

## **Investigating potential influences of graduate teaching assistants on students' sense of belonging in introductory physics labs**

Caitlin Kepple

*Department of Physics and Astronomy, San Francisco State University, 1600 Holloway Ave, San Francisco, CA, 94132*

Kim Coble

*Department of Physics and Astronomy, San Francisco State University, 1600 Holloway Ave, San Francisco, CA, 94132*

Over the past year, the Physics and Astronomy Department at San Francisco State University (SFSU) has implemented a pedagogical training course for incoming graduate teaching assistants (GTAs). While it has been widely accepted that students' sense of belonging in the classroom can be influenced by many factors, our focus is to better understand what students themselves feel contributes most to their sense of belonging and what role GTAs might play in it. We have collected attitudinal surveys from students in the introductory physics sequence for life science majors that pertain to students' perceptions of belonging and relationship to their lab instructor. We have identified an emergent set of factors from student testimonies, showing a number of indirect influences GTAs may have on students' sense of belonging in lab. We found students tend to cite interpersonal relationships with their group and the labwork itself as major contributors to their sense of belonging in Physics I while Physics II students prioritize interpersonal relationships with both their group and the class as a whole. Our goal is to develop a set of student-centered approaches from this data that will ultimately provide insight for future lab instructors to help create an inclusive and accessible laboratory environment.

## INTRODUCTION

### A. Giving voice to under-represented students' opinions

As the physics education community continues to study the experiences of students in the classroom, there is a growing recognition of the need to include equity considerations in those experiences. In particular, a number of recent studies have shown that students' academic sense of belonging in the classroom can ultimately influence their self-efficacy, motivation, and intentions to persist in the field [1-3]. Here we define students' sense of belonging similar to that of Lewis et al. (2016), as the extent a student feels valued, accepted, and a legitimate member of the scientific community [4]. Because the vast majority of the students we consider in this study are not physics majors, we consider both their sense of belonging in the physics laboratory classroom and in the scientific community in general.

San Francisco State University (SFSU), where this study has been conducted, is a large public university of almost 30,000 students and is designated as a Hispanic-serving institution. It is one of the most diverse schools in the country with 35% of students identifying as Hispanic, 28% Asian, 19% White, 6% Black, 6% two or more races, and 6% unknown or other [5]. According to Estrada et al. (2018), historically underrepresented students in STEM fields are especially impacted by their ability to relate to those around them and feel part of the community [6]. Their research postulates that students who feel social inclusion in their academic community are more likely to develop a social identity related to their chosen field. With the growing movement to close opportunity gaps and recognize the many resources that underrepresented students bring to the classroom [7], considering their sense of belonging is essential for doing so.

To give a more complete description of the factors that may contribute to belonging, we use the framework of Rainey et al. (2016) [8] in which they find that sense of belonging may be influenced by students' interpersonal relationships (social relationships with peers/instructor [9]), perceived competence (feels like they understand subject matter [10,11]), personal interest (in the material), and their science identity (feels personal connection with science, e.g. [10,11]). In this paper we hope to both utilize and build on to this framework in order to understand how a diverse student population, such as the students at SFSU, can be best represented in this context.

### B. Instructor influence on student belonging in lab

For undergraduate students, participating in labs can be influential in not only re-iterating content learned in lecture, but also fostering connections with peers and instructors. Because labs are collaborative, interactions between Graduate Teaching Assistants (GTAs) and students can set

the tone for how students develop interpersonal relationships in their field for the rest of their college experience [12,13].

For graduate students, there is often an expectation to teach during at least the first year or two while earning a graduate degree. Many see it as a way to gain teaching experience, getting a small taste for being a college professor. As lab instructors, GTAs have the ability to set classroom norms and expectations, which implies that many of the predictors for students' development of belongingness in science can be influenced by GTAs. Specifically, GTAs are responsible for setting the stage of how students should conduct experiments, work in a collaborative group, and act in a scientific community [14].

Almost all undergraduate students in STEM are required to take a number of laboratory-based courses during their undergraduate degree. However, very little of this experience is likely to be in physics as most majors only require one or two semesters of physics. This means the GTA for a physics lab is one of the first "physicists" students get to know, aside from their lecturer, which can impact how students imagine themselves doing physics. GTAs themselves come into graduate school likely having quite a bit of lab experience, and possibly strongly-held beliefs about what the goal of an undergraduate laboratory class should be [15]. These experiences and beliefs about physics play a major role in how they choose to facilitate the lab. This underscores the importance of GTA training on how to teach physics and perhaps more importantly, how to interact with and support students who may not have the same relationship with the subject as GTAs [16].

The transition between being a student and instructor has been increasingly studied in recent years, which has been met with a resounding call for GTA training as future physics educators [17]. During the Fall 2018 semester, SFSU implemented a GTA pedagogical training course that is required for all incoming graduate students who wish to teach in the Department of Physics and Astronomy. This course, which was initiated by the second author of this paper, maintains explicit goals for GTAs to become aware of how they affect students' sense of belonging and to develop a well-defined set of methods for encouraging belonging. To that end, this paper is part of a larger study aiming to examine how the pedagogical knowledge and student-centered practices of GTAs can impact students' sense of belonging in lab. For this particular paper, our research questions are:

*1. What do students perceive as the major contributors and/or barriers to their sense of belonging in physics lab and in the scientific community?*

*2. What are the potential roles of GTAs affecting student-perceived sense of belonging in a scientific environment?*

## I. METHODS

### A. Student population and setting

While the Physics Education Research community has worked to provide a well-defined set of characteristics that contribute to students' sense of belonging in science, it is important to explore this in a variety of institutional contexts [18]. It is easy for the experiences of those who are typically underrepresented in the field to fall outside research conducted on majority populations, causing these students to feel further marginalized [19]. With this in mind, as SFSU begins the process of reforming its own physics lab curriculum, we wish to better understand how students from a wide range of backgrounds define their sense of belonging and investigate both potential barriers and contributors to their sense of belonging.

As with most institutions, students who enroll in lower division physics and astronomy courses at SFSU are almost all non-physics majors. Our focus for this paper is on students in the algebra-based physics courses, most of whom are biology/life sciences majors. At SFSU, the algebra-based physics track is composed of two semester-long courses that each have a 3-unit lecture component and 1-unit lab component. The labs themselves are almost all taught by GTAs, with a few taught by lecturers in the department. It should also be noted that students are required to pass both the Physics I lecture and lab courses before being permitted to take Physics II. The current lab curriculum uses verification-style labs on different topics each week.

### B. Sense of belonging survey instrument

Over the course of the Fall 2018 and Spring 2019 semesters, we gave Physics I and II students a number of surveys looking at students' self efficacy in lab process skills, self-reported approaches to lab, and sense of belonging. This paper will exclusively focus on results from the sense of belonging portion of the surveys.

The survey was a post-instruction attitudinal survey with Likert-style questions taken from the SF Build Illuminating Pathways survey [20], measuring sense of belonging, science identity and perceptions of the classroom environment. This was followed by four free-response questions asking students directly about their sense of belonging in lab. In the open-response portion of the survey, students were asked what factors from the lab contributed the most to their sense of belonging in a scientific environment and whether their sense of belonging had ever been challenged (what we consider "barriers"). If so, they were prompted to give an example of a time they felt this way and why.

### C. Data collection

The sense of belonging survey was distributed through an online form, which students could complete either in class or at home. Table I shows the number of respondents from both semesters for each course.

TABLE I. Number of participants taking the post-semester lab survey; N-participants (% of total enrollment).

Course	Fall 2018	Spring 2019
Physics I	53 (18.6%)	111 (42.5%)
Physics II	71 (34.6%)	52 (28.4%)
Total	124 (25.3%)	163 (36.7%)

For many of the lab sections, students were told the surveys would count as part of the participation grade. However this was not the case across the board, resulting in a lack of consistent participation for students from Physics I to Physics II. From this we were not able to track a significant number of students longitudinally from one course to the next. Instead, we chose to compare responses from Physics I to Physics II, assuming those who are in Physics II have had more exposure to physics content and laboratory methods. This extra exposure, or persistence to continue with their degree, could have implications for perceived competence in skills, science identity, and overall sense of belonging in science [3]. Thus we are interested in seeing if the factors contributing to sense of belonging are different in Physics I and Physics II.

We performed a Kruskal-Wallis test (KW test) for each Likert-style question to ensure the validity of combining responses from all lab sections of each course/semester [21].

## III. RESULTS

In analyzing the free-response sections of the survey for themes, we were able to find both positive and negative examples of each of the components of sense of belonging in Rainey et al.'s framework, including *Interpersonal Relationships*, *Perceived Competence*, *Personal Interest*, and *Science Identity*. We found that students' responses tended to cluster in some categories much more than others. Furthermore, many students tended to make distinctions between a supportive lab group versus feeling support from the class as a whole. This detail prompted us to subdivide the *Interpersonal Relationships* ("IR") category into three sub-themes: *IR-Group*, *IR-Instructor*, and *IR-Classroom*.

We found two additional categories not seen in Rainey et al.'s framework. Many students cited that simply coming to lab, doing the labwork, or using the equipment is what helped them feel a sense of belonging. We call this additional category *Lab Participation and Content*. We encapsulate students' responses that "nothing in particular" about the lab contributed to their sense of belonging as a category of "*Nothing*."

Figure 1 shows the distribution of students' responses for factors that positively contribute to their sense of belonging in a scientific environment and Figure 2 shows the frequency of barriers, as discussed earlier in the paper. Percentages do not add up to 100%, as student responses can be coded in multiple categories.

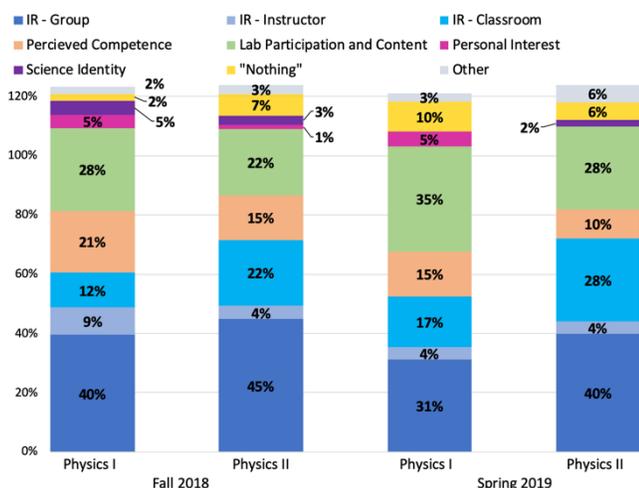


FIG. 1. Student-reported factors from lab that contribute to sense of belonging in a scientific environment. From left to right, N = 43, 67, 99, and 50.

The number of students who answered the free-response questions is smaller than the number of students who took the survey overall, thus we have included these N for each semester/course in the figure captions.

For essentially all groups who took the survey during these two semesters, a large portion of students felt their sense of belonging was reinforced by their groupmates specifically, which we classify as *IR-Group*. For those that cite the class as a whole as contributing to their belonging, which may include but is not limited to: feeling a sense of community, support from other peers in general, or feeling their identity is well represented in the class, we classify as *IR-Classroom*. The *Lab Participation and Content* category is also prominent for all groups, which from students' responses seemed to differ from any category in the existing framework. We also notice few to almost no responses that match *Personal Interest* or *Science Identity*, which may be due to the fact that the survey was given to algebra-based students in a physics lab, thus students may not feel the physics lab specifically contributes to their overall science identity.

We find that there is a difference in what students feel are the major contributors to belonging between Physics I and Physics II. Much of the current research on students' sense of belonging emphasizes the importance of interpersonal relationships in lab [4], which we find is indeed the case for both Physics I and Physics II students. Both classes identify *IR-Group* as one of the most important contributors, however more Physics II students than Physics I cite *IR-Classroom* as being important to their sense of belonging. In addition, more Physics I students than Physics II attribute the labwork itself as a contributor to their sense of belonging.

Factors students attributed as posing as barriers to their sense of belonging included similar themes from the existing framework, such as negative *Interpersonal Relationships*

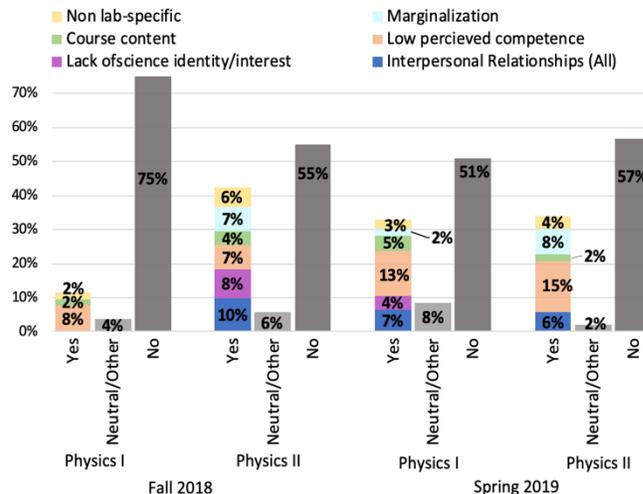


FIG. 2. Student responses to whether their sense of belonging had ever been challenged ("barriers" to belonging). From left to right, N = 45, 68, 93, and 48. The majority of students reported no barriers to sense of belonging.

(with other students, the GTA, or non-specific), low *Perceived Competence*, and lack of *Science Identity/Interest*. In addition, students reported other factors, such as the labwork as being too difficult (*Course Content*), feeling marginalized in class, non-lab related factors, or "neutral." Here we use the code *Marginalization* as students having felt they were treated unequally or that their identity was not equally represented in the class.

From Figure 2, we immediately see that approximately 50-60% of students (or more, in the case of Fall 2018 Physics I) reported that their sense of belonging had not been challenged. For both semesters, a larger proportion of Physics II than Physics I students responded Yes (their sense of belonging had been challenged). Furthermore, we see higher rates in student-reported feelings of *Marginalization* in Physics II than Physics I. However, for all groups except Fall 2018 Physics II, we found that the dominant barrier to sense of belonging was *Low Perceived Competence* in the subject material.

Figure 3 summarizes student responses for the Likert-style statements relevant to our research questions. While most of the statements in the survey focused on students' perceptions of GTAs, we also included statements inquiring about their sense of belonging and science identity. The 5-point scale had a range from "Strongly Agree" (light green) to "Strongly Disagree" (dark purple). We notice that the majority of students report "Agree" or "Strongly Agree" and less than 25% of students report "Disagree" or "Strongly disagree" for almost all questions in the survey (including those statements not included in the figure). We also observe that the statement regarding students' feelings of whether their personal and family history is valued in class is by far the lowest-scoring category for all groups.

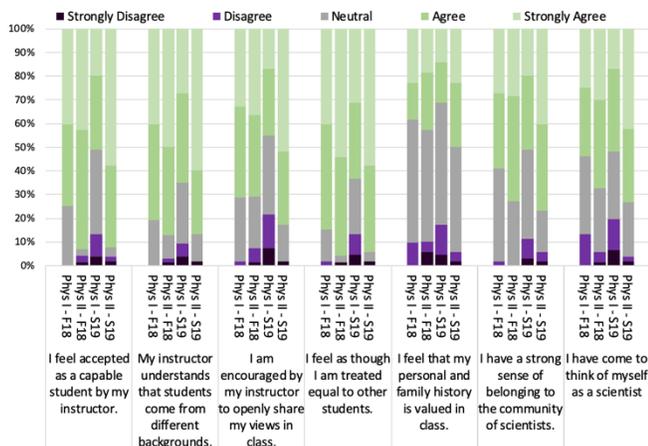


FIG. 3. Survey responses from the Likert-style questions taken from the SF Build Illuminating Pathways survey.

#### IV. DISCUSSION

GTAs teaching labs at SFSU generally have very little influence on the curricular material, the most being how they introduce the topic at the beginning of class. Even so, it is usually left up to the discretion of the GTA to decide the tone for their class and what type of classroom atmosphere they wish to have. As the primary instructor for the course, GTAs then have the option to encourage more or less collaborative learning between groups, and are generally responsible for fostering a sense of teamwork within groups if they wish to do so [13]. This results in GTAs having much more influence on the overall classroom environment and interpersonal relationships than the labwork itself. In Figure 1 we saw that students in Physics II prioritized *IR-Group*, and *IR-Classroom* more than Physics I and also mentioned *Lab Participation and Content* less than the Physics I classes. From this we can say that as students move from Physics I to Physics II, the GTA plays an increasing role in helping develop this sense of belonging as it applies to classroom atmosphere and peer-peer interaction. Even though students rarely mention GTAs outright as contributing to their sense of belonging, GTAs have an indirect influence on sense of belonging through their role in developing interpersonal relationships between groups and the class as a whole.

We notice the themes from Figures 1 and 2 are similar, meaning the same factors might be supporting some students but not others. In Figure 3 we see that the lowest scoring question relates to whether students feel their personal and family history is valued in class. These results point us in potential directions for growth to better meet the needs of underrepresented groups in STEM.

The next step for this project is to analyze additional data from GTA interviews and surveys taken from Summer/Fall 2018 to determine how GTAs feel they impact the overall classroom atmosphere and individual group dynamics. We will also analyze existing data from additional student surveys (e.g. CLASS, SPSI, ECLASS [22-24]) that we feel will further elucidate this narrative of shifting priorities and perceptions as students progress from one level to the next. We feel it would be worth investigating further as to which demographic populations cite particular contributors vs. barriers to belonging [18]. The final step will then be to match students with GTA responses to track whether the methods described by GTAs are contributing to students' sense of belonging.

#### V. CONCLUSIONS

While we have been able to obtain a better understanding of how GTAs might affect students' sense of belonging in lab, it is clear that students do not attribute their sense of belonging to GTAs or instructors directly, but rather indirectly. We also see a shift in the most dominant contributors from Physics I students to Physics II. Physics I students felt that their relationship with their lab group and the labwork itself were most important, while students in Physics II felt that these, as well as the interactions they had with the class overall were significant.

A higher percentage of students in Physics II reported various barriers to their sense of belonging for both semesters. The coded responses for both barriers and contributors had a considerable amount of overlap. We also notice from the Likert-style questions that there is room for growth when it comes to students feeling that their personal and family history is valued in the classroom.

For the future of this project, we plan to apply this framework of student-reported contributors and barriers to belonging to the practices of GTAs. Our ultimate goal is to help new GTAs understand their role in fostering belonging and helping them develop a set of effective, student-centered practices as lab instructors.

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