy, student resistance to active learning, and stereotype threat. First, *instructor immediacy*—the perceived sociopsychological distance between instructors and their students—can be shaped by an instructor's language and behaviors to affect student learning and sense of inclusion (Mehrabian, 1971; Kearney *et al.*, 1988; Kelley and Gorham, 1988). Second, instructors may worry that students will resist innovative teaching techniques; however, the way instructors prime their students for active learning could greatly influence the chances of student resistance (Seidel and Tanner, 2013). Finally, a phenomenon known as *stereotype threat*—when people are concerned with confirming negative stereotypes about groups to which they belong—can negatively impact students' performance on high-stakes exams (Steele and Aronson, 1995). Instructors could impact student performance by either inducing or mitigating stereotype threat with their noncontent language. These factors—instructor immediacy, student resistance, and stereotype threat—suggest that Instructor Talk may be central to student learning, performance, and sense of belonging in a science classroom.

Instructor Talk has been characterized in lecture classrooms taught by faculty at more than a dozen institutions, including faculty at 4-year universities and 2-year community colleges (Seidel *et al.*, 2015; Harrison *et al.*, 2019; Lane *et al.*, 2021; Meaders *et al.*, 2021), and postdoctoral scientists teaching online (Seah *et al.*, 2021). Two frameworks to categorize Instructor Talk emerged from Harrison *et al.* (2019). These frameworks consisted of Positively Phrased Instructor Talk with five categories and 18 subcategories and Negatively Phrased Instructor Talk with five categories and 15 subcategories. Sampling from a large number and range of biology lecture courses taught by faculty, Harrison *et al.* (2019) categorized approximately 90% of Instructor Talk instances in the Positively Phrased framework. The remaining 10% was categorized with the Negatively Phrased framework, which included Instructor Talk that may discourage students or distract from the learning process. Notably, all instructors studied to date had participated in pedagogical training on evidence-based teaching. Therefore, the Instructor Talk characterized in previous studies may not reflect the kinds of Instructor Talk used by instructors with little to no pedagogical training and experience. One may wonder about the characteristics of noncontent language among instructors without pedagogical training or at earlier stages of their careers, like graduate student instructors.

While previous studies have characterized Instructor Talk in lecture classrooms taught by faculty, we have yet to characterize Instructor Talk in laboratory courses taught by graduate teaching assistants, hereafter referred to as GTAs. Graduate students play a key role as instructors. Importantly, science, technology, engineering, and mathematics (STEM) graduate students teach more than 90% of laboratory sections at research institutions in the United States (Sundberg *et al.*, 2005). STEM graduate students also come from more diverse backgrounds than faculty (National Science Foundation, 2021). Interestingly, a congruence between the gender or racial and ethnic identities of GTAs and undergraduates does not appear to correspond to academic performance, but rather, it is the GTAs' professional development in inclusive teaching that may ultimately foster equitable student achievement in science laboratory courses (Wheeler *et al.*, 2017; Lee and Ing, 2020). GTAs play an important role in guiding first-year students and nonmajors through their prerequisite course work. For undergraduate biology students, STEM GTAs in laboratory courses may be the most accessible instructors in their collegiate journey. Therefore, to foster an inclusive and equitable undergraduate student experience in STEM fields, we must consider how to support the pedagogical training of STEM GTAs teaching laboratory courses. Instructor Talk could be a key part of this professional development.

Several researchers have investigated pedagogical training for STEM graduate students (Gormally *et al.*, 2016; Patrick *et al.*, 2016; Lee, 2019). One may question how GTA pedagogical training corresponds to changes in their instruction. A possible outcome to measure may be graduate students' use of noncontent language in their laboratory courses; however, the nature of GTA Instructor Talk has yet to be characterized. Because GTAs are in a different phase of their careers than their faculty counterparts, they likely navigate classroom teaching differently than faculty. Further, STEM GTAs primarily teach laboratory courses and not lectures, so there is a confounding variable for what is unique to labs or to their career phase. In the present study, we hypothesize that several characteristics of GTAs may influence the nature of their Instructor Talk: GTAs' near-peer relationship with students, dual identity as graduate students and instructors, and prior teaching experience and pedagogical training.

First, we hypothesize that GTAs' near-peer relationship with undergraduate students may contribute to the language they use while teaching. Given that undergraduates who persist in STEM majors cite GTAs as more approachable than professors for academic support (Seymour and Hewitt, 1997; Seymour and Hunter, 2019), GTAs may be an exemplar for investigating instructor immediacy. Further, laboratory sections tend to have smaller class sizes than lectures, so GTAs may foster instructor immediacy by offering individualized attention to students. Additionally, according to a survey by the National Postsecondary Student Aid Study, the average age of graduate students in

the biological and biomedical sciences in 2007 was among the lowest of various fields of study in the United States—28.5 years (Bell, 2009). Perhaps due to GTAs' relatively younger age, undergraduate students may perceive GTAs as more relatable, understanding, and able to personalize teaching when compared with faculty instructors in biology (Kendall and Schussler, 2012, 2013). Along with these factors, we predict that GTAs use different kinds of noncontent language when teaching to foster their near-peer relationship with undergraduates. The nature of Instructor Talk used by GTAs could be one explanatory mechanism for student perceptions of GTAs compared with faculty.

Second, despite the benefits GTAs may have with their near-peer relationship and approachability for undergraduates, GTAs generally have less teaching experience relative to faculty. Park and Ramos (2002) described GTAs' lack of ownership in their job and dual identity as both students and instructors. Further, undergraduates may perceive graduate students to be more hesitant, nervous, and uncertain than their faculty counterparts in biology (Kendall and Schussler, 2012). We hypothesize that this dual identity in relation to GTAs' teaching roles may impact their Instructor Talk. For example, GTAs may sense a need to exert control and assume poor behaviors of undergraduate students in anticipation of student resistance to lab activities that they did not design or even teach before. These factors suggest that GTAs' Instructor Talk in lab classrooms would differ from faculty in lecture classrooms.

Third, although GTAs tend to have less teaching experience, they likely encounter a range of professional development opportunities in scientific teaching. Pedagogical training is increasingly available, though widely variable, across institutions (Schussler *et al.*, 2015). Such training can decrease the teaching anxiety felt by GTAs (Chen Musgrove and Schussler, 2022). Further, pedagogical training and prior teaching experience increase the self-efficacy of GTAs and new instructors, both in STEM (DeChenne *et al.*, 2015; Connolly *et al.*, 2018) and across academic departments (Prieto and Altmaier, 1994). Self-efficacy, or the belief in one's own abilities and capacity to deal with various situations, may impact how GTAs communicate with students. Previous research on the outcomes of pedagogical training for early-stage faculty demonstrated shifts in instructors' attitudes about students when the training addressed inclusion in STEM classrooms and explored barriers to learning, like stereotype threat (Frey *et al.*, 2020; O'Leary *et al.*, 2020). Therefore, we hypothesize that prior teaching experience and pedagogical training could correspond to variation in GTAs' Instructor Talk. However, the influence of prior teaching experience and pedagogical training on GTAs' language used in laboratory classrooms has yet to be studied.

Finally, providing opportunities to reflect on one's own Instructor Talk is a potential method for encouraging instructors to be metacognitive about the language they use in the classroom and how it might impact students. Metacognition not only encourages our students to learn but could also be a strategy to improve instructors' teaching (Tanner, 2012). In response to calls for expanding the professional development provided to GTAs (Rushin *et al.*, 1997; Park and Ramos, 2002; Kendall *et al.*, 2013; DeChenne *et al.*, 2015; Chen Musgrove and Schussler, 2022), we anticipate that metacognitive reflection about noncontent instructor language would be an effective intervention for GTA pedagogical training. However, the extent to which GTAs use noncontent language in laboratory courses and their metacognitive reflections on such language have yet to be determined. Findings from a systematic investigation of GTA Instructor Talk could offer a new approach for professional development to better align the language used by GTAs with goals for student learning and inclusion.

Given the importance of GTAs and laboratory courses in undergraduate students' biology education, we investigated the Instructor Talk used by GTAs in this context to address a gap in the research literature. These investigations were guided by the following research questions:

1. To what extent is Instructor Talk present in biology laboratory classrooms taught by GTAs?
2. To what extent can the Instructor Talk used by GTAs be characterized using the existing Instructor Talk frameworks?
3. How, if at all, does the Instructor Talk used by GTAs teaching in laboratory classrooms differ quantitatively and qualitatively from that previously observed among faculty teaching in lecture classrooms?
4. To what extent does the quantity and type of Instructor Talk in laboratory classrooms taught by GTAs vary depending on whether the GTA has gone through professional development in teaching or has prior teaching experience?

METHODS

To address these research questions, GTAs in a master's program at a large urban university audio-recorded their laboratory courses across the biology department. Laboratory courses in the study included those in general biology for majors and nonmajors, cell and molecular biology, ecology and evolution, and physiology. The pedagogy of these laboratory courses varied from traditional cookbook labs to inquiry-based labs; no course-based undergraduate research experiences (CUREs) are represented.

Institutional Research Board

This study was determined to be exempt from oversight by the Institutional Review Board at San Francisco State University under project number E18-322 and represents a master's-level graduate thesis.

Recruitment

A small pilot study was conducted during an initial semester and expanded to a larger study conducted the following semester. For the pilot study, we contacted six GTAs and asked them to audio-record their biology laboratory classrooms. The following semester, we identified 38 GTAs teaching at least one undergraduate laboratory course within the biology department, based on the course schedule and communications with laboratory coordinators. We successfully contacted 37 GTAs and invited them to participate by audio-recording their laboratory courses. A $50 gift card was offered as compensation for completing the required class recordings for the study. Overall, 41 unique GTAs were invited to participate in this research, including both the pilot study (six GTAs invited, five participated) and the main study (37 GTAs invited, two of whom were also in the pilot).

Data Collection

GTAs who agreed to audio-record their courses were issued a standard recorder to be carried in their lab coat pockets and

exchanged monthly to allow for frequent data backups. The number of each audio recorder was saved in a password-protected Excel file along with the name of the GTA to ensure that audio files were connected to a pseudonym for each participant. Only the primary researcher, K.A.G., had access to this encrypted Excel file. At the end of the semester, each GTA was asked to complete an optional, short demographic survey. This survey asked GTAs about their pedagogical training, prior teaching experience, gender, race/ethnicity, and whether they were first-generation college-going students. GTAs were excluded from analyses if fewer than 50% of their class sessions were recorded.

Data Analyses

To investigate whether Instructor Talk is present in biology laboratory courses taught by GTAs and to what extent GTAs' noncontent language can be characterized by existing frameworks, audio recordings were transcribed and instances of Instructor Talk were coded using the methods described in the following sections.

Transcribing and Identifying Instances of Instructor Talk

Audio recordings were only heard by the primary researcher, K.A.G., as they were transcribed. Transcriptions were only associated with pseudonyms. To train the primary researcher, the senior researcher who co-developed the Instructor Talk frameworks with both Seidel *et al.* (2015) and Harrison *et al.* (2019), K.D.T., reviewed transcripts with K.A.G. to identify instances of Instructor Talk. Subsequently, K.A.G. transcribed all possible instances of Instructor Talk, ignoring any student or instructor language about biology content. An instance of Instructor Talk is defined as a coherent set of language used by an instructor that is not directly related to the concepts under study but instead focuses on creating the learning environment (Seidel *et al.*, 2015). The transcriptions of all possible instances of Instructor Talk included an oversampling of instances that were not Instructor Talk, suggesting the primary researcher was generous in identifying instances of Instructor Talk in the transcription process. Wherever possible, Instructor Talk instances were split into pieces that could be assigned to a single framework (Positively Phrased or Negatively Phrased), as well as a single category and subcategory. To compare how Instructor Talk used by GTAs teaching laboratory classrooms differs from previously recorded Instructor Talk from faculty teaching lecture classrooms (Harrison *et al.*, 2019), an instance of Instructor Talk was established if the quote could be coded by a single category and subcategory, as defined in previous studies (Seidel *et al.*, 2015; Harrison *et al.*, 2019).

Validating a Sampling Strategy

To collect Instructor Talk among GTAs teaching laboratory courses, we validated a sampling strategy that was previously established by Harrison *et al.* (2019) for use in lecture classrooms taught by faculty. This sampling strategy was grounded in the observation that the first 15 minutes of a class session will have a representative or enriched sample of Instructor Talk when compared with an entire class session. The samples were even representative of category and subcategory levels of Instructor Talk used for the whole course (Harrison *et al.*, 2019). To assess the validity of this sampling strategy in lab classrooms, class sessions recorded in the initial pilot study were transcribed in their entirety. These class sessions were then analyzed to confirm that this sampling strategy would yield representative or enriched samples of Instructor Talk in laboratory courses. We compared the prevalence of Instructor Talk in the first 15 minutes of a class session with the prevalence of Instructor Talk across an entire class session. Further, to confirm that the sampling method accurately represented instances of Instructor Talk across categories of the frameworks, the entire lab class recordings for the five pilot GTAs were divided into three parts, and categorical instances were quantified in each respective part, which additionally demonstrated that Instructor Talk was indeed concentrated in the beginning of class sessions (see Supplemental Figure A). After confirming the validity of this sampling strategy with laboratory courses, we shifted to transcribing only the first 15 minutes of class session over dozens of courses recorded in the second semester of the study. To compare GTA Instructor Talk in laboratory courses with previously recorded instances of Instructor Talk in lecture courses taught by faculty in Harrison *et al.* (2019), we used the same sampling method as the previous study. Two 15-minute samples per instructor were transcribed—one from early in the semester and one from the middle of the semester—and then combined into a single 30-minute sample per instructor. All GTAs were instructed to record all class sessions throughout the semester without knowledge of which recordings would be analyzed.

Structure of Instructor Talk Frameworks and Coding Instances of GTA Instructor Talk

To characterize the types and prevalence of GTAs' Instructor Talk in biology laboratory courses, K.A.G. and K.D.T. coded transcripts using previously developed Instructor Talk frameworks (Table 1). Seidel *et al.* (2015) and Harrison *et al.* (2019) developed the Positively Phrased and Negatively Phrased Instructor Talk frameworks from transcribed recordings of faculty teaching lecture courses in undergraduate biology. They analyzed instances of Instructor Talk using a grounded theory approach. Each resulting framework consists of five overarching categories and 15–17 subcategories (see Table 1). Notably, the categories and subcategories of the Negatively Phrased Instructor Talk framework mirror those of the Positively Phrased framework. The five categories of the Positively Phrased Instructor Talk framework are 1) Building the Instructor/Student Relationship, 2) Establishing Classroom Culture, 3) Explaining Pedagogical Choices, 4) Sharing Personal Experiences, and 5) Unmasking Science. The mirroring five categories of the Negatively Phrased Instructor Talk framework are 1) Dismantling the Instructor/Student Relationship, 2) Disestablishing Classroom Culture, 3) Compromising Pedagogical Choices, 4) Sharing Personal Judgment, and 5) Masking Science.

In the present study, each transcribed GTA quote was coded as Instructor Talk or Not Instructor Talk. From the resulting Instructor Talk instances, K.A.G. and K.D.T. independently 1) coded whether the Instructor Talk instance was Positively Phrased or Negatively Phrased, 2) assigned the instance to one of the five categories in the corresponding framework, and 3) categorized the instance into one of the remaining subcategories. Instances of Instructor Talk were assumed to be Positively Phrased wherever possible. Negatively Phrased categories were reserved for Instructor Talk that represented "language

TABLE 1. Instructor Talk framework[a]

Positively Phrased		Negatively Phrased	
Category	**Subcategories**	**Category**	**Subcategories**
Building the Instructor/ Student Relationship	Demonstrating Respect for Students	Dismantling the Instructor/ Student Relationship	Ignoring Student Challenges
	Revealing Secrets to Success		Assuming Poor Behaviors from Students
	Boosting Self-Efficacy		Making Public Judgments about Students
Establishing Class Culture	Preframing Classroom Activities	Disestablishing Class Culture	Expecting Students to Know What to Do
	Practicing Scientific Habits of Mind		No instances observed yet
	Building a Biology Community among Students		Discouraging Community among Students
	Giving Credit to Colleagues		Criticizing Colleagues
	Indicating That It Is Okay to Be Wrong or Disagree		Encouraging Only the Right Answer
Explaining Pedagogical Choices	Supporting Learning through Teaching Choices	Compromising Pedagogical Choices	Expressing Doubt in Pedagogical Choice
	Using Student Work to Drive Teaching Choices		Using Convenience to Drive Teaching Choices
	Connecting Biology to the Real World and Career		No instances observed yet
	Discussing How People Learn		Teaching to a Subset of Students
	Fostering Learning for the Long Term		Focusing on the Grade/Short Term
Sharing Personal Experiences	Recounting Personal Information/ Anecdotes	Sharing Personal Judgment	Sharing Self-Judgment/Self-Pity
	Relating to Student Experiences		Distancing from Student Experiences
Unmasking Science	Being Explicit about the Nature of Science	Masking Science	Being Implicit about the Nature of Science
	Promoting Diversity in Science		Intimidating Students from Science
	Fostering Wonder		No instances observed yet

[a]Adapted from Seidel *et al.* (2015); Harrison *et al.* (2019).

that may discourage students or distract from the learning process" (Harrison *et al.*, 2019, p. 2). Each researcher then assigned a category and subcategory, splitting instances into multiple categories or subcategories if necessary, to assign a single code to each instance. The categorization and subcategorization processes were supported using details from the published Instructor Talk framework rubrics (see supplemental material for Harrison *et al.*, 2019) and prior examples of Instructor Talk. Both researchers then met to discuss their assignments and coded each instance to consensus. If an Instructor Talk instance did not fit any category or subcategory, a new category or subcategory would be created.

Post Hoc Quantification and Statistical Analyses

After harvesting and coding instances of Instructor Talk, we quantified and compared the number of different types of Instructor Talk. For each instructor, we quantified the total number of Instructor Talk instances that were coded as Positively versus Negatively Phrased and in each category and subcategory per 30-minute sample. We then calculated the average rate (mean ± SEM) of Instructor Talk used by different groups of instructors, such as GTAs versus faculty, instructors with or without formal pedagogical training, or instructors with or without prior teaching experience. We also compared the average rate (mean ± SEM) of Instructor Talk during the early-semester sample with the average rate of Instructor Talk during the midsemester sample. We tested for normality of the data with the Shapiro-Wilk test and for equal variance with Levene's test in R (R Core Team, 2019). Because unequal variance was to be expected and normality of the data is not essential for Welch's *t* test (Delacre *et al.*, 2017), we performed Welch's unequal variance t tests. Statistical analyses were conducted in R (R Core Team, 2019). To minimize type I error from multiple statistical comparisons in our category-level analyses, Bonferroni corrections were used for the five category-level comparisons of each Instructor Talk framework (significance level was set at 0.01).

Disaggregation of Instructor Talk Data by GTA Teaching Experience and Pedagogical Training

For the purposes of investigating the impact of prior teaching experience and pedagogical training, we categorized GTAs based on their stated prior teaching experience and pedagogical training on the optional demographic survey. GTAs were disaggregated by teaching experience based on their answer to the question, "Do you have any previous experience teaching prior to this semester?" on the demographic survey. GTAs who answered "yes" were listed as having prior teaching experience; GTAs who answered "no" were listed as having no prior teaching experience. GTAs were also categorized by pedagogical training based their answer to the question, "Do you have any formal training in teaching methods (e.g., courses, credentials, workshops)? Please describe." GTAs who described having 5 or more hours of formal pedagogical training were grouped as

having pedagogical training. GTAs who described having fewer than 5 hours of training in effective teaching methods before the start of the semester were grouped as having minimal or no pedagogical training. GTAs were then disaggregated into these three groups:

1. BOTH prior teaching experience AND prior pedagogical training,
2. teaching experience BUT minimal or no pedagogical training, or
3. NO teaching experience AND minimal or no pedagogical training.

None of the GTAs in the present study fit the classification of "NO teaching experience BUT pedagogical training." Given that the assumptions of normality were not met with the Shapiro-Wilk test, statistical differences across groups were tested with the Kruskal-Wallis one-way analysis of variance (ANOVA) test. Dunn's post hoc test (1964) offered pairwise statistical comparisons (significance level set at 0.05). Both Kruskal-Wallis and Dunn's post hoc test were performed in R (R Core Team, 2019).

Identification of Small-Group Instructor Talk

Instructor Talk is defined as "as any language used by an instructor that is not directly related to the concepts under study but instead focuses on creating the learning environment." Previously, this was restricted to instances in which the instructor addressed the entire class (Seidel *et al.*, 2015; Harrison *et al.*, 2019). However, we hypothesized that the structure of laboratory courses may provide opportunities to detect Instructor Talk used with small groups of students. We therefore anticipated a new type of Instructor Talk, Small-Group Instructor Talk, which we predicted would include any instance of Instructor Talk addressing a small group of students, rather than the entire class. Instances of Instructor Talk were considered Small-Group Instructor Talk when the context of the language used or the tone and volume of the instructor's voice made it clear that the instructor was addressing a small group of students or a single student one-on-one during class, rather than the entire class. When there was uncertainty, instances were considered to be addressing the entire class. While Small-Group Instructor Talk potentially could have been present in previous studies, it would not have been captured by the recording methods used. Specifically, the recorder for the lecture courses was kept at the front of the room (Seidel *et al.*, 2015; Harrison *et al.*, 2019), while GTAs were asked to keep recorders for the present study in their pockets. We expected this shift in recording methodology, along with the structure of laboratory courses, might enable the identification of Small-Group Instructor Talk.

GTA Reflection on Instructor Talk Findings

To further engage the participating GTAs in this study, we chose to invite them to discuss the results of this study and reflect on their measured Instructor Talk. Interested and willing GTA collaborators were invited to participate in synchronous meetings and asynchronous reflections on their own Instructor Talk. During the synchronous meetings, GTAs worked in teams to code example instances of Instructor Talk into the five Positively Phrased categories and were asked to reflect on this short experience of qualitative coding. GTAs then received files with their own Instructor Talk samples and were given a few minutes to briefly look through them. The GTAs were then given the opportunity to discuss privately in small groups what their immediate impressions of their Instructor Talk samples were.

After the synchronous meeting, GTAs who were interested in continuing work on this project completed written reflections about their experiences with the project and their own Instructor Talk samples. They were asked to share their response to the following prompt:

> What, if anything, did you learn in reviewing samples of your own Instructor Talk that might influence your teaching in the future?
>
> We appreciate you taking 20–30 minutes or so to share with us in writing your thoughts on the following prompt. Thanks in advance for writing as much detail as you can in complete sentences and paragraphs.

To ensure trustworthiness and independent identification of emergent themes, two coders (K.A.G. and K.D.T.) independently read all GTA reflections and developed their own thematic categories. The two coders came to consensus agreement on the resulting categories, and all language of GTA reflections was discussed and coded into at least one emergent theme. The relative brevity of the reflections, ranging from approximately 30 to 600 words, and the low number of instances of each emergent theme precluded statistical analysis. We will show several examples of themes detected in these reflections.

RESULTS

Participant Population

This study analyzes the data collected from GTAs teaching laboratory courses and compares them with previously published data on faculty teaching lecture courses (Harrison *et al.*, 2019). A summary of the participant population in this study and the participant population of the faculty we used as a comparison is shown in Table 2. All six GTAs who were invited for the pilot study and 20 out of 37 GTAs who were invited for the full study agreed to participate. Five of the six GTAs from the pilot study and 19 of the 37 GTAs from the full study successfully recorded more than 50% of their class sessions and were included in analysis. Two GTAs participated in both studies. This resulted in 22 unique GTAs who audio-recorded 24 unique courses across both semesters.

Validation of a Sampling Method in the Pilot Study

We aspired to gauge the quantity and character of Instructor Talk across a large number of courses. To that end, we validated a previously established sampling strategy in the novel context of laboratory classrooms taught by GTAs. Based on the pilot study of five GTAs' entire lab class recordings that were then divided into three parts, the sampling method was validated to produce representative or enriched profiles of Instructor Talk instances across categories (see Supplemental Figure A). Additionally, we replicated the sampling strategy used by Harrison *et al.* (2019), which examined only the first 15 minutes of a class session with the goal of providing a representative or enriched sample of Instructor Talk. We confirmed that this was

TABLE 2. Participant population

Participant type	Number invited	Participation rate	Sample size (instructors)	Sample size (courses)	Women participants	Participants of color	Participants with prior pedagogical training	Participants with prior teaching experience
GTA	41	51%	22	24	46%	67%	45%	36%
Faculty[a]	59	90%	53	61	58%	Data not available	100%	Data not available

[a]Data reprinted from Harrison *et al.* (2019).

the case in the pilot study by comparing the actual percentage of Instructor Talk that was found in the first 15 minutes with the expected percentage if Instructor Talk were evenly distributed across the class session. The expected percentage of Instructor Talk that would be found in the first 15 minutes of a class session, if Instructor Talk instances were evenly distributed, was calculated by dividing 15 minutes by the length of the class session. For example, if a class session was 60 minutes long, we would expect 25% of the Instructor Talk instances to occur during the first 15 minutes if they were evenly distributed. We compared this with the actual percentage of Instructor Talk instances that occurred during the first 15 minutes using two class sessions for each of the five courses recorded during the initial semester.

As shown in Figure 1, the actual percentage of Instructor Talk that occurred in the first 15 minutes was greater than the expected percentage of Instructor Talk for all five courses (61.0% actual vs. 19.6% expected; 50.7% actual vs. 20.3% expected; 44.8% actual vs. 22.6% expected; 38.2% actual vs. 13.3% expected; 36.9% actual vs. 14.1% expected), suggesting this sampling method would provide representative or enriched samples of Instructor Talk. Therefore, we used this sampling method for the remainder of our analyses. We transcribed two 15-minute samples per instructor—one from early in the semester and one from the middle of the semester. We then combined these early- and midcourse samples into a single 30-minute sample per instructor.

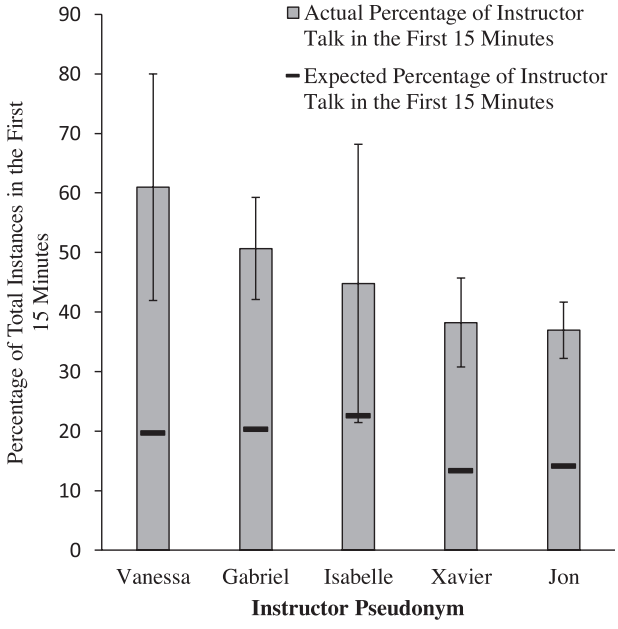

FIGURE 1. Validating a strategy to sample Instructor Talk by comparing the actual percentage of Instructor Talk in the first 15 minutes of a class session (gray bars) with the expected percentage of Instructor Talk (black lines). The average percentage of Instructor Talk instances that would be expected in the first 15 minutes (black lines), assuming a uniform distribution (15 minutes/total class time × 100) is compared with the actual average percentage of Instructor Talk instances in the first 15 minutes (gray bars; *n* = 2 class sessions). Error bars represent mean ± SEM.

Determining Whether Instructor Talk Is Present in Laboratory Classrooms Taught by GTAs

Instructor Talk was found in all 24 courses studied, though the rate of use was highly variable among instructors. Figure 2A depicts the total number of Instructor Talk instances in each instructor's combined 30-minute sample. Figure 2B and C shows the total number of Instructor Talk instances broken down into the 15-minute early- and midcourse samples, respectively, for each instructor. The average rate of Instructor Talk observed per 30 minutes across all 24 courses (mean ± SEM) was 14.0 ± 1.9 instances, and the range was between two and 44 instances per 30 minutes. Both Positively Phrased and Negatively Phrased Instructor Talk were found in laboratory classrooms taught by GTAs, with an average rate of use of Positively Phrased Instructor Talk of 11.8 ± 1.6 instances per 30 minutes and an average rate of use of Negatively Phrased Instructor Talk of 2.3 ± 0.6 instances per 30 minutes. Tables 3 and 4 provide examples of Positively Phrased and Negatively Phrased Instructor Talk instances, respectively, as used by GTAs teaching laboratory courses.

Comparing the Average Quantity of Instructor Talk Used by GTAs Teaching Laboratory Courses with Faculty Teaching Lecture Courses

The average rate of use of Instructor Talk by GTAs teaching laboratory courses (n = 24) was compared with that used by faculty teaching lecture courses (n = 61) in terms of overall Instructor Talk use, Positively Phrased Instructor Talk, and Negatively Phrased Instructor Talk across all categories and subcategories. For some of the categories being compared, the Shapiro-Wilk test showed a nonnormal distribution, and Levene's test showed unequal variance. For comparing groups of unequal variance with assumptions of normality not met (Delacre *et al.*, 2017), we performed Welch's unequal variance t tests. Further, to test the robustness of our chosen statistical analyses to the underlying sample distributions, we also performed the nonparametric Mann-Whitney test on each of these comparisons. For all comparisons, we obtained similarly significant p values (unpublished data).

As shown in Figure 3, the average rate of Instructor Talk used by GTAs teaching laboratory courses was significantly

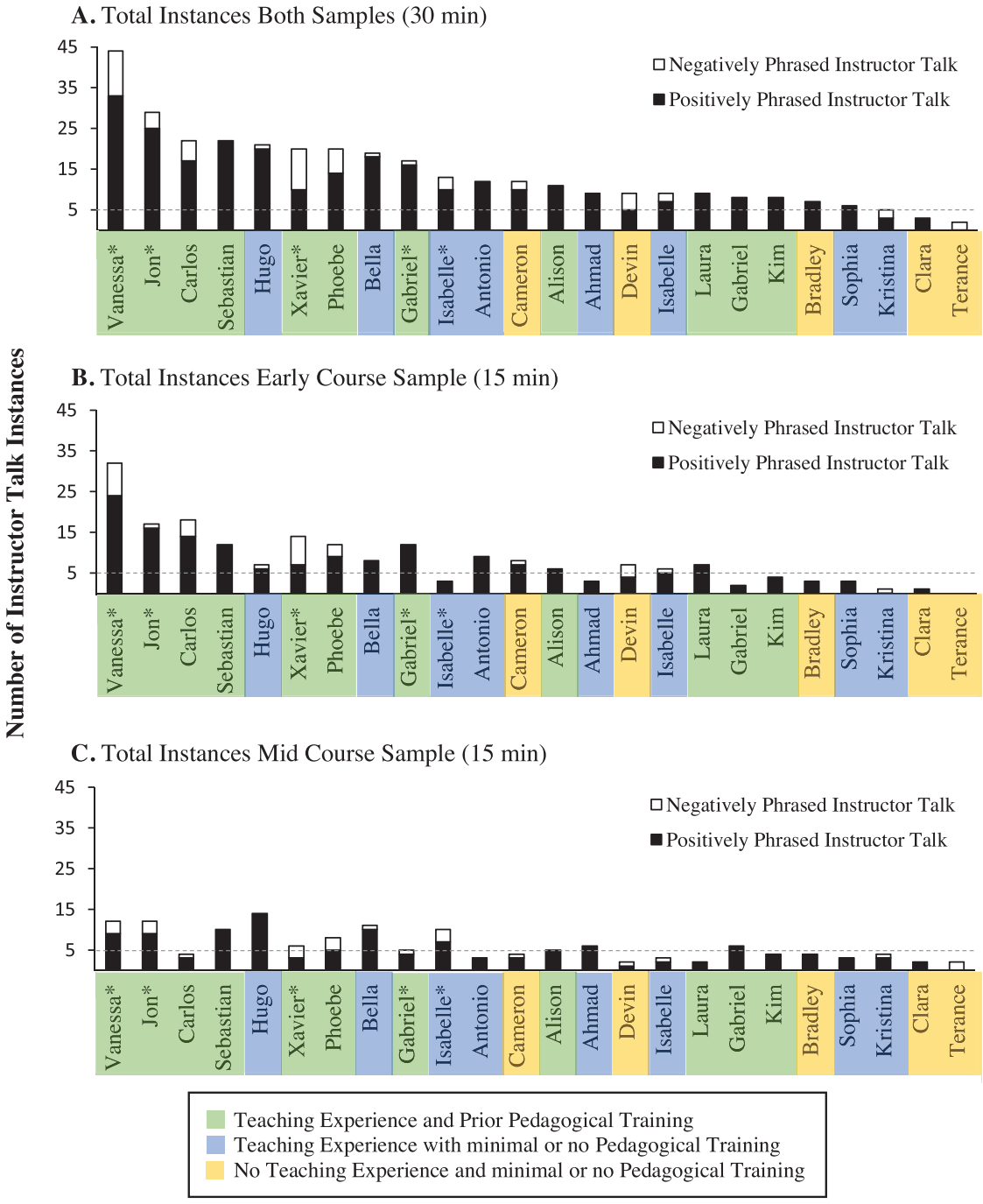

FIGURE 2. Comparison of the rates of use of Positively Phrased Instructor Talk (black bars) and Negatively Phrased Instructor Talk (white bars) per 30 minutes of instruction across 24 courses. Courses are sorted by total amount of Instructor Talk per 30 minutes observed in the combined samples. Courses recorded in the initial semester are indicated by asterisks. (B) Number of Instructor Talk instances found for each instructor for only the early-course sample. (C) Number of Instructor Talk instances found for each instructor for only the midcourse sample. Data are shown for two courses for two GTAs: Gabriel and Isabelle. Dashed line at five instances of Instructor Talk for visual comparison across samples.

higher than by faculty teaching lecture courses (p = 0.03, Welch's unequal variances t test, significance set at 0.05). Specifically, GTAs used 14 ± 1.9 instances per 30 minutes, and faculty used 9.3 ± 0.9 instances per 30 minutes of instruction. The mean and SEM are shown as a bar graph in Figure 3A, and the distribution of individual data points is shown in a box-and-whisker-plot in Figure 3B. Table 5 lists the overall average rate of Instructor Talk use by GTAs and faculty and the rates of use of Positively and Negatively Phrased Instructor Talk.

As shown in Figure 4, the rate of Positively Phrased Instructor Talk observed by GTAs teaching laboratory courses was compared with faculty teaching lecture courses. The overall

TABLE 3. Example instances of Positively Phrased Instructor Talk

Category	Subcategory	Example instances
Building the Instructor/ Student Relationship	Demonstrating Respect for Students	"Pretty much like, raise your hand if you work a job. Raise your hand if you work two jobs. Okay that's great—what about three jobs? No three jobs. I've had students that are like, 'I commute, I work two jobs, I have a crazy workload'… and so I really understand that. So, if there's times that if you can't make it, all I ask is that you communicate with me."
		"What we're going to do now, is I want to get to know you all."
	Revealing Secrets to Success	"Preferably, before each lab, you would have read the lab manual. Today, I know you can't read it because some people don't have it. It's good to know what's happening because you'll go faster. And it's kind of weird when like everyone's done and they're just staring at you and you're still shuffling things around trying to figure out what's going on. So, read the lab manual before and that'll help you be prepared."
		"Please, please, please ask questions if you're confused about anything that's going on in this class. Come to my office hours if you need more help. Also, like I said earlier, I'm pretty good about responding to my email, so if you guys email me, I'm pretty good about responding to that."
	Boosting Self-Efficacy	"Pros: I want every single person in this class to get an A. And you are all a thousand percent capable of getting an A in this class. Lecture and lab. And I'm going to be that motivator for you and try to be like, 'You know you can do this.'"
		"The people who have taken the quiz, they have done really well, so I know everybody's going to do really well."
Establishing Class Culture	Preframing Classroom Activities	"All right, if y'all would transition from the talking portion to the writing portion. So, take the next 1 or 2 minutes. Write down the core of what you came up with about what you expect from the class."
		"So, [today is] kind of a packed class. Not every class is going to be like this. We'll probably get out pretty early most of the time. But today we're probably going to go to the end."
	Practicing Scientific Habits of Mind	"So, we're going to start collecting results now. So, go ahead and write down in your lab notebooks what you guys think your predictions are going to be."
		"I'm going to stop talking and you guys can talk to your groups. Make sure that you remember all the information from last lab and try to think about what results we should expect to see."
	Building a Biology Community among Students	"Get to know your classmates. I cannot stress enough that we have a really big class. There should be at least 10 people that like get you, have the same classes as you, can support you. This is a science community. And the more I can foster that, the better that you're going to do in this class."
		"Preferred pronouns are really important. We want to make sure that you are in a safe environment. We want to make sure we're addressing each other correctly."
Establishing Class Culture	Giving Credit to Colleagues	No instances observed.
	Indicating it's OK to be Wrong/Disagree	"Let's all come back now. So, can I have one pair share? Just raise their hand, what it is they talked about with their partner and then what they wrote on the index card. And remember, if you think that you got it wrong or something, that's okay. We're all here to kind of learn and figure it out together."
		"Again, I have a lot of people come to me and say the terminology is way over my head right now. And I'm here to tell you that is totally okay, because we are in the very beginning, this is completely new to pretty much everyone here. Like, who here knew a lot of these terms. Exactly! When I took this class, I had no idea … We're challenging to use the other parts of your brain that maybe you have not been familiar with before."
Explaining Pedagogical Choices	Supporting Learning through Teaching Choices	"And I don't expect this to be a very long midterm, because I don't think that's necessary to adequately sort of assess your knowledge and give you a fair chance to show off what you've learned, which is the point of a midterm."
		"I'll also include any PowerPoints I use. Some days I like to use PowerPoints, other days I don't. I have PowerPoints for everything, so it will all be posted. It's just whether or not I decide to actually use it in class. I like to do some combinations. Some things are really nice to do on the board, that's why I do that. Some things are just a lot of text and you need to have something a little bit more visual. I'll make sure all those resources are available for you guys."

(*Continues*)

TABLE 3. Continued

Category	Subcategory	Example instances
	Using Student Work to Drive Teaching Choices	"So, I'm going to leave you guys with the yellow [index card], so you can have something that you already know. And I'm going to grab the blue one, because I want to know how I can help you guys. If we need to go over something else, then I can help you guys with that. And that will be like super, super helpful." "With whatever time is left over, you guys can work on that review sheet. And then if there are consistent questions, then that's an indicator to me that I could go over that for the whole group."
	Connecting Biology to the Real World and Career	"After this semester you're all going to be experts in science. So, you can be the advocate for your family." "No matter what field you guys go into, you're going to need to write a lot at some point. Whether it's short memos in nursing, whether it's lab notes as a [health professional], whether you're doing research and you need to actually do publications. Writing is like super-duper important."
	Discussing How People Learn	"Because you don't know something just because you heard someone say it a couple minutes ago. You need to sleep to consolidate the memory. You need to talk to a friend or your study group to get different perspectives. Learning doesn't happen that quickly, really. So, it's going to be challenging."
	Fostering Learning for the Long-Term	No instances observed.
Sharing Personal Experiences	Recounting Personal Information or Anecdotes	"I was born in [city], I lived in [state] my whole life. I'm trying to get my PhD. Right now, I'm getting my master's. Hopefully one day I'll have my own lab. I worked as [redacted] when I was an undergrad." "I've been teaching for about 4 years at colleges. I taught at [university]. So, I've been around teaching a lot. Doesn't mean I'm perfect at it. But just so you guys know, I kind of know what I'm talking about some of the time. And if I'm ever wrong, feel free to ask a question or to present a question."
	Relating to Student Experiences	"I was also an undergrad here. I took [introductory biology] at this school. So, I know a little bit about what you guys are going through right now and what you guys have done already. I took the practicals just like you did. A little bit of stuff has changed, but not too much." "So, my name is [first and last name]. You guys can just call me [first name]. In case you guys don't know I'm an instructor. So, if you need to address me formally it's going to just be Mr/s, not professor, so you don't add professor to my name. Nobody told me that when I was an undergrad and I always got really confused, so just so you guys know."
Unmasking Science	Being Explicit about the Nature of Science	"And if I'm ever wrong, feel free to ask a question or to present a question. That's what the point is. That's the point of academia. The point is for us to be able to learn how to ask questions and how to challenge things respectfully so that we can get the accurate information. Especially in science, that's what we're always looking for, right? We're always trying to get as much clarity as possible." "A lot of science is a bunch of jargon unfortunately. A lot of lingo makes it sound way… scarier than it is."
	Promoting Diversity in Science	No instances observed.
	Fostering Wonder in Science	"So, you guys have a lot of growth on your plates. I looked over them all. You have awesome stuff. Some really creepy stuff. Lots of colorful things. So that's awesome." "I'm excited for the semester"

rate of use of Positively Phrased Instructor Talk was 12 ± 1.6 instances per 30 minutes for GTAs and 8.5 ± 0.9 instances per 30 minutes for faculty. Figure 4 compares the average rate of use of Instructor Talk by GTAs and faculty for each of the Positively Phrased Instructor Talk categories (Figure 4A) and subcategories (Figure 4B). No significant differences were observed when comparing the rate of Positively Phrased Instructor Talk at the category level between GTAs in laboratory courses and faculty in lecture settings (see Table 6 for p values, Welch's unequal variances t test with Bonferroni corrections for five categorical comparisons, significance set at 0.01). Two subcategories showed more Instructor Talk use by GTAs: Revealing Secrets to Success within the Building the Instructor/Student Relationship category and Preframing Classroom Activities within the Establishing Class Culture category. GTAs used Instructor Talk that could be categorized as Revealing Secrets to Success at 1.8 ± 0.4 instances per 30 minutes, while faculty used 0.7 ± 0.2 instances per 30 minutes. Furthermore, GTAs used 3.0 ± 0.4 instances of Instructor Talk per 30 minutes that could be categorized as Preframing

TABLE 4. Example instances of Negatively Phrased Instructor Talk

Category	Subcategory	Example instance
Dismantling the Instructor/Student Relationship	Ignoring Student Challenges	"There are 18 sections of this lab. There is literally no reason why you can't make a single section."
		"Alright, so it doesn't sound like you guys are talking, so that means that you guys know everything, which is great. So, we're just going to move right on."
	Assuming Poor Behaviors from Students	"If you ever need to miss a class, because you're sick, or because some emergency happened back home. I'd prefer if you guys emailed me first or email me at some point, so I know that's what's going on, it's not you guys are just missing class. So, please just email me. If you don't, then I'm just going to assume that you just ditched. So, it's like kind of, communicate with me."
		"Cleaning up after yourself. If you leave a giant mess for me to clean up and I see that it's your seat, I might get grumpy and take some points off of [participation]."
	Making Public Judgments about Students	"I know [name]'s not here, and that's everybody, so … No shade to [name], if that's what …you know … I'm sure she's got better things to do…"
		"That being said, it does kind of hurt my feelings when I'm talking, and I have like students full on blasting rap in their ears and I can hear it. So, it's like, if you're walking around the room and you're taking notes and taking pictures, play your music. I don't care. That being said, if I'm up here talking, I expect phones are down, hoods are off."
Disestablishing Class Culture	Expecting Students Know What to Do	"I'm not going to read through all these rules and regulations for you. You guys have been in a lab before? Okay, wonderful."
		"I'll give you the answer for the first one because it seems that some people may be a little confused. An assay means a test or appraisal to determine the components of a substance or object. All you had to do was Google it, because I sent you the question, so…"
	Discouraging Community among Students	No instances observed.
	Criticizing Colleagues	"One of the other lab instructors said that the way he does this lab is he doesn't answer any questions, he makes everybody else work on their own. Because he says that you guys have to learn how to … what did he say? You have to read simple instructions."
	Encouraging Only the Right Answer	"Hopefully I'll be able to drill that into your head by the end of the lab."
		"I'm going to keep on repeating that, because if you guys miss that on the test, I'm going to be very upset."
Compromising Pedagogical Choices	Expressing Doubt in Pedagogical Choice	No instances observed.
	Using Convenience to Drive Teaching Choices	"So, I have this … they gave me like yarn to demonstrate mitosis, but I would rather show you a video, like always. Because I'm actually not sure how to do it with yarn."
		"I have office hours on Friday from 2–3 pm. Last semester literally no one came. So, I might change this under the table, being like if you want to talk to me, email me. So, I don't have to stay that long."
	Teaching to a Subset of Students	No instances observed.
	Focusing on the Grade/Short Term	"This lab notebook, this is basically a third of your grade. So, if you don't do well on the lab notebook, then your grade for this class really suffers. So, this class is out of 300 points. Your lab notebook is 100 points. So, I would work really hard on your lab notebook."
		"These very simple questions that you can just memorize off your table—I guarantee you if you know this basic table you can walk into that practical and get half credit just on that alone."
Sharing Personal Judgment	Sharing Self-Judgment or Self-Pity	"All right, so, just a forewarning—I suck at names … So, I'm really bad at this. So, if I butcher your name, I'm totally sorry. And let me know if you have like a nickname or something you want to go by."
		"So, they want you to label like … wow so that's … [sarcastically] I'm a really great drawer…"
	Distancing from Student Experiences	No instances observed.
Masking Science	Being Implicit about the Nature of Science	No instances observed.
	Intimidating Students from Science	No instances observed.

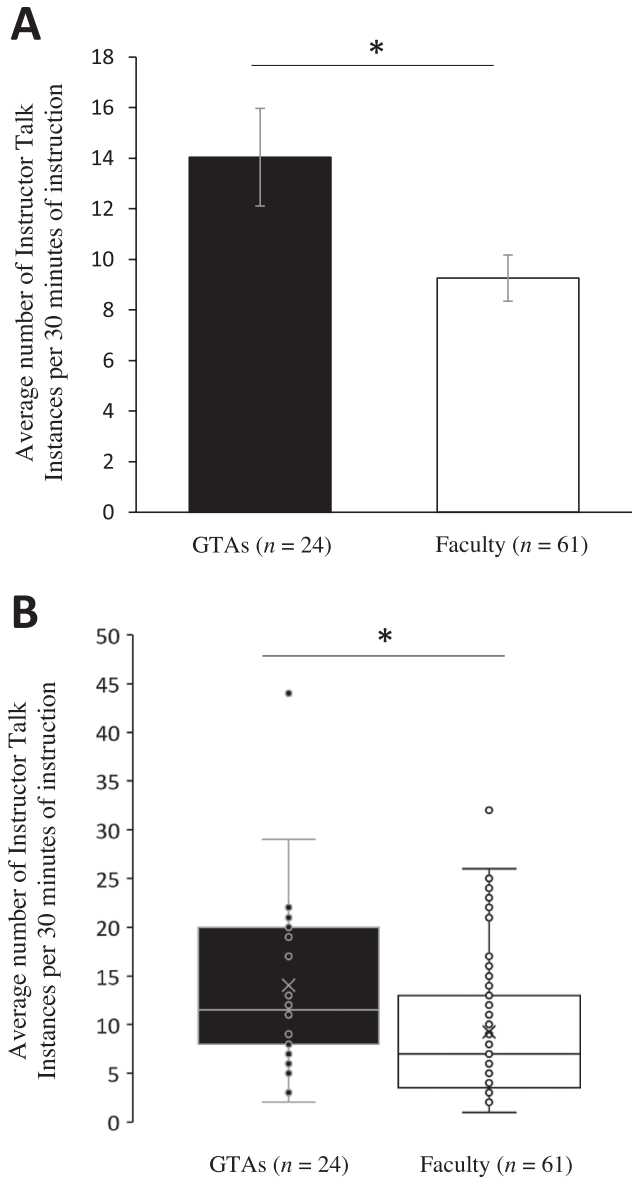

FIGURE 3. Comparing the average rate of Instructor Talk use per 30 minutes by GTAs and by faculty in courses as (A) bar graph with mean ± SEM and (B) box-and-whisker plot. Faculty data are from Harrison *et al.* (2019). (Welch's unequal variances *t* test, **p* = 0.03.)

Classroom Activities, while faculty used 1.3 ± 0.2 instances per 30 minutes. While these two subcategories showed increased use by GTAs, the number of instances observed at the subcategory level precludes comparative statistical analyses. GTAs used more Positively Phrased Instructor Talk, but this was not statistically significant for any of the Positively Phrased Instructor Talk categories (see Figure 4). The Positively Phrased Instructor Talk category-level data are summarized in Table 6 and the subcategory-level data are summarized in Table 7.

As shown in Figure 5, the overall rate of use of Negatively Phrased Instructor Talk was 2.3 ± 0.6 instances per 30 minutes for GTAs and 0.8 ± 0.2 instances per 30 minutes for faculty. One category, Dismantling the Instructor/Student Relationship, showed a statistically significant difference. For this category, GTAs used 1.3 ± 0.4 instances per 30 minutes, while faculty used 0.1 ± 0.03 instances per 30 minutes ($p < 0.01$, Welch's unequal variances *t* test with Bonferroni corrections for five categorical comparisons, significance set at 0.01). Furthermore, this increase at the category level for Dismantling the Instructor/Student Relationship may be caused by an increased use of the subcategory Assuming Poor Behaviors, for which GTAs used 1.0 ± 0.3 instances per 30 minutes; however, instances of this subcategory were not found in the faculty sample. For the remaining four categories of the Negatively Phrased Instructor Talk framework, no significant differences were observed when comparing GTAs in laboratory courses and faculty in lecture settings (see Table 8 for *p* values, Welch's unequal variances *t* test with Bonferroni corrections for five categorical comparisons, significance set at 0.01). Subcategory-level use of Negatively Phrased Instructor Talk is shown in Figure 5B; however, the number of subcategory observations precludes comparative statistical analyses. Figure 5 shows the rate of use of all five Negatively Phrased categories (Figure 5A) and 15 subcategories (Figure 5B). The Negatively Phrased category-level data are summarized in Table 8 and the subcategory data in Table 9.

Comparing Instructor Talk Used by GTAs Based on Their Prior Pedagogical Training and Prior Teaching Experience

As shown in Figure 6, GTAs with prior teaching experience and pedagogical training used more Instructor Talk than GTAs without prior teaching experience and with minimal or no pedagogical training. Figure 6 illustrates the average rate of use of Instructor Talk for total Instructor Talk, Positively Phrased Instructor Talk, Negatively Phrased Instructor Talk, early-course sample, and midcourse sample for 1) GTAs with both teaching experience and prior pedagogical training ($n = 11$); 2) GTAs with teaching experience with minimal or no prior pedagogical training ($n = 8$); and 3) GTAs with no teaching experience and minimal or no prior pedagogical training ($n = 5$). Table 10 summarizes this data along with *p* values as calculated by Kruskal-Wallis one-way ANOVA.

GTAs with both prior teaching experience and pedagogical training used 19 ± 3.2 instances of Instructor Talk per 30 minutes of instruction; GTAs with prior teaching experience but minimal or no pedagogical training used 12 ± 2.0 instances per 30 minutes; GTAs with neither prior teaching experience nor pedagogical training used 6.6 ± 1.9 instances per 30 minutes. This was found to be statistically significant (Kruskal-Wallis, $\chi^2 = 7.1$, $p = 0.029$). Dunn's post hoc test detected a statistically significant difference between GTAs with *neither* pedagogical training nor teaching experience and GTAs with *both* training and experience ($p = 0.027$, adjusted with Bonferroni method).

While we observed significantly higher levels of Positively Phrased Instructor Talk for instructors with teaching experience and pedagogical training, it was less clear for Negatively Phrased Instructor Talk. GTAs with both prior teaching experience and pedagogical training used 16 ± 2.4 instances of Positively Phrased Instructor Talk and 3.4 ± 1.3 instances of Negatively Phrased Instructor Talk per 30 minutes of instruction. GTAs with prior teaching experience but minimal or no pedagogical training used 11 ± 2.1 instances of Positively Phrased Instructor Talk and 1.1 ± 0.4 instances of Negatively Phrased Instructor Talk per 30 minutes of instruction. GTAs without

TABLE 5. Overall rate of use of Instructor Talk use by GTAs teaching laboratory classrooms and faculty teaching lecture classrooms

	Instructor Talk instances per 30 minutes (mean ± SEM)	Positively Phrased Instructor Talk instances per 30 minutes (mean ± SEM)	Negatively Phrased Instructor Talk instances per 30 minutes (mean ± SEM)
GTAs (n = 24)	14 ± 1.9	12 ± 1.6	2.3 ± 0.6
Faculty (n = 61)[a]	9.3 ± 0.9	8.5 ± 0.9	0.8 ± 0.2
p value	p = 0.03	p = 0.04	p = 0.04

[a]Data reprinted from Harrison *et al.* (2019).

teaching experience and minimal or no pedagogical training used 5.0 ± 1.7 instances of Positively Phrased Instructor Talk and 1.6 ± 0.7 instances of Negatively Phrased Instructor Talk per 30 minutes of instruction. This difference was statistically significant for Positively Phrased Instructor Talk (Kruskal-Wallis, χ^2 = 8.2, p = 0.017), but not for Negatively Phrased Instructor Talk (Kruskal-Wallis, χ^2 = 0.56, p = 0.75). Dunn's post hoc test detected a statistically significant difference in Positively Phrased Instructor Talk between GTAs with *neither* pedagogical training nor teaching experience and GTAs with *both* training and experience (p = 0.013, adjusted with Bonferroni method).

There was also a statistically significant difference in the amount of Instructor Talk used during the early-course and midcourse samples. The early-course sample had 12 ± 2.5 instances per 15 minutes for GTAs with both prior teaching experience and pedagogical training, 5.0 ± 1.0 instances per 15 minutes for GTAs with prior teaching experience but minimal or no pedagogical training, and 3.8 ± 1.6 instances per 15 minutes for GTAs without teaching experience and minimal or no pedagogical training (Kruskal-Wallis, χ^2 = 7.4, p = 0.024). The midcourse sample had 6.7 ± 1.0 instances per 15 minutes for GTAs with both prior teaching experience and pedagogical training, 6.8 ± 1.5 instances per 15 minutes for GTAs with prior teaching experience but minimal or no pedagogical training, and 2.8 ± 0.5 instances per 15 minutes for GTAs without teaching experience and minimal or no pedagogical training (Kruskal-Wallis, χ^2 = 6.5, p = 0.040). Interestingly, for the midcourse sample, Dunn's post hoc test detected a statistically significant difference between GTAs with *neither* pedagogical training nor teaching experience and GTAs with *both* training and experience (p = 0.038, adjusted with Bonferroni method), but this comparison was not significant for the early-course sample (p = 0.054, adjusted with Bonferroni method). These results are also summarized in Figure 6 and Table 10.

A Potentially New Type of Instructor Talk: Small-Group Instructor Talk in Pilot Study

Due to the nature of laboratory classrooms, instructors have greater opportunity to walk around the room and work with groups of students, and we hypothesized that there might be a new type of Instructor Talk: Small-Group Instructor Talk. We found that only a small percentage of the total Instructor Talk instances were addressed to a small group of students rather than the entire class. The percentage of total Instructor Talk instances that were addressed to a small group of students for each of the courses in the initial pilot semester were: Xavier

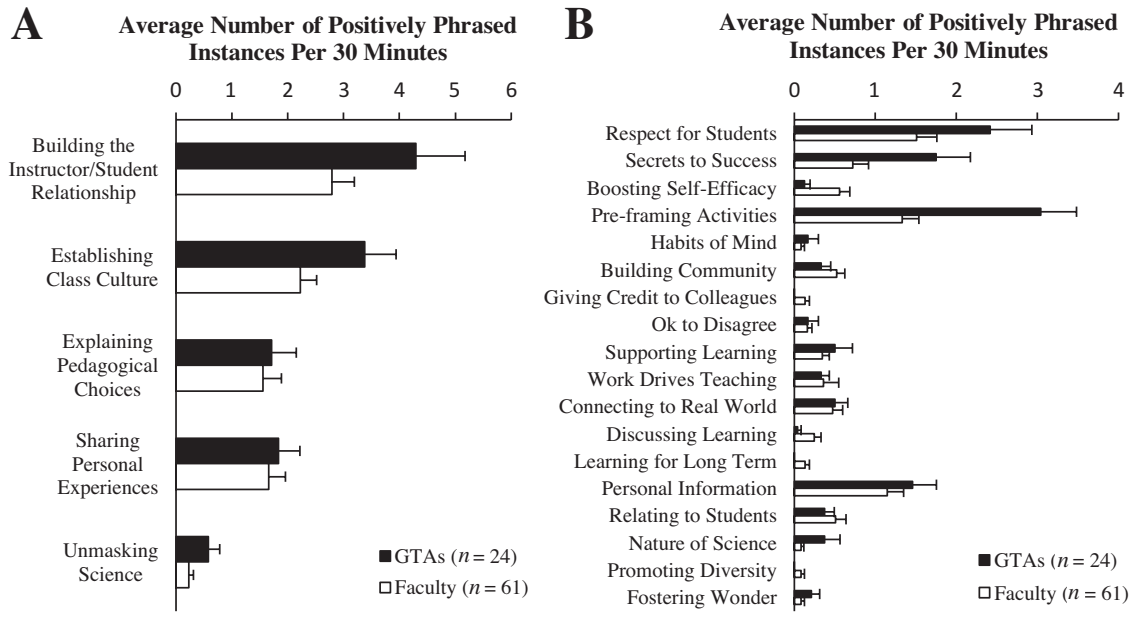

FIGURE 4. Comparing the prevalence of Positively Phrased Instructor Talk categories and subcategories used by GTAs (black bars) and by faculty (white bars). The average number instances of the categories (A) and subcategories (B) of Instructor Talk per 30 minutes for 24 laboratory courses taught by GTAs (black bars) and 61 lecture courses taught by faculty (white bars). Error bars represent mean ± SEM. Faculty data are from Harrison *et al.* (2019).

TABLE 6. Positively Phrased categories of Instructor Talk use listed as number of Instructor Talk instances per 30 minutes (mean ± SEM)

	Building the Instructor/ Student Relationship	Establishing Class Culture	Explaining Pedagogical Choices	Sharing Personal Experiences	Unmasking Science
GTAs (n = 24)	4.3 ± 0.9	3.4 ± 0.6	1.7 ± 0.4	1.8 ± 0.4	0.6 ± 0.2
Faculty (n = 61)[a]	2.8 ± 0.4	2.2 ± 0.3	1.6 ± 0.3	1.7 ± 0.3	0.2 ± 0.1
p value	p = 0.12	p = 0.07	p = 0.68	p = 0.90	p = 0.21

[a]Data reprinted from Harrison *et al.* (2019).

TABLE 7. Positively Phrased subcategories of Instructor Talk use listed as number of Instructor Talk instances per 30 minutes (mean ± SEM)

	Category	Subcategory	GTAs	Faculty[a]
Positively Phrased Instructor Talk	Building the Instructor/Student Relationship	Demonstrating Respect for Students	2.4 ± 0.5	1.5 ± 0.3
		Revealing Secrets to Success	1.8 ± 0.4	0.7 ± 0.2
		Boosting Self-Efficacy	0.1 ± 0.1	0.6 ± 0.1
	Establishing Class Culture	Preframing Classroom Activities	3.0 ± 0.4	1.3 ± 0.2
		Practicing Scientific Habits of Mind	0.2 ± 0.1	0.1 ± 0.04
		Building a Biology Community	0.3 ± 0.1	0.5 ± 0.1
		Giving Credit to Colleagues	Not observed	0.1 ± 0.1
		Indicating It Is Okay to Be Wrong/Disagree	0.2 ± 0.1	0.2 ± 0.1
	Explaining Pedagogical Choices	Supporting Learning through Teaching Choices	0.5 ± 0.2	0.3 ± 0.1
		Using Student Work to Drive Teaching Choices	0.3 ± 0.1	0.4 ± 0.2
		Connecting Biology to the Real World and Career	0.5 ± 0.2	0.5 ± 0.1
		Discussing How People Learn	Not observed	0.2 ± 0.1
		Fostering Learning for the Long-Term	Not observed	0.1 ± 0.1
	Sharing Personal Experiences	Recounting Personal Information or Anecdotes	1.5 ± 0.3	1.1 ± 0.2
		Relating to Student Experiences	0.4 ± 0.1	0.5 ± 0.1
	Unmasking Science	Being Explicit about the Nature of Science	0.4 ± 0.2	0.1 ± 0.4
		Promoting Diversity in Science	Not observed	0.1 ± 0.4
		Fostering Wonder in Science	0.2 ± 0.1	0.1 ± 0.4

[a]Data reprinted from Harrison *et al.* (2019).

(2%), Gabriel (6%), Vanessa (8%), Jon (14%), and Yolanda (22%). As such, we did not continue to investigate Small-Group Instructor Talk in the subsequent semester and in the full study.

Qualitative Analyses of GTA Reflections on Their Own Instructor Talk

After reviewing their own Instructor Talk, the GTA participants reflected on what they learned from looking at their Instructor Talk and how it might impact their teaching in the future. Responses were received from 17 of the 22 GTA instructors (77% participation rate).

Five themes emerged from these reflections, and excerpts from these reflections are included in Table 11.

The five emergent themes and their prevalence among GTAs were: Intending a Future Focus on Instructor Talk (n = 10/17), Acknowledging Negatively Phrased Instructor Talk (n = 8/17), Aspiring to Use Specific Categories of Instructor Talk (n = 3/17), Reporting Little Learned from Instructor Talk (n = 3/17), Differing Instructor Talk across Different Courses (n = 1/17). Up to three examples of GTA reflections related to each of these emergent themes are provided as excerpts in Table 11. Specifically, 10 GTA reflections of the 17 included themes stating that seeing their Instructor Talk sample will affect the language they use in the classroom in the future. Additionally, eight reflections noted that seeing their Negatively Phrased Instructor Talk caused them to reflect on the importance of phrasing and how words are perceived. Furthermore, three reflections named specific categories of Instructor Talk that they wanted to use more of in the future. One GTA's Instructor Talk was different in two courses the GTA taught, which the GTA attributed to a difference in

TABLE 8. Negatively Phrased categories of Instructor Talk use listed as number of Instructor Talk instances per 30 minutes (mean ± SEM)

	Dismantling the Instructor/Student Relationship	Disestablishing Class Culture	Compromising Pedagogical Choices	Sharing Personal Judgment	Masking Science
GTAs (n = 24)	**1.3 ± 0.4**	0.2 ± 0.1	0.6 ± 0.2	0.2 ± 0.08	Not observed
Faculty (n = 61)[a]	**0.1 ± 0.03**	0.2 ± 0.08	0.3 ± 0.1	0.2 ± 0.07	0.03 ± 0.02
p value	***p* < 0.01**	p = 0.60	p = 0.26	p = 0.47	p = 0.08

[a]Data reprinted from Harrison *et al.* (2019).

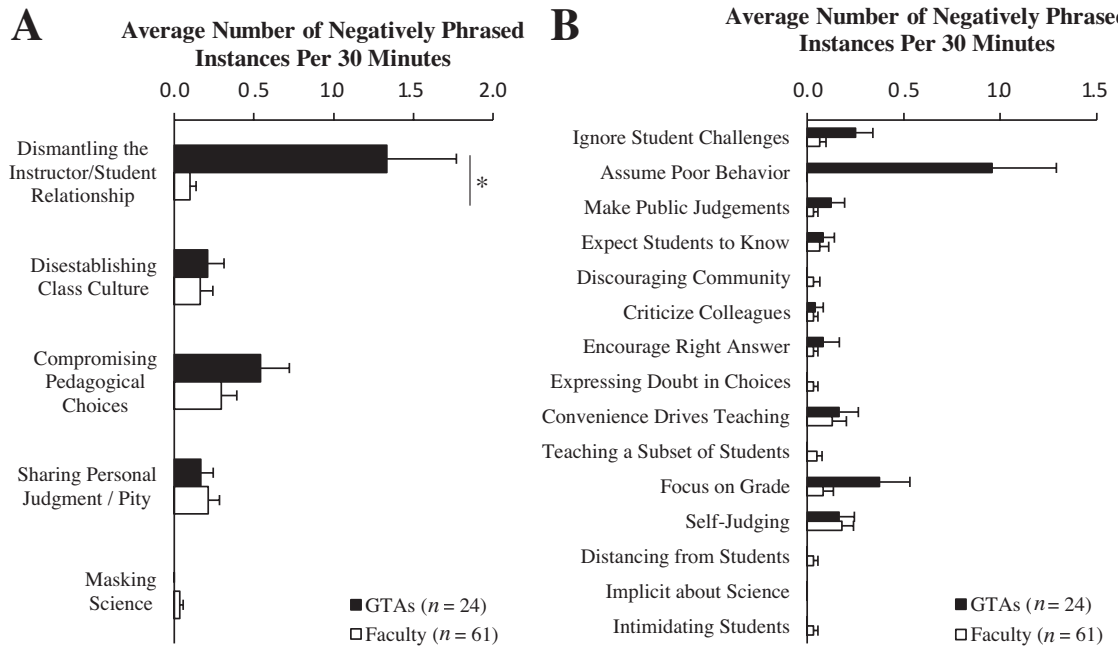

FIGURE 5. Comparing the prevalence of Negatively Phrased Instructor Talk categories and subcategories used by GTAs (black bars) and by faculty (white bars). The average number instances of the categories (A) and subcategories (B) of Instructor Talk per 30 minutes for 24 laboratory courses taught by GTAs (black bars) and 61 lecture courses taught by faculty (white bars). Error bars represent mean ± SEM. Faculty data are from Harrison *et al.* (2019). (Welch's unequal variances *t* test with Bonferroni corrections, *$p < 0.01$.)

confidence level when teaching those two courses. Finally, three GTAs expressed that there is little or nothing from this experience that will affect their teaching going forward.

DISCUSSION

This study addresses a gap in the literature about the quantity and nature of Instructor Talk used by GTAs in laboratory courses. It was therefore an exciting find that Instructor Talk is indeed present in this new context. Prior studies have investigated Instructor Talk in lecture courses taught by faculty (Seidel *et al.*, 2015; Harrison *et al.*, 2019; Lane *et al.*, 2021; Ovid *et al.*, 2021) and postdocs (Seah *et al.*, 2021). This study also addresses a gap in the literature regarding the use of Instructor Talk by instructors who have not completed prior pedagogical training or have not had prior teaching experience. Here, we discuss our findings about noncontent language used by GTAs in laboratory courses, comparisons with faculty teaching lecture courses, the impact of GTA pedagogical training and prior teaching experience on Instructor Talk, and the surprising lack of Small-Group Instructor Talk observed in the pilot study.

TABLE 9. Negatively Phrased subcategories of Instructor Talk use listed as number of Instructor Talk instances per 30 minutes (mean ± SEM)

	Category	Subcategory	GTAs	Faculty[a]
Positively Phrased Instructor Talk	Dismantling the Instructor/Student Relationship	Ignoring Student Challenges	0.25 ± 0.09	0.07 ± 0.03
		Assuming Poor Behaviors from Students	0.96 ± 0.33	Not observed
		Making Public Judgments about Students	0.13 ± 0.07	0.03 ± 0.02
	Disestablishing Class Culture	Expecting Students Know What to Do	0.08 ± 0.06	0.07 ± 0.05
		Discouraging Community among Students	Not observed	0.03 ± 0.03
		Criticizing Colleagues	0.04 ± 0.04	0.03 ± 0.02
		Encouraging Only the Right Answer	0.08 ± 0.08	0.03 ± 0.02
	Compromising Pedagogical Choices	Expressing Doubt in Pedagogical Choice	Not observed	0.03 ± 0.02
		Using Convenience to Drive Teaching Choices	0.13 ± 0.09	0.13 ± 0.07
		Teaching to a Subset of Students	Not observed	0.05 ± 0.03
		Focusing on the Grade/Short Term	0.38 ± 0.16	0.08 ± 0.05
	Sharing Personal Judgment	Sharing Self-Judgment or Self-Pity	0.17 ± 0.08	0.18 ± 0.06
		Distancing from Student Experiences	Not observed	0.03 ± 0.02
	Masking Science	Being Implicit about the Nature of Science	Not observed	Not observed
		Intimidating Students from Science	Not observed	0.03 ± 0.02

[a]Data reprinted from Harrison *et al.* (2019).

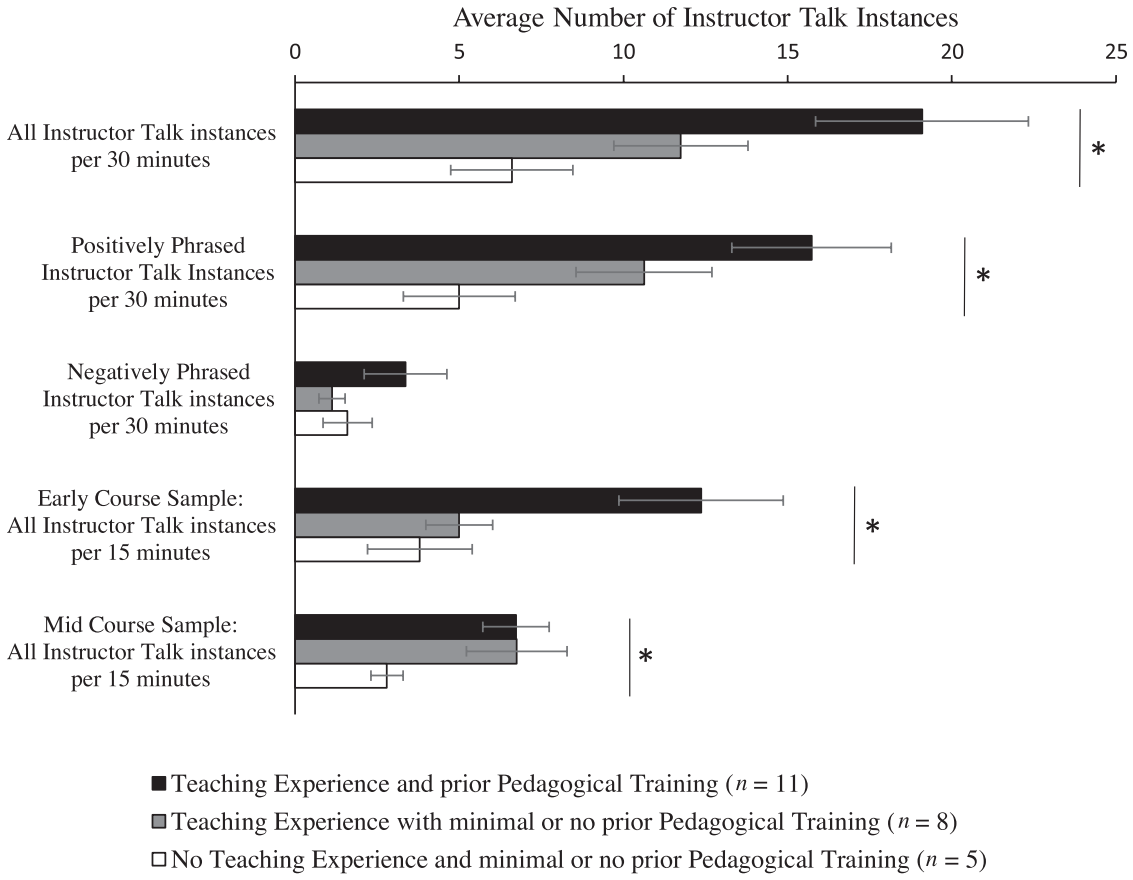

FIGURE 6. Comparing the average rate of Instructor Talk use per 30 minutes by GTAs with prior teaching experience and prior pedagogical training (black bars), GTAs with prior teaching experience but minimal or no prior pedagogical training (gray bars), and GTAs with no prior teaching experience and minimal or no prior pedagogical training (white bars). Error bars represent mean ± SEM. (Kruskal-Wallis one-way ANOVA test, *$p < 0.05$.)

Noncontent Language Used by GTAs in Laboratory Classes Can Be Characterized Using the Existing Instructor Talk Frameworks, Regardless of GTAs' Pedagogical Training or Previous Teaching Experience

It was unclear whether graduate students would use noncontent language in their laboratory classes and whether such language could be categorized with the existing Instructor Talk frameworks. To our surprise, GTAs used noncontent language in laboratory classes that reflected the categories of the existing Instructor Talk frameworks. While emerging frameworks have been developed for measuring Instructor Talk that may be unique to the first day of lecture courses (Lane *et al.*, 2021; Meaders *et al.*, 2021) or online teaching during the pandemic (Seah *et al.*, 2021), the present study demonstrates that the Instructor Talk frameworks originally developed for biology lecture courses can be used to categorize Instructor Talk used by GTAs in laboratory courses. Importantly, we observed from our pilot study that Instructor Talk used by GTAs in the first 15 minutes overrepresented the amount of Instructor Talk used throughout the entire class session, indicating that the previously developed sampling method (Harrison *et al.*, 2019) could be used across a large sample of laboratory courses. Further, our findings fill a gap in the literature by investigating the Instructor Talk of biology instructors with little to no pedagogical training. Interestingly, even GTAs with no formal pedagogical training used Instructor Talk that could be characterized with the existing frameworks, suggesting that these frameworks could be used to investigate Instructor Talk of untrained instructors. Additionally, future studies could explore the applicability of Positively Phrased and Negatively Phrased Instructor Talk frameworks in the context of other courses commonly led by GTAs, such as discussion sections, or even different kinds of laboratory courses, such as CUREs.

Increased Negatively Phrased Instructor Talk Use by GTAs Teaching Laboratory Classes May Reflect GTA Dual Identity as both Student and Instructor

GTAs in lab classrooms used more Negatively Phrased Instructor Talk than did faculty in lecture classrooms. This trend was most clear in the category Dismantling the Instructor/Student Relationship and associated subcategory Assuming Poor Behaviors. Forty-two percent of all of the Negatively Phrased Instructor Talk used by GTAs fell in the subcategory Assuming Poor Behaviors, which included assuming that students do not want to be in class, participate in activities, or learn, as well as assuming that students were sleeping in class, not doing their homework, or not studying. In contrast, this subcategory was not observed at all in a prior faculty sample (Harrison *et al.*, 2019).

TABLE 10. Rate of use of Instructor Talk by GTAs disaggregated by prior teaching experience and pedagogical training (mean ± SEM)

	Overall Instructor Talk instances per 30 minutes	Positively Phrased Instructor Talk instances per 30 minutes	Negatively Phrased Instructor Talk instances per 30 minutes	Early-Course sample all Instructor Talk instances per 15 minutes	Midcourse sample all Instructor Talk instances per 15 minutes
Prior teaching experience AND prior pedagogical training ($n = 11$)	**19 ± 3.2**	**16 ± 2.4**	3.4 ± 1.3	**12 ± 2.5**	**6.7 ± 1.0**
Prior teaching experience, BUT minimal or no prior pedagogical training ($n = 8$)	**12 ± 2.0**	**11 ± 2.1**	1.1 ± 0.4	**5.0 ± 1.0**	**6.8 ± 1.5**
NO prior teaching experience AND minimal or no prior pedagogical training ($n = 5$)	**6.6 ± 1.9**	**5.0 ± 1.7**	1.6 ± 0.7	**3.8 ± 1.6**	**2.8 ± 0.5**
Kruskal-Wallis	$\chi^2 = 7.1$ **$p = 0.027$**	$\chi^2 = 8.2$ **$p = 0.017$**	$\chi^2 = 0.56$ $p = 0.75$	$\chi^2 = 7.4$ **$p = 0.024$**	$\chi^2 = 6.5$ **$p = 0.039$**

Bold indicates statistical comparison was significant with Bonferroni adjustment.

Here we explore preliminary hypotheses for how GTA identity might influence this increased use of Negatively Phrased Instructor Talk.

GTAs' unique position in the classroom may be a potential driver of Negatively Phrased Instructor Talk. GTAs are historically underpaid and given little influence over the content that they are expected to teach (Park and Ramos, 2002; Muzaka, 2009). Increased use of Negatively Phrased Instructor Talk may reflect GTAs themselves not wanting to lead specific classroom activities that they do not have the agency to change. GTAs have dual identities as both students and instructors, while being expected to effectively teach undergraduates who are often only a few years behind them academically and rarely being given agency in the curriculum they are expected to teach (Park and Ramos, 2002). Further, one might consider how GTAs anticipate and pre-empt the phenomenon of student resistance (Seidel and Tanner, 2013). Given the lack of agency in course design, GTAs may be expressing to undergraduates that they can empathize with them and are "in the know" about student resistance, accept it as inevitable, and therefore take little to no responsibility for student engagement. One wonders if this dual identity and potential reduced agency in their classrooms may result in increased use of Negatively Phrased Instructor Talk that signals that no one wants to be in class, such as:

> Okay, so should we get started so we can leave? I like leaving. Yeah. That always is an incentive.

GTAs' dual identity as both instructors and students may play another role in the Instructor Talk they use, due to the power dynamic it creates. Because of their status as students themselves, GTAs are more likely to be early in their careers and to be new to teaching. Of the 42% of Negatively Phrased Instructor Talk instances that fell within the subcategory Assuming Poor Behaviors, many asserted the GTA's authority with a "don't mess with me" attitude, such as:

> Don't cheat. Please don't cheat. I will not have any sympathy for you if you cheat.

Instances such as these show that GTAs may be concerned about being taken advantage of by students because of their status. It is possible that GTAs' difference in position compared with faculty could also lead some GTAs to respond by overcorrecting and asserting their authority as the instructor by using Negatively Phrased Instructor Talk. Previous research has explored GTAs' ability to establish power with their students, stating that GTAs may be too inexperienced to be able to effectively communicate their credibility and power (Pytlak and Houser, 2014). Additionally, it has been found that GTAs are more "hesitant, nervous, uncertain, and unsure how to begin teaching" (Kendall and Schussler, 2012, 2013). We posit that GTAs may respond to the ambiguous position of being both instructors and students and their uncertainty of how to manage being instructors by using Negatively Phrased Instructor Talk that assumes poor behaviors from their students.

Such language may be common for instructors new to teaching, not just GTAs. Further research could investigate Instructor Talk used by instructors at varying points in their careers or could investigate correlations between GTA perceptions of teaching, professional identity, and their use of Instructor Talk.

GTAs Teaching Laboratory Courses May Use More Positively Phrased Instructor Talk Than Previously Observed with Faculty Teaching Lecture Courses

Our study found a trend of GTAs using more Positively Phrased Instructor Talk than previous observations found with faculty. We explore here two potential reasons—near-peer status and laboratory course structure—that may contribute to these findings and that could guide future research. Two subcategories showed increased Instructor Talk use by GTAs: Preframing Classroom Activities within the Explaining Pedagogical Choices category and Revealing Secrets to Success within the Building the Instructor/Student Relationship category.

Increased GTA use of Positively Phrased Instructor Talk may relate to GTAs' near-peer status with their undergraduate students. One place where the increase in Instructor Talk use was particularly clear was the subcategory Revealing Secrets to Success and corresponding category Building the Instructor/

TABLE 11. Excerpts from reflections written by GTAs after reviewing their Instructor Talk (*n* = 17)

Description	Example excerpts
Intending a future focus on Instructor Talk (*n* = 10)	"There is a voice and style that I want to have as an instructor, and I found that I hold to that voice and style. Seeing my Instructor Talk makes me realize how important it is to be meta-cognitive and intentional with the way we speak. Within our/my Instructor Talk, I can try to be more consistent with protecting the ethos of the class space."
	"I could remember when I said such dialogue and how I was really nervous but excited to see the students entering the class. I mostly had Instructor Talk on getting to know students, setting a classroom environment, as well as mentioning my personal interests … I hope to continue to make it my mission for my classroom environment to be safe, where students can freely express themselves and share their ideas. I also hope that now since I switched career paths to wanting to become a professor, it makes me more aware of my dialogue and to continue to focus on how my Instructor Talk impacts students."
	"It is odd to see my Instructor Talk in text format. When I read through it, I don't even remember ever saying most of those things, which might go to show how we can say so much during a class, and while I may not remember what I said, one of my students might… As a small example, I never consciously considered classroom culture, thus I never actively tried to build the type of classroom culture I wanted to surround my students with. Sure, there were a few things I did consistently like play instrumental music while students worked, or encouraged students to come to my office hours, but I could have done so much more with my words and actions. I know that my shortcomings as an instructor could be remedied through more experience, but also through training. If training is available and accessible for instructors, especially GTAs, it could be a valuable grease in the higher education machine, like investing in the bigger picture of the students' educational experience."
Acknowledging Negatively Phrased Instructor Talk (*n* = 8)	"My first response when I read my own quotes was, 'did I really say that?' I think it was shocking to read through some of the quotes because I honestly couldn't remember that I had said some of those things. But, I think it was very eye-opening to actually see those quotes written out. Even though I couldn't remember saying some of those things, seeing the quotes in front of me gave me a chance to reflect on why I might have said some of the things that I did. A majority of the 'positively-phrased' statements I made were intentional. I remember that those were times that I tried to word my statements more carefully. For the 'negative[ly]-phrased' statements, looking at the statements, I think I had good intentions but the words I spoke didn't really reflect those intentions. And thinking about it now, I think I was unconsciously projecting from previous experiences I had teaching."
	"To be outright critical of myself, I learned that the words I say, though initially with good intention, could be perceived differently by students. Moving forward, these samples allow me to reflect so I could choose my words wisely in the future. Looking back, I could have said things differently—in another form. Analyzing these samples influence[s] my future teaching by having me reflect on what I say and how I say it (the delivery)."
	"From the samples of my Instructor Talk have really been eye-opening to say the least. I find that every time I come across as negative it reflects how my attempt at humor can backfire. Looking back at it now, I can totally see how that can be perceived as a negative saying or have a negative connotation to it. I tried to be humorous in the lab because I want the students to loosen up and have fun, but I never perceived it as a possibility of it creating a harmful environment. This just goes to show that even though the good intention might be there, if there isn't any proper training or just being mindful of the way you speak, teach, and communicate with the students then there's no point. In the future, I will make sure to maximize my mindfulness on how I speak to my students. I will also seek out more mentoring and training to become the best instructor I can be."
Aspiring to utilize specific categories of Instructor Talk (*n* = 3)	"I saw that I had a lot of Instructor Talk in the [Building the Instructor/Student Relationship] category. I think this makes sense, since my philosophy of teaching should be that students should feel comfortable enough with the teacher to ask questions and talk openly about their ideas. Also, one of the most common positive remarks I have received about my teaching is that I am approachable. It's nice to have concrete examples of what I have said that hopefully helps build the student/instructor relationship. I hope in the future to use more Instructor Talk in the establishing classroom culture as well as unmasking science. I think by doing that, I can create a more inclusive classroom."
	"Reviewing the Instructor Talk I noticed that there are other categories of Instructor Talk that I am not using. My Instructor Talk was more inclined into personal experiences and building the instructor/student relationship. But there is so much more that we can do with our Instructor Talk. From this experience I became aware of what I was talking [about] in the classroom… Instructors should be aware of the influence that their Instructor Talk have on the students. For my future teaching opportunities, I want to be more aware and recognize the needs of the classroom to use my Instructor Talk in a positive and uplifting way. As well as, creating learning opportunities without them being filled with class material. I think all teachers should be educated in this topic."
	"After reviewing my Instructor Talk, I am pretty happy with what I saw. I think that one area I really want to work on expanding upon is fostering wonder in science, as that is what I really want my students to get out of the experience. As a reflection on what the results show, I think a lot of my students left with the tools of a scientist without necessarily the interest in being scientist. I also think that I could use more examples of diverse scientist[s] (outside of myself), that could help reach some of the students who aren't able to see themselves in science yet."
Differing Instructor Talk across different courses (*n* = 1)	"As each semester passed, my students seemed to become more and more energetic, and I couldn't figure out why. I think one reason is that my phrasing has gotten better over the years, and my students were absorbing my positivity. I also got more comfortable in my own skin and stopped doubting myself, leading to less self-criticizing talk… I also thought it was interesting that it seems like in one of my classes, I was doing way more Instructor Talk than the other—this may be because I was way less confident in myself for one class, as it was the first time I was teaching it and the GTAs had very little guidance. The class was overall very quiet, and I have been trying to find more ways to reduce the quietness. This may have led to both less Instructor Talk and less class participation, which I think were due to a lack of confidence I had and because I was typically less motivated to teach that class due to the fact that I rarely knew exactly what to do to teach it."
Reporting little learned from Instructor Talk (*n* = 3)	"I really enjoyed learning about this research and that I find its implications relevant (to the teaching field in general), interesting and potentially impactful. Although I did enjoy seeing my teacher talk, I did not find anything particularly useful that might inform my future teaching. I believe that reviewing and reflecting on the 'teacher talk' aspect of my classroom persona could be revealing, both of certain strengths and areas for improvement."
	"I learned that I speak very informally and use a lot of 'umms' when I talk. This was helpful to see I should work on speaking with more confidence."
	"I learned that I am way more informal than I thought I was. I also think I need to assert my power because I felt as though I talked as another student than a teacher."

Student Relationship. Through this type of Instructor Talk, GTAs shared study strategies or other tips for succeeding in learning or in life. GTAs used more than double the number of Instructor Talk instances than faculty in this particular subcategory; however, with the small number of total instances present at the subcategory level, this was not statistically significant. We predict that some of this apparent increase in Positively Phrased Instructor Talk may be related to the fact that GTAs are near peers to their undergraduate students and may better identify with the struggles their students are encountering than faculty instructors (Muzaka, 2009). Undergraduate students perceive their GTA instructors as more relatable, understanding, and engaging than their faculty counterparts (Kendall and Schussler, 2012). It may be the case that GTAs maintain a near-peer status through their Instructor Talk by promoting instructor immediacy. Given undergraduate students' heightened sense of relatability to GTAs, perhaps an affinity bias leads undergraduates to be more receptive to supportive messaging from GTAs. Future research could explore the interplay between Instructor Talk and instructor near-peer status to expand our knowledge of how an instructor's identity affects the way the instructor uses language in the class and students' receptivity to such language.

Another potential factor in our observed increased use of Positively Phrased Instructor talk is the laboratory course structure. GTAs also use significantly more Instructor Talk in the subcategory Preframing Classroom Activities and associated category Establishing Class Culture. This subcategory includes preparing students for in-class activities and sharing how much time activities will take or the activity structure. Given the hands-on nature of laboratory courses, this particular increase in Instructor Talk may have been due to the course type—laboratory versus lecture—rather than the instructor type. However, this is unclear, as some lecture courses may include substantial active learning, which would also be framed by Instructor Talk. Further, some laboratory courses might simply involve following lab manuals without instructor input. Without more data on the nature of the courses we studied, we are unable to resolve whether this increase was due to instructor type or course type. Future investigations might compare the Instructor Talk of GTAs in discussion sections compared with laboratory courses.

GTA Teaching Experience and Pedagogical Training Were Associated with More Instructor Talk

Among GTAs with teaching experience and prior pedagogical training, there was a higher rate of both Positively Phrased and overall Instructor Talk use when compared with GTAs with no teaching experience and minimal or no prior pedagogical training. We hypothesize that prior teaching experience and pedagogical training may both work to increase GTAs' self-efficacy, in turn creating the increased use of Positively Phrased Instructor Talk that was seen. GTAs with more experience in the classroom may be more likely to feel confident in their abilities and feel a greater sense of self-efficacy (DeChenne *et al.*, 2015). This may enable GTAs to focus not only on what they are teaching, but also how they are teaching. As the present study did not measure self-efficacy, future studies could consider correlating GTA Instructor Talk with validated measures in graduate student teaching self-efficacy (Boman, 2008, 2013).

Further, previous research has shown that pedagogical training can increase self-efficacy for GTAs (Prieto and Altmaier, 1994; DeChenne *et al.*, 2015). Increased self-efficacy due to participating in pedagogical training could further contribute to the increased Instructor Talk that is seen. In addition, instructors of STEM pedagogical training may model using Positively Phrased Instructor Talk that GTAs may then mimic in their own classrooms. Additionally, a previous study on pedagogical training of active learning demonstrated the value of GTAs practicing the new skill themselves (Patrick *et al.*, 2016), suggesting that GTAs might practice Positively Phrased Instructor Talk with one another to gain self-efficacy and practice with this language in their own courses.

Both prior teaching experience and pedagogical training were associated with increased amounts of Positively Phrased and overall Instructor Talk for GTAs. Future research may be able to disentangle the effects of prior teaching experience and pedagogical training that we were unable to address in the current study. Given previous research on early-stage faculty training about phenomena such as stereotype threat in STEM (Frey *et al.*, 2020; O'Leary *et al.*, 2020), one wonders how pedagogical training for STEM GTAs that focuses on inclusion could employ Instructor Talk to mitigate stereotype threat and foster equitable student outcomes. Future studies might consider student outcomes in biology laboratory courses using validated psychometric measures (e.g., Wineinger *et al.*, 2021) correlated with GTAs' Instructor Talk. Our findings of increased Instructor Talk among GTAs with pedagogical training provided yet another call for systematic integration of training in effective and inclusive science teaching for all scientific trainees.

Reflecting on Their Instructor Talk May Provide Instructors an Opportunity for Metacognition

After discussing Instructor Talk, reviewing their own Instructor Talk, and reflecting individually in writing on their own, 82% of GTAs asserted that they had learned something about their teaching and that they had actionable items for improving their future Instructor Talk. There have been calls to provide more pedagogical training to GTAs and improve pedagogical training already available to GTAs for evidence-based teaching practices (Rushin *et al.*, 1997; Park and Ramos, 2002; Kendall *et al.*, 2013; DeChenne *et al.*, 2015). Our findings provide another avenue for GTA pedagogical development, namely, an opportunity to be metacognitive about the language they use in the classroom (Tanner, 2012). While three GTAs did not mention learning anything that would impact their future teaching, 14 GTAs noted specific things they learned from reviewing their Instructor Talk and mentioned actionable items that they would be taking with them into their future teaching. Additionally, the Instructor Talk categories provided GTAs with an analytical framework with which they could identify specific areas for improvement or changing the language they used in their classrooms. Three GTAs noted specific categories in which they intended to use more Instructor Talk in the future to better align their classroom environments with their intentions.

GTAs noted remembering some of their Positively Phrased Instructor Talk, stating that those instances were said intentionally. Many GTAs were surprised by their Negatively Phrased Instructor Talk, sharing that their Negatively Phrased Instructor Talk was intended positively, often either as a joke or sarcasm, and that they could now see how their phrasing could lead to misinterpretations of their intentions. Humor used by instructors

may be beneficial in creating a positive classroom environment and building the instructor–student relationship; however, humor that students perceive as offensive may disestablish the instructor–student relationship and decrease student sense of belonging (Cooper *et al.*, 2018). Therefore, professional development that encourages GTAs to be metacognitive about the language they use and how they employ humor may be beneficial. Furthermore, such reflection may support instructors in making the small changes to their phrasing needed to use Positively Phrased Instructor Talk in their jokes, sarcasm, and casual language. Future studies might consider how undergraduate students perceive GTAs' use of what researchers have categorized as Negatively Phrased Instructor Talk.

Surprisingly, Minimal Small-Group Instructor Talk Was Observed among GTAs Teaching in the Laboratory Course Setting

Due to the nature of laboratory courses, in which students often work in small groups on laboratory activities, we expected to observe Small-Group Instructor Talk, i.e. any Instructor Talk that addresses a small group of students rather than the entire class. However, we found very few instances of Small-Group Instructor Talk in the pilot study, which monitored entire class sessions for five GTAs. Specifically, we transcribed and coded two class sessions—one on the first day and another midsemester—for each GTA in the pilot study. It is possible that there are more instances of Small-Group Instructor Talk to be discovered. Importantly, our sampling method for the full study focused on the first 15 minutes of the class session, at which point GTAs may not have been engaged in small-group conversations. As such, future studies investigating Small-Group Instructor Talk in laboratory courses might consider validating a sampling method for the middle of the class session. Further, it may be the case that GTAs may not be prepared to do small-group instruction, thus limiting the frequency of GTAs' small-group engagement. Notably, some GTAs were having conversations with small groups of students, but this language did not fall within the Instructor Talk framework. It is also possible that language that falls on the edge of content may not be codable based on our criteria for Instructor Talk.

This type of language has been studied using the Classroom Discourse Observation Protocol, which focuses on language that directly relates to content, but involves the instructor engaging students "in the construction, justification, and evaluation of knowledge as opposed to simply providing factual knowledge" (Kranzfelder *et al.*, 2019, p. 2). One might predict that Small-Group Instructor Talk could be captured in courses structured with active-learning and group work if instructors carry a recorder with them (e.g., in their pockets). However, this type of discourse may be commonly used with small groups of students who may be asking content- or procedure-specific questions, and therefore would not be categorized as Instructor Talk. While it is possible that communication and guidance with small groups of students primarily falls outside the Instructor Talk framework, it is also possible that Small-Group Instructor Talk occurs infrequently. This could imply that the one-on-one attention we predict exists in laboratory settings is not as prevalent as assumed. Alternatively, this lack of Small-Group Instructor Talk could be unique to GTAs who may be more hesitant in their teaching ability and therefore less likely to feel comfortable talking to students in small groups. Although Small-Group Instructor Talk was not widely prevalent in our pilot study, future investigations might consider this phenomenon in contexts where small-group activities are common, such as in CUREs or biology courses with active-learning components.

Limitations and Future Directions

As alluded to earlier, there was a fundamental conflation of variables inherent in our study: course type and instructor type. Our study investigated Instructor Talk used by GTAs teaching laboratory courses and compared it with Instructor Talk of faculty teaching lecture courses. A research design that could separate these variables would compare the current findings to with results from faculty teaching laboratory courses and/or GTAs teaching lecture courses. However, graduate students typically only teach discussions or laboratories and rarely teach lecture courses. Furthermore, in a 4-year research university setting, it is uncommon to find faculty teaching laboratory courses. While this statistic has not been recently examined, national surveys of more than 70 top institutions have found that between 71 and 93% of institutions' laboratory courses are primarily instructed by GTAs (Sundberg and Armstrong, 1993; Sundberg *et al.*, 2005). Future studies are needed in other settings, such as community colleges, liberal arts universities, and undergraduate-only universities, in which Instructor Talk could be studied with faculty members teaching laboratory courses to address this limitation of the current study.

While we have discovered that Instructor Talk is indeed used by GTAs in laboratory courses, our findings may not generalize to all GTAs in all contexts. This study was restricted to the specific context of GTAs teaching laboratory classes at a large, urban 4-year university. A logical next step would be to investigate Instructor Talk in novel contexts such as other institution types with varied GTA populations and training programs. Furthermore, the GTAs involved were those who agreed to audio-record their courses, and it is possible that Instructor Talk of nonparticipating GTAs may be different from that studied here or even not present at all. Finally, this study investigated Instructor Talk from an instructor-centric point of view, and future studies are needed to investigate the impacts of Instructor Talk on undergraduate students by considering both their academic and affective outcomes, as well as student memories and perceptions of GTA Instructor Talk.

CONCLUSION

We set out to address a gap in the literature—knowledge about the noncontent language used by GTAs teaching laboratory courses—that could have impacts on equity and inclusion in biology education and on the student experience. Our findings here expand upon previous Instructor Talk research. We found that Instructor Talk is indeed found in the novel context of laboratory courses taught by GTAs and can be characterized using the existing frameworks for Instructor Talk. Further, this study fills a gap in the literature by exploring Instructor Talk for biology instructors with little to no pedagogical training or experience. We found that GTAs with prior teaching experience and pedagogical training used more Instructor Talk—specifically more Positively Phrased Instructor Talk—than GTAs without teaching experience and pedagogical training, reinforcing the

importance of providing pedagogical training for GTAs. Additionally, we found that GTAs teaching laboratory courses use more Instructor Talk—both Positively and Negatively Phrased—than faculty teaching lecture courses. Future research could explore important aspects of GTA identity, including near-peer status and self-efficacy, and how they relate to Instructor Talk. Overall, our results provide evidence that Instructor Talk may vary at different science instructor career stages. The present study impels future work to investigate the prevalence of non-content language (or lack thereof) for instructors with minimal pedagogical training and the impacts of Instructor Talk on in/equitable student outcomes in STEM.

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