The Influence of Instructor Behaviors and the Perceived Motivational Climate on Undergraduate Students' Experiences in College STEM Laboratories

Troy O. Wineinger,[†]* Mary D. Fry,[†] and E. Whitney G. Moore[‡]
[†]Department of Health, Sport & Exercise Science, University of Kansas, Lawrence, KS 66045;
[‡]Department of Kinesiology, College of Health & Human Performance, East Carolina University, Greenville, NC 27858

ABSTRACT
Biology laboratory instructors play a key role in creating an optimal environment where college students try hard and enjoy their classroom experiences. This study used achievement goal perspective theory to examine the influence of instructor behaviors on science, technology, engineering, and mathematics (STEM) students' perceptions of the motivational climate (caring, task, ego) and their adaptive (i.e., effort, enjoyment, performance self-esteem, and social self-esteem) and maladaptive (i.e., shame) experiences in the biology laboratory setting. Students (N = 563; women, 65%; men, 35%) enrolled in biology laboratory courses voluntarily completed a survey during the final week of the semester. Results of two structural equation modeling analyses across gender and racial identities made two important contributions to the STEM higher education literature: 1) when instructors engaged in effective teaching behaviors, students were more likely to perceive a caring/task-involving climate and, in turn, report adaptive motivational responses (i.e., increased effort, enjoyment, self-esteem; decreased shame); and 2) neither gender nor race moderated the measurement of the latent parameters. This research has important pedagogical implications, as teaching assistants could be trained to engage in these effective behaviors to optimize students' STEM learning experiences.

INTRODUCTION
The U.S. federal government recently announced an initiative to boost science, technology, engineering, and mathematics (STEM) education to prepare for the approximate 3.5 million STEM jobs that will need to be filled by 2025 (Lazio and Ford, 2019). This large vacancy in STEM occupations is concerning, as the National Center for Education Statistics (2017) found that 35% of the students studying to fill these positions changed to a non-STEM major. The Bureau of Labor Statistics has projected STEM occupations will grow two times faster than all other professions in the next decade (Zilberman and Ice, 2021), so the need to fill these vacant STEM positions and reduce the number of students opting out of their STEM educational pursuits is pressing. As a result, administrators, educators, and policy makers are all searching for ways to enhance the culture of STEM education to attract and retain a diverse group of students to prepare them for these important positions (Wilson, 2011). In particular, laboratory courses provide an ideal avenue to generate interest and commitment to working in STEM fields due to the smaller class sizes and opportunities students have to engage in hands-on learning and build relationships with instructors and peers.

While both laboratory and lecture courses are regarded as central to learning, researchers have found that pairing course content with corresponding laboratory content resulted in greater student learning than lecture alone (Neilson *et al.*, 2010; Matz *et al.*, 2012). Enhanced learning likely results from students having hands-on

Derek Braun, *Monitoring Editor*
Submitted Jul 19, 2021; Revised Sep 13, 2022; Accepted Sep 28, 2022
CBE Life Sci Educ December 1, 2022 21:ar81
DOI:10.1187/cbe.21-07-0184
*Address correspondence to: Troy O. Wineinger (towineinger@ku.edu).

opportunities to gain experience and implement the knowledge obtained from lecture courses to actual experiments. In addition, compared with large lecture courses, the student-to-instructor ratios in laboratory courses are much smaller, which allows students more opportunities to form meaningful relationships with their peers and instructors, ask questions, process concepts, and better learn the material. It is noteworthy that students' experiences in the laboratory setting have been associated with enhanced interest in completing STEM degrees and pursuit of occupations in STEM fields (VanMeter-Adams *et al.*, 2014). Although laboratory courses can be beneficial for students in STEM, a growing body of literature on STEM pedagogy indicates that students' learning and overall experiences in the laboratory vary and are sometimes deficient due to inexperienced instructors and/or ineffective course instruction (Hofstein and Lunetta, 1982; Schussler *et al.*, 2015; Gormally *et al.*, 2016).

For example, Kendall and Schussler (2012) surveyed undergraduate students across a variety of science and non–science majors and found that, regardless of class type (i.e., lecture vs. laboratory), students perceived STEM faculty members, as compared with teaching assistants, as possessing enhanced knowledge and authority over curriculum that was germane to learning. It may follow that students would be more likely to achieve optimal learning experiences and outcomes when laboratory courses are taught by faculty members with advanced knowledge of subject matter and strong teaching efficacy. However, on many college campuses, especially large research-centered institutions, few full-time faculty teach these laboratory courses (Sundberg *et al.*, 2005). Instead, inexperienced graduate students are often assigned teaching assistantships and receive minimal to no training with little direction from more experienced professionals. As a result, many teaching assistants are left on their own to decipher how they will teach these courses (Rushin *et al.*, 1997; Schussler *et al.*, 2015). Having teaching assistants who lack experience and training is frequently part of departmental practices and norms that have been established and implemented for years. It would seem then, that many STEM academic departments could benefit from more closely aligning their STEM laboratory courses with best teaching practices that optimize student learning (Ames and Archer, 1988; Koca, 2016).

One useful theoretical framework for addressing student learning is Nicholls' (1984, 1989) achievement goal perspective theory. He developed this theory to understand how to maximize each student's potential. He maintained that instructors should do everything possible to create a task-involving climate, wherein students gauge success based on their personal effort and improvement rather than their normative standing within a class. Nicholls and other motivational researchers (Duda and Nicholls, 1992; Roberts, 2012) identified additional features of the climate, which include encouraging cooperation among classmates, striving to make everyone feel like they play an important role in the class, and viewing mistakes as part of the learning process.

Newton *et al.* (2007) added a caring component to the task-involving features, defining a caring climate as "one where individuals perceive a particular setting to be interpersonally inviting, safe, supportive, and capable of providing the experience of being valued and respected" (p. 70). The caring dimension of the climate provides a foundation for all students to genuinely perceive that they are valued and esteemed members of a group. Researchers (e.g., Roberts, 2012; Fry and Hogue, 2018; Fry and Moore, 2019) suggest that, when instructors can establish a climate with salient caring and task-involving features, individuals are likely to experience a host of affective, cognitive, and behavioral benefits. In contrast, some instructors create what is referred to as an ego-involving climate, where students perceive that their instructor rewards and values ability (e.g., intellect) and normative outcomes (e.g., grades), creates rivalry among classmates, gives most of the praise and recognition to a small number of students, and more often punishes mistakes. Nicholls (1984, 1989) theorized, and research supports, that students' perceptions of the motivational climate predict distinct and contrasting cognitive, affective, and behavioral responses from students (Ames and Archer, 1988; Wineinger *et al.*, 2021).

Specifically, when individuals perceive features of a caring and task-involving climate, they garner positive experiences and adaptive outcomes (Roberts, 2012; Harwood *et al.*, 2015; Fry and Hogue, 2018; Fry and Moore, 2019), including enhanced levels of self-esteem, effort, and enjoyment, as well as lower levels of shame. In contrast, individuals who perceive an ego-involving climate report more problematic responses, such as elevated levels of shame and lower levels of self-esteem, effort, and enjoyment. Specific to the college laboratory setting, Wineinger and colleagues (2021) found that students' perceptions of a caring and task-involving climate in their biology laboratory courses were positively associated with them reporting higher levels of effort and enjoyment. If students are focused on factors they have more control over (e.g., effort) and perceive a very welcoming and supportive environment (e.g., caring), it follows that these students may choose to exert high effort and find themselves enjoying the subject matter. Clearly, effort and enjoyment are central to creating and sustaining students' motivation and positive experiences in their academic endeavors.

Lucardie (2014), for example, found that having fun and experiencing enjoyment served as a key motivator for adult students to attend classes, master course content, and connect with others in their learning environment. Further, across 25 Carnegie R1 (i.e., R1: Doctoral Universities—Very high research activity) colleges in the United States, students who reported experiencing a positive laboratory environment and enjoying their research tasks were more likely to remain in their STEM research programs (Cooper *et al.*, 2019). In contrast, students who reported experiencing a negative laboratory environment were more likely to leave their research programs. Thus, there is mounting support for the benefits students can receive when learning in a positive laboratory environment.

While these studies have established the importance of students having positive experiences in their laboratory courses, research identifying the specific behaviors that facilitate teaching assistants' creation of a caring and task-involving climate is limited. Although research is limited in the academic domain, Smith and colleagues (2005) conducted foundational research investigating leaders' behaviors in the physical domain. Specifically, they reported athletes were more likely to report being in a task-involving climate and having a positive experience when they perceived their coaches were engaging in behaviors such as providing positive and encouraging feedback and helping athletes learn from their mistakes. In contrast, when athletes perceived their coaches provided limited positive feedback, more punishment feedback, and frequently ignored mistakes (i.e., did not provide technical feedback), they were more likely to perceive an ego-involving climate and have a negative experience (e.g., anxiety) on their sport teams.

Building upon the work of Smith and colleagues (2005), Brown and Fry (2014) considered the caring and task-involving features of the climate to develop a measure to assess effective instructor behaviors (i.e., as perceived by members of a fitness center). They examined the relationship between exercisers' perceptions of staff's behaviors, the caring and task-involving climate, and members' own behaviors. They found that, when exercisers perceived friendly and supportive staff behaviors, they were more likely to perceive a caring and task-involving climate with low ego-involving climate tendencies, which resulted in them engaging in greater task-involving and caring behaviors with other members. These instructor behaviors, such as making eye contact, interacting with every participant, and being available and welcoming, were important to exercisers' experiences and shaped how they perceived the climate. Additionally, the researchers found that exercisers' perceptions of their instructors' behaviors were positively associated with their commitment to continued exercise and life satisfaction. These findings suggest that individuals' perceptions of their instructors' behaviors may serve as a precursor to the type of climate they will perceive, although research is currently lacking relative to the academic domain.

Wineinger *et al.* (2021) have called for researchers to expand this research gap by having students identify the specific behaviors and strategies their teaching assistants employ to foster both caring and task-involving climates and reduce ego-involving climates, in order to inform teaching policies and practices. Although from the physical domain, Brown and Fry's (2014) work is particularly salient, as it provides support for the validity and reliability of a survey measure to assess effective teaching behaviors. In addition to investigating instructor behaviors, there is a need to expand on Wineinger and colleagues' (2021) work to assess the effects of climate on other important affective, cognitive, and behavioral outcomes, such as enhanced self-esteem and lower levels of shame (Fry and Moore, 2019).

Self-esteem has been described as the attitudes (i.e., positive or negative) individuals have toward themselves or their subjective evaluations of their personal self-worth (Rosenberg, 1989). Little work has been conducted to assess the influence of self-esteem on students' experiences in the college laboratory setting. Hogue and colleagues (2019), however, examined the influence of the perceived motivational climate on college students' state self-esteem when learning a new physical activity skill and found that participants who perceived a caring and task-involving climate reported significantly greater levels of performance and social self-esteem than those in an ego-involving climate. Further, Heatherton and Polivy (1991) reported that failure in academic and laboratory settings led to students experiencing decreased levels of performance self-esteem in both public (i.e., receiving public feedback) and private (i.e., receiving a poor exam grade) contexts, whereas students' social self-esteem was only affected by failure in public. Additionally, they found that poor performance on important exams (i.e., midterm exams), as well as anticipation of performing poorly, was detrimental to students' performance self-esteem. These findings, as well as both direct and indirect support for the effects that self-esteem can have on college students' anticipated grades, perseverance of effort, consistency of interest, and grade point average (GPA; Heatherton and Polivy, 1991; Weisskirch, 2018; Abdulghani *et al.*, 2020), suggest the need to examine the influence of climate on students' self-esteem in the college laboratory setting.

Similar to self-esteem (Velotti *et al.*, 2017), students' perceptions of shame in their academic endeavors has been associated with their overall experience and functioning in the college laboratory setting. Fontana and colleagues (2017) found that athletes' perceptions of an ego-involving climate on their sport teams were positively associated with shame and negatively associated with compassion for peers and coaches. In addition, Hogue and colleagues (2013) found college students performing a novel skill in an ego-involving climate experienced enhanced cortisol (i.e., stress) hormone reactivity and greater self-reported shame, anxiety, stress, and self-consciousness relative to those learning the same task in a caring and task-involving climate (i.e., where a reduction in salivary cortisol signaled a low stress response occurred). Although Fontana *et al.* (2017) and Hogue *et al.* (2013) conducted their work in the physical domain, their results (both psychological and physiological) align with the work of Pekrun *et al.* (2002) and Meyer and Turner (2002), who have associated maladaptive emotions like shame with impaired student academic achievement and exam performance, learning goals, and motivation to learn.

Based on the research described, the purpose of this study was twofold. The first purpose was to examine the relationship between students' perceptions of their teaching assistants' behaviors on their perceptions of the motivational climate and the effects of climate on their psychological outcomes (i.e., self-esteem, shame, effort, enjoyment) within their biology laboratory courses. We hypothesized that, when students report their teaching assistants engage in effective behaviors (e.g., "Is friendly toward me," "Recognizes me"), they will be more likely to perceive a higher caring and task-involving climate and, in turn, will report higher effort, enjoyment, and self-esteem and lower shame in their laboratory courses. In contrast, an opposite pattern of relationships is expected with regard to students' perceptions of an ego-involving climate.

The second purpose was to consider the extent to which the instructor behaviors' measure, which was originally developed for the exercise setting, is viable for use in college biology laboratory courses. The climate measures are relatively new to the college biology laboratory setting, and though they are hypothesized to reveal results that are consistent with theory and prior research, we followed best practices by explicitly testing for differences by gender as well as race. Considering that non-White groups and women in STEM have shown lower retention rates (Riegle-Crumb *et al.*, 2019; Huang *et al.*, 2020), examining how men, women, and diverse racial groups perceive these constructs is critical for verifying the use of these measures in a biology laboratory context.

METHODS

A trained research team administered surveys and collected data in laboratory courses. These courses are required in tandem with a gateway lecture course (taught by a tenured faculty member) for biology majors and students advancing in other STEM degrees. The surveyed laboratory courses ranged in size from 12 to 14 students and were under the instruction of one

TABLE 1. Scale items with item level and parcel factor loadings for race and gender models[a]

Instructor behaviors survey				
	Race model		Gender model	
In this lab, I feel the instructor…	Non-White (n = 191)	White (n = 350)	Men (n = 178)	Women (n = 368)
Behaviors parcel 1	**0.96**	**0.96**	**0.95**	**0.96**
Behavior 16: Makes me feel welcome.	0.87	0.91	0.88	0.90
Behavior 7: Greets me warmly when I walk in the door.	0.80	0.84	0.73	0.86
Behavior 5: Has a positive attitude toward me.	0.88	0.83	0.88	0.82
Behavior 6: Is helpful.	0.80	0.82	0.79	0.80
Behavior 13: Notices improvements I've made.	0.75	0.76	0.74	0.76
Behavior 2: Recognizes me.	0.67	0.74	0.68	0.75
Behaviors parcel 2	**0.94**	**0.95**	**0.94**	**0.96**
Behavior 11: Is friendly toward me.	0.83	0.87	0.86	0.86
Behavior 8: Encourages me to try my best.	0.83	0.84	0.81	0.84
Behavior 14: Loves their job.	0.76	0.81	0.76	0.82
Behavior 15: Wants to be working as a lab instructor.	0.60	0.82	0.70	0.77
Behavior 12: Makes eye contact with me.	0.76	0.75	0.79	0.75
Behavior 1: Makes an attempt to know my name.	0.60	0.70	0.63	0.70
Behaviors parcel 3	**0.93**	**0.98**	**0.96**	**0.97**
Behavior 9: Seems happy I'm in this lab section.	0.79	0.86	0.75	0.86
Behavior 10: Encourages me to strive toward my academic goals.	0.80	0.82	0.78	0.82
Behavior 17: Talks/interacts with me.	0.80	0.81	0.80	0.81
Behavior 18: Wants me to understand the results of lab.	0.76	0.78	0.82	0.76
Behavior 4: Is available when I need them.	0.76	0.73	0.73	0.75
Behavior 3: Introduces me to other students when appropriate.	0.61	0.63	0.60	0.64

The bolded numbers represent the factor loadings for the parceled items.
[a]Items listed below each parcel are averaged to create the respective parcel. The factor loadings are from the items in the configural model with items averaged together to create the parcel.

teaching assistant. There were a total of 12 teaching assistants (all graduate students) who taught multiple laboratory course sections (two to three per teaching assistant) in this study. The laboratory courses had structured experiments that were designed for students to further investigate concepts covered in their corresponding lecture courses. The Institutional Review Board at T.O.W.'s college approved this study, as did the participating administrators from the college's biology department, and consent was attained from all students who participated.

Participants

Students enrolled at a large college in the U.S. Midwest were invited to complete a brief survey during the final week of their molecular and cellular biology laboratory courses, and 97% of students participated. The majority of participants (N = 563) reported being women (65%), freshmen (74%), and White/non-Hispanic (62%). As only one individual reported nonbinary gender identification, we lacked statistical power to include them in the analyses as their own group (Cooper *et al.*, 2020). In addition, 20% of students reported being first-generation college students, and 26% of students reported being eligible for Pell Grant assistance.

Measures

The survey included measures of students' perceptions of instructor behaviors, motivational climate (i.e., caring, task-involving, ego-involving), performance and social self-esteem, shame, effort, and enjoyment in their respective laboratory courses, and demographic information. To support the content validity of the measures, a variety of biology administrators, instructors, and students reviewed the survey items, and there was unanimous agreement that the items were appropriate for use in the biology laboratory course setting.

Instructor Behaviors

Students' perceptions and impressions of the specific behaviors of their laboratory teaching assistants were examined using the 17-item Staff's Behaviors Scale (Brown and Fry, 2014). This measure was originally developed to identify staff behaviors that foster a caring and task-involving climate in an exercise setting. Although established in the exercise setting, the measure was readily adapted to the laboratory setting due to the behaviors (e.g., greeting students warmly upon arrival, making eye contact) being fairly universal in importance and generalizable across educational settings. The stem for the measure was changed from "When exercising at [name of franchise], I feel the staff/instructors…" to read "In this lab, I feel the instructor…" A sample item is "Greets me warmly when I walk in the door." One question was added to the original items, which read "Wants me to understand the results of the lab." Students responded to items using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Brown and Fry (2014) reported a composite reliability value of 0.97 for the Staff's Behaviors Scale in the exercise setting. With regard to the current study, the factor loadings for the Staff's Behaviors Scale items were acceptable, as they were all above 0.70 (i.e., ranging from 0.93 to 0.98; see Table 1). These results suggest the measure is appropriate for use with students in the biology laboratory setting.

Caring Climate

The 13-item Caring Climate Scale (Newton *et al.*, 2007) assessed the extent to which students perceived the environment within their laboratory courses to be interpersonally inviting, safe, and a setting where all are treated with kindness and respect. The stem was "In this lab…," and a sample item is "The instructor cares about the students." Students responded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Wineinger *et al.* (2021) verified the concurrent validity and reliability (composite reliability = 0.97) of the Caring Climate Scale in the college laboratory setting.

Perceived Motivational Climate

Students' perceptions of the task- and ego-involving features of the climate within laboratory courses was assessed using the 12-item Perceived Motivational Climate in Exercise Questionnaire–Abbreviated (Moore *et al.*, 2015), which was adapted by Wineinger *et al.* (2021) for the biology laboratory setting. The stem for each question was "In this lab…," and sample items include "the instructor emphasizes to always try your best" (task-involving) and "Students are hesitant/embarrassed to ask the instructor or other students for help" (ego-involving). Students responded to the items using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Wineinger *et al.* (2021) provided reliability (composite reliability: task-involving = 0.90, ego-involving = 0.69), as well as concurrent and discriminant validity support for the measurement climate scales in the college laboratory setting with this adapted version.

State Self-Esteem

The social (seven items) and performance (seven items) subscales of the State Self-Esteem Scale (Heatherton and Polivy, 1991) were used to assess students' perceptions of how others perceive them (i.e., social self-esteem) and how they perceive their own abilities in the laboratory (i.e., performance self-esteem). Students responded to the 14 items using a five-point Likert scale ranging from 1 (not at all) to 5 (extremely). The stem for each question was "During this lab…," and sample items included "I worry whether I am regarded as a success or a failure" (i.e., social self-esteem) and "I feel confident about my abilities" (i.e., performance self-esteem). The State Self-Esteem Scale has displayed high reliability ($\alpha = 0.92$), as well as concurrent and discriminant validity in studies examining undergraduate students in the college academic setting (Heatherton and Polivy, 1991).

Shame

The 10-item inadequate and deficient subscale of the Internalized Shame Scale (Cook, 1996) measured students' experiences of shame-related feelings in the laboratory setting. Students responded on a five-point Likert scale ranging from 0 (never) to 4 (almost always). The stem for each question was "When I'm in this lab…," and a sample item included "I feel intensely inadequate and full of self-doubt." The Internalized Shame Scale has displayed high reliability ($\alpha = 0.95$) with undergraduate students in the laboratory setting (Cook, 1996).

Effort

Students' perceptions of the amount of personal effort they exerted throughout their laboratory course was assessed using the four-item effort subscale of the Intrinsic Motivation Inventory (McAuley *et al.*, 1989). Items were tailored for the laboratory setting, and students responded using a five-point Likert scale with responses ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I try very hard during lab sessions." This instrument demonstrated adequate reliability (composite reliability = 0.81) as well as concurrent and discriminant validity in the college laboratory setting (Wineinger *et al.*, 2021).

Enjoyment

Students' perceptions of enjoyment during laboratory sessions was assessed using the five-item enjoyment subscale of the Academic Satisfaction Instrument (Duda and Nicholls, 1992). Students responded to items using a five-point Likert scale with responses ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I find lab sessions interesting." Wineinger and colleagues (2021) provided support for the reliability (composite reliability = 0.87) and concurrent and discriminant validity for using this measure in the college laboratory setting.

Statistical Procedures

Fundamental checks of normality and missing data were assessed via IBM SPSS v. 26 (IBM Corporation, 2019) followed by calculations of descriptive statistics; skewness and kurtosis criterion are −2 to 2 and −7 to 7, respectively (Aryadoust and Raquel, 2019). Of the missing data (1.35%), only 0.84% was missing on the scale measure items, and this was determined to be missing at random (MAR) based upon Little's MCAR test being nonsignificant when race was taken into account (p = 0.737 to 1.000). Thus, requirements were met for using full-information maximum likelihood (FIML) (Enders, 2010; Enders and Baraldi, 2018) during the confirmatory factor analyses (CFAs) and structural equation modeling (SEM) analyses (Little, 2013) in the R package lavaan 0.6-5 v. 3.5.2 (Rosseel, 2012).

Introduction to CFA and SEM

Conducting analyses in a CFA and SEM framework means that measurement error variance is separated from reliable, true score variance of the construct for each indicator. A CFA is comprised of three measurement invariance testing steps (configural, weak, and strong), which are followed by testing for homogeneity of latent parameters (i.e., means, variances, correlations) across the grouping variable (i.e., race or gender identity), before testing the hypothesized relationships for significance at the structural level (i.e., SEM; Little, 2013). Each modeling step is built sequentially upon the preceding step(s). Step 1, configural invariance, tests the overall model fit to the data (Little, 2013). Step 2, weak invariance, then tests that the factor loadings can be constrained to equality across groups (i.e., gender or race). Passing weak invariance provides support that the constructs are defined similarly and equally well across groups. Step 3, strong invariance, builds upon weak invariance by testing indicator means (i.e., item intercepts) that can also be constrained to equality across groups. Passing these three measurement invariance tests supports that any group differences found in subsequent tests of latent parameters represent true group differences, not measurement differences. These CFA tests build psychometric evidence for the measurement model of the constructs by assessing the internal validity of the constructs and the equality of that internal validity across the groups being modeled (i.e., gender or race). The CFA model has all constructs correlated with one another. SEM converts correlations to regression coefficients to test theory-based hypotheses. Finally, in the SEM, regression coefficients are tested for significance to determine the most parsimonious SEM model to represent the relationships in the data.

CFA Procedures

There are two different, two-group CFA models being conducted with all nine latent constructs: instructor behaviors, caring climate, task-involving climate, ego-involving climate, social self-esteem, performance self-esteem, shame, effort, and enjoyment. One model was across race (i.e., White and non-White), and a second model was across gender (i.e., woman and man). All the steps are completed for the race model and then again for the gender model. For the race model, 541 of the 563 student respondents reported their race/ethnicity identity (White = 350; non-White = 191), and so were included in the two-group race model. The individual non-White ethnic groups were limited in sample size and prevented examination by each race/ethnicity. Specifically, students identified as East Asian/Asian Americans (n = 53), South Asian/Indian Asians (n = 27), Latino/Hispanic Americans (n = 36), Black (n = 16), and other (e.g., mixed race; n = 59) were in the non-White group. SEM is a large-sample analysis technique (Little, 2013); a power analysis supported having sufficient power (β = 0.81) to find a small effect (r = 0.38) significant (α = 0.001) with a sample size of 190 for a model of our complexity. Thus, having our sample size of 190 facilitates being powered to find small differences between groups (i.e., means, variances, correlations). These power analyses support the subsample groupings used in our study. For gender, 546 of the 563 respondents identified their gender (men = 178; women = 368), and so were included in the two-group gender model. To account for the nested nature of the data (i.e., students in labs), the cluster option within lavaan was used to adjust the standard errors, as variance can be reduced due to the nonindependence of students within laboratory sections.

The fixed-factor method (i.e., latent variances fixed to 1.0, and latent means fixed to 0.0; standardized metric) was employed (Little, 2013). First, the item-level configural model was run so the item factor loadings could be used to calculate the composite reliability for the constructs. For constructs without existing facets, three equally informative parcels were calculated with the counterbalance method, which averages items with stronger and weaker loadings (Little, 2013). The items of the task-involving and ego-involving climate constructs were averaged into the three parcels based on published scale facets (Moore *et al.*, 2015; Wineinger *et al.*, 2021). Due to the low number of items for effort and enjoyment constructs, no parceling was done. The configural model acceptably fits the data based on comparative fit index (CFI) and Tucker-Lewis index (TLI) values of at least 0.90 and root-mean-square error of approximation (RMSEA) and standardized root-mean-square residual (SRMR) values of 0.08 or less (Little, 2013). The acceptability of the weak (i.e., factor loadings equated across groups) and strong (i.e., intercepts equated across groups) invariance models was based on a change in CFI of 0.01 or less, and the RMSEA of the more constrained model (e.g., weak invariance) fitting within the 90% confidence interval (CI) of the RMSEA for the less-constrained model (e.g., configural model; Little, 2013).

Once the CFA measurement invariance tests are passed, the homogeneity of the latent (i.e., construct) parameters (i.e., means, variances, correlations) across groups can be tested. For each of these homogeneity tests, a nested chi-square difference test is used to determine whether the constraints (e.g., means constrained to equality across groups) resulted in significant misfit to the data compared with the unconstrained model. Given the sample size, an alpha level of 0.001 was used for these and all subsequent nested model chi-square tests of latent parameters (Little, 2013).

SEM Procedures

Finally, to test the theory-based indirect effect hypotheses, correlations were converted to regression paths. Then, the regression paths were sequentially tested for significance with the nested chi-square difference test ($\alpha \leq 0.001$). Nonsignificant nested chi-square difference tests support that the constraint (e.g., regression coefficient set to 0) is appropriate. Constraints resulting in significant misfit (i.e., significant chi-square difference) support that the regression path is significant and needed in the model. To reach the most parsimonious model, significant paths were kept in the model and nonsignificant paths were pruned (i.e., kept out of the model). Then R^2 values, indirect effects, and 95% bias-corrected accelerated (BCa) CI values were calculated with the most parsimonious, final model.

RESULTS

Descriptive results are presented in Table 2. The composite reliability values for each of the scales was above 0.60, as recommended by Hair *et al.* (1998). On average, students perceived the instructor behaviors as engaging and supportive, although the students' responses did range from nearly the lowest score possible (1.28) to the highest (5.0). Similarly, the students, on average, reported their laboratory course climate as moderately caring and task-involving and low ego-involving in nature. It should be noted that there was variability in students' responses across all three climate scales (i.e., caring: 1.23–5.00; task-involving: 2.00–5.00; ego-involving: 1.00–4.17). Additionally, most students reported experiencing low shame in their laboratory courses and modest levels of social and performance self-esteem, effort, and enjoyment throughout the semester.

Race Model

CFA (Race Measurement Model). The two-group (i.e., White and non-White) item-level, configural model had somewhat poor fit (χ^2_{5476} = 11555.014, CFI = 0.81, TLI = 0.80, RMSEA = 0.067, SRMR = 0.073), as expected. The parceled configural model had acceptable fit (χ^2_{738} = 1530.86; CFI = 0.94; TLI = 0.93; RMSEA = 0.066, 95% CI [0.061, 0.071]; SRMR = 0.055). The model passed weak invariance (ΔCFI < 0.01; RMSEA = 0.065) and strong invariance (ΔCFI < 0.01; RMSEA = 0.064; see Table 3a for all model fits). Therefore, the factor loadings and indicator intercepts for the constructs were equally good across groups (i.e., White and non-White). Passing the CFA measurement invariance tests and the good reliability values supported that the internal measurement structure of the constructs was acceptable and consistent across these racial groups.

TABLE 2. Means, standard deviations, minimum, maximum, composite reliability (CR), and correlations for all students

Item and parceled model-fit indices and nested chi-square tests[a]													
Measure	M	SD	Min	Max	CR	1	2	3	4	5	6	7	8
1. Instructor behaviors	4.13	0.66	1.28	5.00	0.97								
2. Caring climate	4.31	0.63	1.23	5.00	0.97	0.88*							
3. Task-involving climate	4.02	0.62	2.00	5.00	0.85	0.76*	0.74*						
4. Ego-involving climate	2.15	0.62	1.00	4.17	0.77	–0.50*	–0.58*	–0.52*					
5. Social self-esteem	4.24	0.79	1.00	5.00	0.90	0.17*	0.20*	0.22*	–0.38*				
6. Performance self-esteem	4.15	0.65	1.44	5.00	0.85	0.28*	0.30*	0.33*	–0.37*	0.75*			
7. Shame	0.48	0.70	0.00	4.00	0.94	–0.19*	–0.22*	–0.22*	0.37*	–0.82*	–0.70*		
8. Effort	4.03	0.64	1.50	5.00	0.79	0.39*	0.35*	0.42*	–0.27*	0.05	0.15*	–0.03	
9. Enjoyment	3.88	0.72	1.40	5.00	0.89	0.55*	0.50*	0.57*	–0.41*	0.17*	0.27*	–0.14*	0.56*

[a]All measures used a 1 to 5 Likert scale, except for the measure for Shame, which was assessed on a 0 to 4 Likert scale.
*$p < 0.01$.

Next, the omnibus homogeneity tests of the latent parameters (i.e., means, variances, and correlations) were conducted. The omnibus homogeneity tests were nonsignificant for the latent means ($p = 0.24$), variances ($p = 0.88$), and correlations ($p = 0.04$), meaning that the latent means, variances, and correlations did not differ significantly by race. Thus, in the SEM, all of these constraints could be kept in the model, so it was essentially treated as a single-group rather than two-group (i.e., White and non-White) model.

SEM Race Results. Finally, regression paths from teaching assistant behaviors to the three climates and from the three climates to the student outcomes were tested for significance. The final, most parsimonious regression model (Figure 1) was theoretically sound and accounted for 42% of ego-involving variance, 75% of task-involving variance, and 81% of caring variance, along with 11–44% of variance for the outcome variables. Two indirect effects through ego-involving climate were significant: 1) behaviors → ego-involving climate → social self-esteem (β = 0.22, BCa 95% CI [0.19, 0.32]) and 2) behaviors → ego-involving climate→ shame (β = –0.22, BCa 95% CI [–0.29, –0.21]). Three indirect effects through the task-involving climate were significant: 1) behaviors → task-involving climate → performance self-esteem (β = 0.33, BCa 95% CI [0.31, 0.47]); 2) behaviors → task-involving climate → enjoyment (β = 0.57, BCa 95% CI [0.68, 0.86]); and 3) behaviors → task-involving climate → effort (β = 0.45, BCa 95% CI [0.40, 0.61]).

Gender Model

CFA (Gender Measurement Model). The two-group (i.e., male and female) item-level configural model resulted in somewhat poor model fit (χ^2_{5476} = 11594.58, CFI = 0.81, TLI = 0.80, RMSEA = 0.067, SRMR = 0.072), as expected. The parceled, configural model had acceptable fit (χ^2_{738} = 1582.08; CFI = 0.94; TLI = 0.92; RMSEA = 0.068, 95% CI [0.064, 0.073]; SRMR = 0.056), so the general pattern of relationships between the indicators and constructs was supported. Next, the model passed weak invariance (ΔCFI < 0.01, RMSEA = 0.067) and

TABLE 3. Item and parceled model fit indices and nested chi-square tests[a]

Table 3a. Race grouping	χ^2	*df*	CFI	TLI	SRMR	RMSEA	90% CI	$\Delta\chi^2$	*p* value	Pass
Configural (item level)	11,555.01	5476	0.809	0.801	0.073	0.067	[0.065; 0.068]			No
Configural (parceled)	1530.86	738	0.940	0.929	0.055	0.066	[0.061; 0.071]			Yes
Weak invariance	1541.64	759	0.940	0.931	0.057	0.065	[0.061; 0.070]			Yes
Strong invariance	1554.03	780	0.941	0.934	0.057	0.064	[0.059; 0.069]			Yes
Mean homogeneity	1565.90	789	0.940	0.934	0.060	0.064	[0.059; 0.068]	11.87	0.22	Yes
Variance homogeneity	1558.43	789	0.941	0.934	0.072	0.064	[0.059; 0.068]	4.40	0.88	Yes
Correlation homogeneity	1609.98	825	0.939	0.936	0.074	0.063	[0.058; 0.068]	51.55	0.04	Yes
Pruned regression	1641.75	840	0.937	0.935	0.078	0.063	[0.059; 0.068]	31.77		
Table 3b. Gender grouping	χ^2	*df*	CFI	TLI	SRMR	RMSEA	90% CI	$\Delta\chi^2$	*p* value	Pass
Configural (item level)	11,594.58	5476	0.808	0.800	0.072	0.067	[0.065; 0.068]			No
Configural (parceled)	1582.08	738	0.936	0.924	0.056	0.068	[0.064; 0.073]			Yes
Weak invariance	1597.20	759	0.936	0.926	0.058	0.067	[0.063; 0.072]			Yes
Strong invariance	1633.95	780	0.935	0.927	0.058	0.067	[0.062; 0.071]			Yes
Mean homogeneity	1646.62	789	0.934	0.927	0.059	0.067	[0.062; 0.071]	12.67	0.18	Yes
Variance homogeneity	1631.77	789	0.935	0.928	0.070	0.066	[0.062; 0.071]	–2.18	1.00	Yes
Correlation homogeneity	1672.99	825	0.934	0.931	0.069	0.065	[0.061; 0.070]	39.04	0.33	Yes
Pruned regression	1695.83	840	0.933	0.931	0.073	0.065	[0.061; 0.070]	22.84		

[a]CFI (acceptable ≥ 0.90); (acceptable ≥ 0.90); SRMR (acceptable ≤ 0.08); RMSEA (acceptable ≤ 0.08.

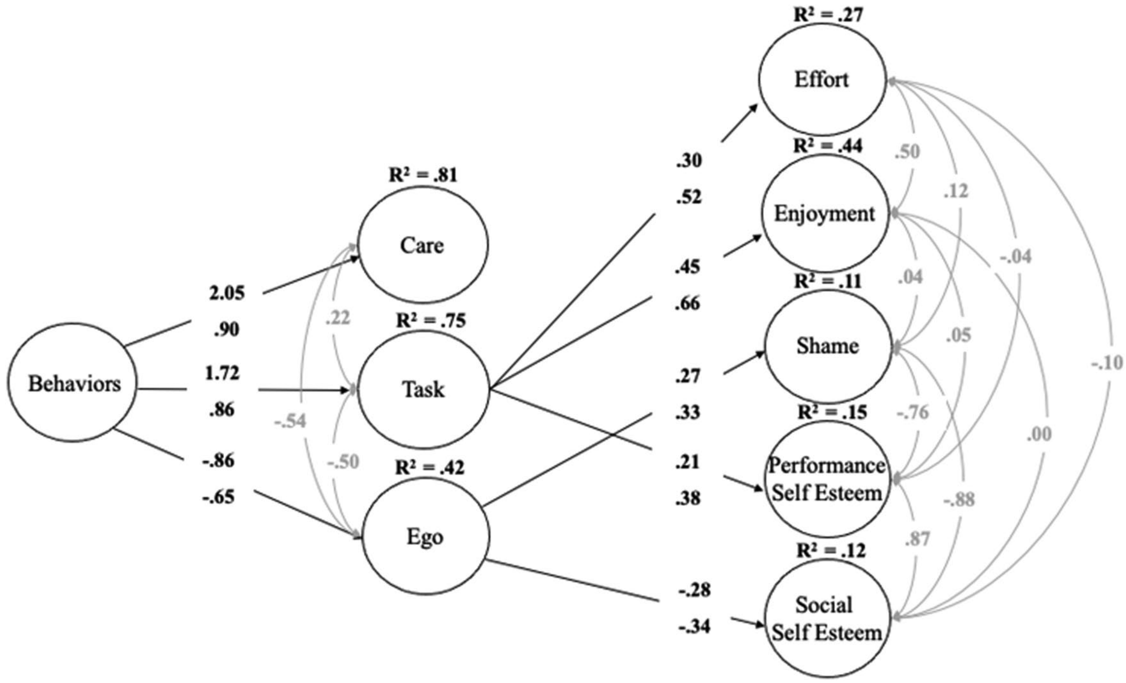

FIGURE 1. Pruned regression path model for race. Model fit (SRMR = 0.08, CFI = 0.94, TLI = 0.94, RMSEA = 0.06). Significant ($p \leq 0.001$) theory-driven regression paths are presented. Both unstandardized (top number) and standardized (bottom number) regression coefficients are presented for each significant path. Significant indirect effects were: Behaviors → EI → Social SE ($b = 0.22$, BCa 95% CI [0.19, 0.32]); Behaviors → EI → Shame ($b = -0.22$, BCa 95% CI [–0.29, –0.21]); Behaviors → TI → Performance SE ($b = 0.33$, BCa 95% CI [0.31, 0.47]); Behaviors → TI → Enjoyment ($b = 0.57$, BCa 95% CI [0.68, 0.86]); and Behaviors → TI → Effort ($b = 0.45$, BCa 95% CI [0.40, 0.61]). EI, ego-involving climate; TI, task-involving climate; SE, self-esteem.

strong invariance (ΔCFI < 0.01, RMSEA = 0.067), supporting that the factor loadings and intercepts could be constrained to equality across gender groups (see Table 3b). Therefore, as in the race model, the evidence supported the measurement quality of the constructs was acceptable and consistent across men and women. Having evidence of consistent measurement quality across gender permitted testing of the homogeneity of the latent parameters (i.e., construct means, variances, correlations) across gender. As in the race model, all three omnibus tests of homogeneity were passed: means ($p = 0.18$), variances ($p = 1.00$), and correlations ($p = 0.34$). Thus, these parameters were homogenous across genders, and the constraints were maintained for the SEM analyses.

SEM Gender Results. Finally, the hypothesized regression paths were tested for significance, and all nonsignificant paths were kept out of the final model, resulting in the most parsimonious version of the regression model (Figure 2). The relationships in this final, parsimonious model were theoretically sound and accounted for 38% of ego-involving climate variance, 72% of task-involving climate variance, and 81% of caring climate variance, along with 16–45% of variance for the outcome variables. The three significant indirect effects through ego-involving climate were: 1) behaviors → ego-involving climate → social self-esteem (β = 0.26, BCa 95% CI [0.24, 0.34]); 2) behaviors → ego-involving climate → performance self-esteem (β = 0.18, BCa 95% CI [0.13, 0.31]); and 3) behaviors → ego-involving climate → shame (β = –0.25, BCa 95% CI [–0.34, –0.23]). The three significant indirect effects through task-involving climate were: 1) behaviors → task-involving climate → performance self-esteem (β = 0.18, BCa 95% CI [0.13, 0.27]); 2) behaviors → task-involving climate → enjoyment (β = 0.57, BCa 95% CI [0.72, 0.99]); and 3) behaviors → task-involving climate → effort (β = 0.46, BCa 95% CI [0.46, 0.59]).

DISCUSSION

The purpose of this study was to examine 1) the relationship between students' perceptions of their teaching assistants' behaviors and students' perceptions of the motivational climate and 2) the effects of the motivational climate on students' experiences within their laboratory courses. Results from this study provide partial support for the hypotheses, as the teaching assistants' behaviors were shown to directly predict students' perceptions of the motivational climates and indirectly predict students' experiences in their laboratory courses. Specifically, students who perceived that their teaching assistants exhibited effective behaviors (e.g., makes eye contact, has a positive attitude) were more likely to report experiencing a caring and task-involving climate, as well as higher levels of effort, enjoyment, and self-esteem. In addition, perceptions of these instructor behaviors resulted in students being less likely to perceive an ego-involving climate and to experience less shame in their laboratory courses. These findings were consistent across gender and race. Furthermore, these findings align with Brown and Fry's (2014) results and provide support that these effective instructor behaviors (e.g., friendly, supportive) are equally beneficial across achievement settings and are key for predicting and helping students perceive a caring and task-involving climate.

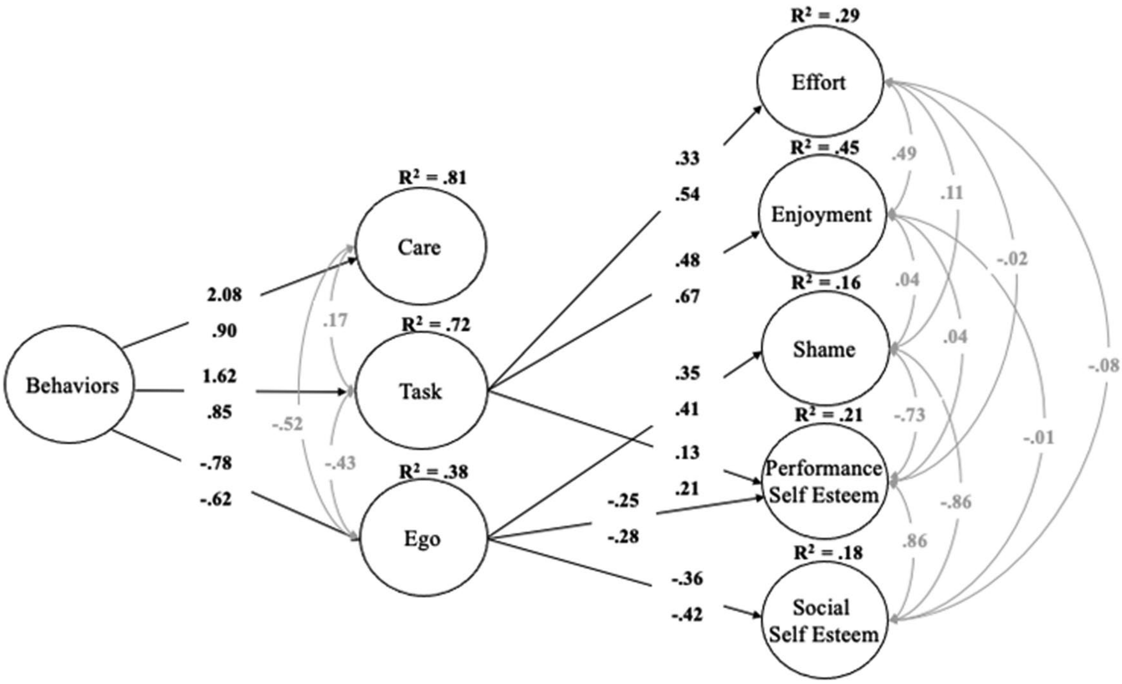

FIGURE 2. Pruned regression path model for gender. Model fit (SRMR = 0.07, CFI = 0.93, TLI = 0.93, RMSEA = 0.06). Significant theory-driven regression paths ($p \leq 0.001$) are presented. Both unstandardized (top number) and standardized (bottom number) regression coefficients are presented for each significant path. Significant indirect effects were: Behaviors → EI climate → Social SE (β = 0.26, BCa 95% CI [0.24, 0.34]); Behaviors → EI climate → Performance SE (β = 0.18, BCa 95% CI [0.13, 0.31]); Behaviors → EI climate → Shame (β = −0.25, BCa 95% CI [−0.34, −0.23]); Behaviors → TI climate → Performance SE (β = 0.18, BCa 95% CI [0.13, 0.27]); Behaviors → TI climate → Enjoyment (β = 0.57, BCa 95% CI [0.72, 0.99]); and Behaviors → TI climate → Effort (β = 0.46, BCa 95% CI [0.46, 0.59]). EI, ego-involving climate; TI, task-involving climate; SE, self-esteem.

Particularly noteworthy in the current study is the support for the validity and reliability of the adapted instructor behaviors' measure for use in college biology laboratory courses. The CFA indicated a strong factor structure (i.e., passed measurement invariance), item loadings (greater than 0.70), and high measurement reliability (composite reliability > 0.60). Though continued research will be necessary to further confirm the psychometric properties of the instrument, initial results suggest the utility of the measure in the academic domain. In addition, the climate measures (i.e., caring, task-involving, ego-involving) demonstrated strong psychometric properties, consistent with Wineinger *et al.* (2021), who originally adapted the climate measures for biology laboratory courses. These validated behavior and climate measures may be helpful tools to researchers and practitioners interested in assessing students' perceptions of their biology laboratory experiences.

It is important to note that limited research (Smith *et al.*, 2005; Brown and Fry, 2014) has examined the specific teaching behaviors that are linked to students' perceiving a caring and task-involving climate, and this is the case for both the academic and physical domains. Unique to this study is the focus on the antecedents of students' perceptions of a caring and task-involving climate, as it is clearly valuable to have students identify the extent to which their teaching assistants adaptively interact with their students. The strategies included in the instructor behaviors (e.g., notices improvements, is helpful) measure are primary and straightforward actions that any teaching assistant could strive to incorporate into pedagogical practices. Clearly not all laboratory teaching assistants are engaging in these behaviors, as demonstrated in the wide range of student responses and the moderate overall mean score (see Table 2). Together, these results suggest that training may be beneficial to provide opportunities to discuss and practice implementing these instructor behaviors to create or augment the caring and task-involving climate.

In addition to the significant link between the teaching assistants' behaviors and the climate variables, the SEM models also supported strong relationships between the climate scales and student outcomes. As expected, the ego-involving climate was associated with more maladaptive student responses, including greater shame and lower performance and social self-esteem. These results are concerning, as Tangney and colleagues (1996) assessed the influences of different maladaptive emotions (i.e., shame, guilt, embarrassment) on undergraduate students' overall functioning in life and found that life experiences that elicited shame were the most destructive and disruptive in their lives. In a like manner, Pekrun *et al.* (2002) and Meyer and Turner (2002) found that shame and similar negative emotions undermine college and secondary students' learning and overall experiences in the classroom. Although there were slight variations in the race and gender models, the maladaptive effects of fostering an ego-involving climate were demonstrated in both models. These results indicate that an ego-involving climate was fostered when students perceived their teaching assistants did not demonstrate engaging and supportive behaviors, and this type of climate served as a significant predictor of outcomes unlikely to lead to sustained motivation and achievement over time.

Similarly, the features of an ego-involving climate appear to be detrimental to students building social and performance self-esteem during their laboratory course experiences. Social self-esteem is reflected in students feeling comfortable, adequate, and accepted by their peers regarding their public image, whereas performance self-esteem is a measure of the extent to which students feel academically competent and capable of completing rigorous course and program requirements (Heatherton and Polivy, 1991). Undergraduates' social and performance self-esteem has been negatively associated with students' reported levels of anxiety and depression and positively linked with their general self-esteem (Heatherton and Polivy, 1991). These findings are key, as students' self-esteem predicts their perseverance and anticipated grades (Weisskirch, 2018; Abdulghani *et al.*, 2020). The range of students' responses and the overall mean score of the ego-involving climate indicated that some students were unfortunately experiencing an ego-involving climate in their laboratory courses. Given the maladaptive experiences associated with an ego-involving climate, fostering such an environment in STEM laboratory courses may be one of the worst pedagogical practices teaching assistants can exhibit if the goal is to optimize the experience of every student.

Clearly, perceptions of an ego-involving climate are magnified and maladaptive functioning is likely to occur when teaching assistants fail to engage in effective behaviors (e.g., are friendly, provide encouragement). However, the current study highlights adaptive functioning and benefits for students who have laboratory teaching assistants who effectively foster a caring and task-involving climate. Specifically, and with regard to both the gender and race models, perceptions of a task-involving climate were a significant positive predictor of effort, enjoyment, and performance self-esteem. The features of a task-involving climate (e.g., encouraging effort, improvement, and cooperation) appear to be paramount for enhancing students' adaptive motivational responses in the college laboratory setting. These findings align with those of previous climate researchers who have consistently linked task-involving climates to higher levels of effort and enjoyment across achievement settings (for a review, see Fry and Moore, 2019), as well as to individuals' social and performance self-esteem and shame (Hogue *et al.*, 2013, 2019; Fontana *et al.*, 2017) in the physical domain. Although Weisskirch (2018) did not assess the influence of a task-involving climate, they did report that undergraduate students' self-esteem and perseverance of effort were predictors of estimated grades and that higher levels of self-esteem predicted consistency in academic interest. As such, STEM instructors may benefit from enhancing features of a task-involving climate in the laboratory setting.

Previous climate research has established that perceptions of a caring and task-involving climate complement each other and are associated with multiple positive outcomes (Fry and Moore, 2019). It should be noted, however, that the caring climate did not emerge as a significant contributor to the outcome variables when all three climate scales (i.e., caring, task-involving, ego-involving) were included as independent variables in the current SEM models. The high correlation between the caring and task-involving climate constructs in the regression models (i.e., resulting in high shared residual variance) may explain why one predictor variable (i.e., caring climate) did not appear to contribute to the model. Iwasaki and Fry (2016) experienced this phenomenon as well in their SEM analyses, as they reported a high correlation between the caring and task-involving climate constructs that may also have prevented the caring climate from making a unique contribution in predicting the outcome variables in their study. As expected, and found by Iwasaki and Fry (2016) and in the current study, all bivariate correlations were significant and in the theoretically predicted directions. From a practical standpoint, including all the features of a caring and task-involving climate is critical, regardless of the idiosyncrasies of the analyses.

Limitations and Future Research

While there are definite strengths to this study, limitations should be noted. First, the variables are captured at a single point in time, and it would be preferable to examine the relationships between instructor behaviors, climate scores, and student outcomes at multiple points across a semester, as well as across semesters. This would allow researchers to examine the dynamic processes involved in these complex phenomena. Second, this study was conducted with one biology laboratory course (i.e., molecular and cellular biology) at one university, and it would be beneficial to expand data collection to include multiple biology laboratory courses at a variety of institutions of higher education to assess the generalizability of the findings. A third limitation involves the categorization of students by race/ethnicity. In the present study, for the purpose of the SEM models, students were identified as White versus non-White. Although students of diverse race/ethnicity participated in the study, numbers were inadequate to look more specifically at each race/ethnic group. Race/ethnicity has been identified as an important demographic variable in STEM education (de Brey *et al.*, 2019; National Center for Education Statistics, 2019), because some groups are underrepresented in STEM fields (e.g., students who identified as being White were awarded higher percentages of STEM bachelor's degrees than students identifying as being Hispanic, Pacific Islander, Black, and/or Native American/Alaskan Native). However, incorporating race/ethnicity into research designs is complicated due to its intersectionality with accessibility, socioeconomic status, and first-generation status (Bowleg, 2012).

With regard to future research directions, there are multiple avenues to pursue. First, the results provided support for the psychometric properties of the measures (instructor behaviors, climate, and student outcomes) in the college biology laboratory setting. These measures are inexpensive, readily available, and simple to administer within courses and across programs to assess student experiences. A fruitful direction for researchers to consider is conducting training sessions for STEM teaching assistants. The newly adapted measures could then both assess and assist instructors in enhancing their usage of effective behaviors that engage and support student learning and assess the influence of the training on students' perceptions of the caring and task-involving climates and their motivational and behavioral outcomes. It may be that such training would result in higher retention of students in STEM majors and, over time, would combat the current shortage of STEM professionals (Zilberman and Ice, 2021) across fields. Future research is needed to determine the efficacy of training teaching assistants on how to infuse these behaviors into their laboratory courses. Finally, examining students' perceptions of the climate in their STEM courses (e.g., physics, chemistry, engineering) longitudinally and across their academic programs would also be a valuable avenue for continued research. It may be that the benefits of a caring and task-involving climate increase the longer students experience this type of psychosocial environment across their academic programs.

Other avenues for future research involve adding a qualitative component in which teaching assistants whose students perceive they create a high caring and task-involving or low caring and task-involving climate are interviewed to examine their teaching experiences. Contrasting these teaching assistants' skill sets and views about creating positive laboratory learning environments for students could provide insight on how to assist STEM laboratory teaching assistants in gaining the knowledge and ability to foster positive and optimal learning environments for all students. It would also be interesting to observe teaching assistants in the classroom and examine their natural behaviors and interactions with students. This approach would allow for consideration of behaviors that augment the ones already identified in this study, as well as detect behaviors that may be particularly problematic for students (e.g., making comments that lead students to feel self-conscious or question their ability). Another tactic would be to conduct focus groups with students who rated their teaching assistants as either highly effective or ineffective at creating a caring and task-involving climate in their laboratory courses. Students would be able to give specific examples of teaching assistants' behaviors that impacted their experiences across a course. There are also many student outcome variables that have not been included in the STEM climate research. For example, it follows that students who perceive a high caring and task-involving climate (e.g., are focused on their personal effort and improvement) might have better relationships with teaching assistants and peers in the programs, greater psychological well-being, and higher grades/GPAs and retention and graduation rates. Researchers might consider including outcome variables such as these in future research.

In conclusion, the results of this study suggest that not only do teaching assistants have the ability to influence the climate their students perceive, but creating a caring and task-involving climate directly impacts students' motivational and behavioral outcomes in the college laboratory setting. Facilitating students' enjoyment, effort, and social and performance self-esteem in laboratory classrooms can increase students' engagement and academic performance as well as the likelihood they will complete their STEM degrees. This study has important pedagogical implications for administrators, policy makers, teaching assistants, and all seeking to optimize learning in college STEM courses.

ACKNOWLEDGMENTS

The authors would like to acknowledge Dr. Denny Swartzlander and Dr. Kalia Colyott for their assistance in conducting this study.

REFERENCES

Abdulghani, A. H., Almelhem, M., Basmaih, G., Alhumud, A., Alotaibi, R., Wali, A., & Abdulghani, H. M. (2020). Does self-esteem lead to high achievement of the science college's students? A study from the six health science colleges. *Saudi Journal of Biological Sciences*, *27*(2), 636–642. doi: 10.1016/j.sjbs.2019.11.026

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology*, *80*(3), 260–267. doi: 10.1037/0022-0663.80.3.260

Aryadoust, V., & Raquel, M. (2019). *Quantitative data analysis for language assessment*, Vol. 1, *Fundamental techniques*. New York, NY: Routledge.

Bowleg, L. (2012). The problem with the phrase women and minorities: Intersectionality—an important theoretical framework for public health. *American Journal of Public Health*, *102*(7), 1267–1273. doi: 10.2105/AJPH.2012.300750

Brown, T. C., & Fry, M. D. (2014). Motivational climate, staff and members' behaviors, and members' psychological well-being at a national fitness franchise. *Research Quarterly for Exercise and Sport*, *85*(2), 208–217. doi: 10.1080/02701367.2014.893385

Cook, D. R. (1996). Empirical studies of shame and guilt: The Internalized Shame Scale. In Nathanson, D. L. (Ed.), *Knowing feeling: Affect, script, and psychotherapy* (pp. 132–165). New York, NY: W. W. Norton & Company.

Cooper, K. M., Auerbach, A., Bader, J. D., Beadles-Bohling, A. S., Brashears, J. A., Cline, E., … & Brownell, S. E. (2020). Fourteen recommendations to create a more inclusive environment for LGBTQ+ individuals in academic biology. *CBE—Life Sciences Education*, *19*(3), es6. https://doi.org/10.1187/cbe.20-04-0062

Cooper, K. M., Gin, L. E., Akeeh, B., Clark, C. E., Hunter, J. S., Roderick, T. B., … & Brownell, E. S. (2019). Factors that predict life sciences student persistence in undergraduate research experiences. *PLoS ONE*, *14*(8), e0220186. doi: 10.1371/journal. pone.0220186

de Brey, C., Musu, L., McFarland, J., Wilkinson-Flicker, S., Diliberti, M., Zhang, A., … & Wang, X. (2019). *Status and trends in the education of racial and ethnic groups 2018 (NCES 2019-038)*. Washington, DC: National Center for Education Statistics, U.S. Department of Education. Retrieved June 29, 2021, from https://nces.ed.gov/pubsearch/

Duda, J. L., & Nicholls, J. G. (1992). Dimensions of achievement motivation in schoolwork and sport. *Journal of Educational Psychology*, *84*(3), 290–299. doi: 10.1037/0022-0663.84.3.290

Enders, C. K. (2010). *Applied missing data analysis*. New York: Guilford.

Enders, C. K., & Baraldi, A. N. (2018). Missing data handling methods. In Irwing, P., Booth, T., & Hughes, D. J. (Eds.), *The Wiley handbook of psychometric testing: A multidisciplinary reference on survey, scale and test development* (pp. 139–185). Chichester, West Sussex, England: Wiley Blackwell. https://doi.org/10.1002/9781118489772.ch6

Fontana, M. S., Fry, M. D., & Cramer, E. (2017). Exploring the relationship between athletes' perceptions of the motivational climate to their compassion, self-compassion, shame, and pride in adult recreational sport. *Measurement in Physical Education and Exercise Science*, *21*(2), 101–111. doi: 10.1080/1091367X.2017.1278698

Fry, M. D., & Hogue, C. M. (2018). Psychological considerations for children and adolescents in sport and performance. In Braddick, O. (Ed.), *Oxford research encyclopedia of psychology* (Vol. *1*, pp. 1–27). New York: Oxford University Press. doi: 10.1093/acrefore/9780190236557.013.177

Fry, M. D., & Moore, E. W. G. (2019). Motivation in sport: Theory to application. In Anshel, M. H., Petrie, T., Labbe, E., Petruzello, S., & Steinfeldt, J. (Eds.), *APA handbook of sport and exercise psychology* (Vol. 1, Sport psychology, pp. 273–299). Washington, DC: American Psychological Association.

Gormally, C., Sullivan, C. S., & Szeinbaum, N. (2016). Uncovering barriers to teaching assistants (TAs) implementing inquiry teaching: Inconsistent facilitation techniques, student resistance, and reluctance to share control over learning with students. *Journal of Microbiology & Biology Education*, *17*(2), 215–224. doi: 10.1128/jmbe.v17i2.1038

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis with readings* (5th ed.). Saddle River, NJ: Prentice Hall College Division.

Harwood, C. G., Keegan, R. J., Smith, J. M. J., & Raine, A. S. (2015). A systematic review of the intrapersonal correlates of motivational climate perceptions in sport and physical activity. *Psychology of Sport and Exercise*, *18*, 9–25. http://dx.doi.org/10.1016/j.psychsport.2014.11.005

Heatherton, T. F., & Polivy, J. (1991). Development and validation of a scale for measuring state self-esteem. *Journal of Personality and Social Psychology*, *60*(6), 895–910. doi: 10.1037/0022-3514.60.6.895

Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Education Research*, *52*(2), 201–217. doi: 10.2307/1170311

Hogue, C. M., Fry, M. D., & Fry, A. C. (2019). The protective impact of learning to juggle in a caring, task-involving climate versus an ego-involving climate on participants' inflammation, cortisol, and psychological responses. *International Journal of Sport and Exercise Psychology*, *8*(3), 273–289. https://doi.org/10.1080/1612197X.2019.1696868

Hogue, C. M., Fry, M. D., Fry, A. C., & Pressman, S. D. (2013). The influence of a motivational climate intervention on participants' salivary cortisol and psychological responses. *Journal of Sport & Exercise Psychology*, *35*(1), 85–97. doi: 10.1123/jsep.35.1.85

Huang, J., Gates, A. J., Sinatra, R., & Barabási, A. L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. *Proceedings of the National Academy of Sciences USA*, *117*(9), 4609–4616.

IBM Corporation. (2019). *IBM SPSS statistics for Mac, Version 26.0*. Retrieved May 10, 2021, from www.ibm.com/support/pages/downloading-ibm-spss-statistics-26

Iwasaki, S., & Fry, M. D. (2016). Female adolescent soccer players' perceived motivational climate, goal orientations, and mindful engagement. *Psychology of Sport and Exercise*, *27*, 222–231. doi: 10.1016/j.psychsport.2016.09.002

Kendall, K. D., & Schussler, E. E. (2012). Does instructor type matter? Undergraduate student perception of graduate teaching assistants and professors. *CBE—Life Sciences Education*, *11*(2), 187–199. doi: 10.1187/cbe.11-10-0091

Koca, F. (2016). Motivation to learn and teacher-student relationship. *Journal of International Education and Leadership*, *6*(2), 1–20.

Lazio, R., & Ford, H. (2019, June 6). The U.S. needs to prepare workers for STEM jobs. *SHRM*. Retrieved July 9, 2021, from www.shrm.org/hr-today/news/hr-magazine/summer2019/pages/the-u.s.-needs-to-prepare-workers-for-stem-jobs.aspx

Little, T. D. (2013). *Longitudinal structural equation modeling.* New York: Guilford.

Lucardie, D. (2014). The impact of fun and enjoyment on adult's learning. *Procedia—Social and Behavioral Sciences*, *142*(14), 439–446. doi: 10.1016/j.sbspro.2014.07.696

Matz, R. L., Rothman, E. D., Krajcik, J. S., & Banaszak Holl, M. M. (2012). Concurrent enrollment in lecture and laboratory enhances student performance and retention. *Journal of Research in Science Teaching*, *49*(5), 659–682. doi: 10.1002/tea.21016

McAuley, E. D., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the intrinsic motivation inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, *60*(1), 48–58. doi: 10.1080/02701367.1989.10607413

Meyer, D. K., & Turner, J. C. (2002). Discovering emotion in classroom motivation research. *Educational Psychologist*, *37*(2), 107–114. doi: 10.1207/S15326985EP3702_5

Moore, E. W. G., Brown, T. C., & Fry, M. D. (2015). Psychometric properties of the Abbreviated Perceived Motivational Climate in Exercise Questionnaire. *Measurement in Physical Education and Exercise Science*, *19*(4), 186–199. doi: 10.1080/1091367X.2015.1072819

National Center for Education Statistics. (2017). *Percentage of 2011–12 first time postsecondary students who had ever declared a major in an associate's or bachelor's degree program within 3 years of enrollment, by type of degree program and control of first institution: 2014*. Washington, DC: Institute of Education Sciences, U.S. Department of Education. Retrieved June 19, 2021, from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2018434

National Center for Education Statistics. (2019). Table 318.45: Number and percentage distribution of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student: 2008–09 through 2017–18.In *Digest of Education Statistics: 2019*. Washington, DC: U.S. Department of Education. Retrieved June 19, 2021, from https://nces.ed.gov/programs/digest/d19/tables/dt19_318.45.asp

Neilson, K. G., Huysken, K., & Kilibarda, Z. (2010). Assessing the impact of geoscience laboratories on student learning: Who benefits from introductory labs? *Journal of Geoscience Education*, *58*(1), 43–50. doi: 10.5408/1.3544293

Newton, M., Fry, M. D., Watson, D. L., Gano-Overway, L. A., Kim, M. S., Magyar, M. T., & Guivernau, M. R. (2007). Psychometric properties of the caring climate scale in a physical activity setting. *Revista de Psicologia del Deporte*, *16*(1), 67–84. doi: 10.1037/t55043-000

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*(3), 328–346. doi: 10.1037/0033-295X.91.3.328

Nicholls, J. G. (1989). *The competitive ethos and democratic education*. Cambridge, MA: Harvard University Press.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, *37*(2), 91–105. doi: 10.1207/S15326985EP3702_4

Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. *Educational Researcher*, *48*(3), 133–144. https://doi.org/10.3102/0013189X19831006

Roberts, G. C. (2012). Motivation in sport and exercise from an achievement goal theory perspective: After 30 years, where are we. In Roberts, G. C. (Eds.), *Advances in motivation in sport and exercise*, pp. (1–50). Champaign, IL: Human Kinetics.

Rosenberg, M. (1989). *Society and the adolescent self-image*. Middletown, CT: Wesleyan University Press.

Rosseel, Y. (2012). *lavaan*: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. Retrieved May 10, 2021, from www.jstatsoft.org/v48/i02

Rushin, J. W., Saix, J. D., Lumsden, A., Streubel, D. P., Summers, G., & Bernson, C. (1997). Graduate teaching assistant training: A basis for improvement of college biology teaching and faculty development? *American Biology Teacher*, *59*(2), 86–90. doi: 10.2307/4450255

Schussler, E. E., Read, Q., Marbach-Ad, G., Miller, K. R., & Ferzli, M. (2015). Preparing biology graduate teaching assistants for their roles as instructors: An assessment of institutional approaches. *CBE—Life Sciences Education*, *14*(3), ar31. doi: 10.1187/cbe.14-11-0196

Smith, S. L., Fry, M. D., Ethington, C. A., & Yuhua, L. (2005). The effects of female athletes' perceptions of their coaches' behaviors on their perceptions of the motivational climate. *Journal of Applied Sport Psychology*, *17*(2), 170–177. doi: 10.1080/10413200590932470

Sundberg, M. D., Armstrong, J. E., & Wischusen, E. W. (2005). A reappraisal of the status of introductory biology laboratory education in U.S. colleges and universities. *American Biology Teacher*, *67*(9), 525–529. doi: 10.1662/0002-7685(2005)067[0525:AROTSO]2.0.CO;2

Tangney, J. P., Miller, R. S., Flicker, L., & Barlow, D. H. (1996). Are shame, guilt, and embarrassment distinct emotions? *Journal of Personality and Social Psychology*, *70*(6), 1256–1269. doi: 10.1037//0022-3514.70.6.1256

VanMeter-Adams, A., Frankenfeld, C. L., Bases, J., Espina, V., & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE—Life Sciences Education*, *13*(4), 687–697. doi: 10.1187/cbe.13-11-0213

Velotti, P., Garofalo, C., Bottazzi, F., & Caretti, V. (2017). Faces of shame: Implications for self-esteem, emotion regulation, aggression, and well-being. *Journal of Psychology*, *151*(2), 171–184. doi: 10.1080/00223980.2016.1248809

Weisskirch, R. S. (2018). Grit, self-esteem, learning strategies and attitudes and estimated and achieved course grades among college students. *Current Psychology*, *37*(1), 21–27.

Wilson, S. M. (2011). *Effective STEM teacher preparation, induction, and professional development.* Retrieved July 10, 2021, from https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072640.pdf

Wineinger, T. O., Fry, M. D., & Moore, E. W. G. (2021). Validation of climate and motivational measures for use in the biology laboratory setting. *Journal of Biological Education*, 1–14. doi: 10.1080/00219266.2021.1909633

Zilberman, A., & Ice, L. (2021, January). Why computer occupations are behind strong STEM employment growth in the 2019–29 decade. *Beyond the Numbers*, *10*(1). Retrieved June 17, 2021, from www.bls.gov/opub/btn/volume-10/why-computer-occupations-are-behind-strong-stem-employment-growth.htm