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Validation of Climate and Motivational Measures for Use in the Biology Laboratory Setting

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Abstract

The purpose of this study, grounded in the Achievement Goal Perspective Theory (AGPT) and a Caring framework, was to effectively adapt previously validated measures of caring, task-involving (CTI), and ego-involving (EI) climates for college exercise classes to the college biology laboratory setting. The items' measurement quality was assessed over two studies. Students (N_{Study1} = 249, female 73%; N_{Study2} = 199, female 78%) enrolled in biology laboratory courses were invited to complete a survey during the last two weeks of their laboratory course. Confirmatory factor analysis (CFA) revealed overall good fit; however, two EI items had low loadings, so their wording was revised for Study 2. CFA results of Study 2 provided reliability and validity support for the use of these relatively brief and easy to administer measures in the college laboratory setting. This research provides additional support for creating CTI climates in the college laboratory setting.

Keywords: graduate teaching assistant, caring, task-involving, Achievement Goal Perspective Theory, STEM

Effort and enjoyment are important student outcomes in college courses that can positively influence student learning, satisfaction with peers, and the overall ability to master content in the classroom. Researchers emphasize that these outcomes are vital to students' satisfaction with their coursework, perceptions of learning something new, and fostering higher levels of intrinsic motivation (Brown & Fry, 2014; Hernik & Jaworska, 2018). One factor affecting students' effort and enjoyment is their perceptions of the psychosocial environment in their classrooms. Students' perceptions of a positive and supportive motivational class climate have been positively and significantly linked to their effort and enjoyment in primary school (Ames & Archer, 1988), physical education (Moore & Fry, 2017), and particular college class settings (Brown & Fry, 2014; Moore & Fry, 2014). These important motivational constructs have not been explored in university biology course settings. Recently, researchers (Victorino, et al., 2019) found university students' perceptions of the campus climate (e.g., feeling respected) significantly and positively predicted the students' science, technology, engineering, and mathematics (STEM) course engagement. While examining students' perceptions of the overall university climate is important, students' perceptions of the motivational climate specific to their STEM courses would be expected to more significantly affect their experiences and motivation to continue in STEM fields. This would include individuals in biology, future allied health, and medical professionals. As such, the purpose of this research was to examine the relationship between students' perceptions of the motivational climate in their biology laboratory courses to their effort and enjoyment of the courses. Successfully adapting to the university biology laboratory setting measures of motivational constructs that previously produced reliable and valid scores in university exercise classes will be essential to accurately assess students' perceptions of the psychosocial environment and their experiences in the laboratory setting.

Of interest is that individuals perceiving a positive psychosocial environment in physical activity settings are more likely to report greater levels of effort, enjoyment, and intrinsic motivation leading to enhanced commitment to being physically active (Brown & Fry, 2014; Moore & Fry, 2017). One theory that has been helpful in understanding how to foster these positive outcomes **and maximize the motivation of every student** is the Achievement Goal Perspective Theory (AGPT) developed by educational psychologist John Nicholls (1984, 1989). He suggests that individuals who are task-involved will be more likely to report experiencing greater levels of effort, enjoyment, intrinsic motivation, as well as having better interpersonal relationships and psychological well-being (Fry & Hogue, 2018). When task-involved, individuals maintain a self-referenced view of ability, **focus** on the current task, and **base** success on their personal effort and improvement, whereas those who are ego-involved gauge their ability and success through comparisons with others based on favorable normative outcomes (Duda et al., 1995).

Nicholls' (1984, 1989) proposes that a key strategy for promoting task-involvement is to create a psychosocial environment that exemplifies task-involving (TI) features and minimizes ego-involving (EI) tendencies. **He positions** that leaders can create a TI climate across achievement settings by rewarding personal effort and improvement, fostering cooperation with others, making all feel they play an important role, and treating mistakes as part of the learning process. In contrast, in an EI climate leaders value and emphasize performance and normative outcomes, foster rivalries among peers, punish mistakes, and extend recognition primarily to the highest performers (Nicholls, 1984, 1989). In addition to Nicholls' suggestions for creating a TI climate, motivational researchers Newton and colleagues (2007) have proposed an additional caring (C) feature of the climate to be assessed when examining individuals' experiences in sport and exercises settings. The C feature of the climate assesses the extent to which individuals perceive that everyone in a particular achievement setting is treated with kindness and respect. Newton and colleagues (2007) based much of their developmental efforts of the C feature of climate on the work of educational philosopher Noddings (1984, 2005), who advocated for youngsters to feel cared for in the educational setting. Researchers Battistich and colleagues (2000) employed the principles of Noddings (1984) in a comprehensive educational reform with the aim to help elementary schools reflect caring communities. Battistich et al., (2000) found that helping schools create a more C climate resulted in youths exhibiting enhanced prosocial behaviors and psychological functioning (Battistich et al., 2000). These findings align with the mounting body of motivational climate literature, which has consistently linked individuals' perceptions of a **caring and task-involving (CTI)** climate with positive outcomes (Fry & Hogue, 2018; Fry & Moore, 2019).

In the past decade, the AGPT and C framework has been applied to the exercise setting, including college exercise classes, with similar results to those seen in sport and primary education (Brown & Fry, 2014; Moore & Fry, 2014; Newland, et al., 2017). This research started with the development of the Perceived Motivational Climate in Exercise Questionnaire (Huddleston, et al., 2012). Researchers examining the effects of perceiving a CTI exercise class climate have found positive associations with college students' competence, effort, enjoyment, commitment, ownership, and empowerment (Brown & Fry, 2014; Moore & Fry, 2014; Newland, et al., 2017). Furthermore, college students' perceptions of an EI exercise class climate were positively associated with increased tension/pressure, and negatively associated with effort, enjoyment, competence, commitment, ownership, and empowerment (Brown & Fry, 2014; Moore & Fry, 2014). Similar results have been found among high school students (Chamberlin et al., 2017; Hogue, et al., 2019; Moore, 2015; Moore & Fry, 2017). In an experimental setting, **college students learning a new skill in a CTI climate self-reported greater levels of effort and enjoyment, and experienced lower stress levels (i.e., both self-reported and objectively measured via salivary cortisol)**; whereas college students in the EI climate reported greater anxiety, self-consciousness, and shame, as well as increased self-reported and objectively measured stress (Hogue et al., 2013). This research over the past decade supports the impact of the class motivational climate for college students in exercise classes.

Central to the current study is how AGPT and C Framework **tenets** extend to the university academic class setting, specifically biology laboratories. These laboratories are often required as gateway courses for kinesiology majors and those seeking to enter into allied health and medical professions (Bassett et al., 2018). Although all academic courses may merit consideration for implementing a CTI climate, laboratory courses would be particularly essential to investigate. Laboratory courses offer a learning environment unlike the ordinary college classroom and are a focal point of most, if not all, university biology courses. Compared to large lecture courses, the student to instructor ratios in laboratory courses are much smaller, and students are given more hands-on opportunities to gain experience and implement the knowledge obtained from lecture courses to actual experiments. Although laboratory courses are highly regarded as beneficial for students in STEM, researchers Hofstein and Lunetta (1982) indicate students' learning and motivational responses are sometimes sub-optimal due to inadequate instruction and teaching effectiveness.

Inadequate learning experiences in STEM laboratory settings likely occur on many university campuses, especially large research centered institutions, as researchers have found that STEM laboratories are often taught by graduate students with limited teaching

experience (Kendall & Schussler, 2012). Sundberg and colleagues (2005) surveyed 65 universities in the U.S. and found that STEM discipline GTAs teach 71% and 91% of laboratory courses at comprehensive and research universities, respectively. Graduate students with assigned teaching assistantships (GTAs) often receive minimal to no training and are left to decipher how they will teach these laboratory courses with little direction from more experienced professionals (Rushin et al., 1997). **Expanding on the work of Rushin et al., (1997), Schussler and colleagues (2015) set out to assess the contemporary state of teaching and professional development for biology GTAs in the U.S. and Canada. In their study, they gathered survey data from 71 institutions, which largely reported requiring some form of mandatory training before being able to teach. While these results may indicate progress is being made, over half of the responding institutions reported that the trainings were likely not adequate for enhancing best pedagogical practices. Similarly, research conducted by the National Union of Students (NUS, 2013) surveyed 1476 graduate students who teach at their institutions in the UK and found that 22% of respondents received no form of training for teaching; more than 75% of those who did receive training reported the training was not helpful.** Of concern is that the current instructional state of college laboratory courses falls short of the type of academic environment that would promote the best learning and academic success.

As a result, an important area of inquiry involves considering the quality of experience students have in their biology laboratory courses. Of particular interest is exploring the relationship between students' perceptions of the climate in their biology laboratory courses to their self-reported levels of effort and enjoyment in those courses. **This relationship is of particular interest as previous qualitative research conducted by Lucardie (2014) found**

that enjoyable learning experiences fostered students' motivation to attend classes and learn new information and skills, as well as enhance concentration and absorption of the materials being taught.

To examine these research aims, it is necessary to have validated measures of the climate (i.e., C, TI, EI), effort, and enjoyment for use in biology courses. Thus, two studies were conducted to adapt existing measures to the college laboratory setting and then validate these adapted measures with a second, independent sample. **The purpose of Study 1 was to employ survey** measures with previously verified psychometric properties in the college exercise class setting to the college laboratory setting, to determine if the same measures can be used to examine students' perceptions of the climate and their motivational responses (i.e., effort, enjoyment). **Additionally, the purpose of** Study 2 was to validate the findings of Study 1 and to ensure the psychometric properties held among an additional sample of college laboratory students. Structural equation modeling (SEM) was employed to determine if the psychometric properties of the previously verified latent constructs of C, TI , and EI climate, as well as effort, and enjoyment remain in college laboratory settings. It was hypothesized that by modifying the wording of each measure to fit the laboratory setting, the psychometric properties of the latent constructs would be tenable and accurate to assess students' responses. Validity evidence would be provided by the following hypothesized correlations being significant: C and TI positively correlated with each other, enjoyment, and effort; while EI negatively correlated with C, TI, enjoyment, and effort.

Method

Data was collected from students enrolled in multiple sections of a physiology laboratory course across two consecutive semesters. Students in Study 1 were enrolled in

the course during the spring semester, while students in Study 2 were enrolled the following fall semester. Instructors for this laboratory course were GTAs for the biology department. Each of these studies were approved by the Institutional Review Board and Biology Program at the first author's university, and consent was acquired from all participants. A trained research team administered the survey to all laboratory sections.

Participants

Study 1.

Biology laboratory students (*N* = 249; female 73%) enrolled at a Midwestern university in the U.S. were invited to complete a brief survey during the final two weeks of their laboratory course. Students in Study 1 reported being primarily sophomores (58%), white/non-Hispanic (70%), and pursuing 19 different degrees of study.

Study 2.

Students (*N* = 199; female 78%) enrolled in a biology laboratory course at the same university were again invited to complete a survey during the last two weeks of their laboratory course. Students in Study 2 reported they were primarily sophomores (62%), white/non-Hispanic (67%), and pursuing 10 different degrees of study.

Measures

Each participant completed a survey, which assessed student perceptions of the motivational climate (i.e., C, TI, EI) in their respective laboratory sections and included measures of effort and enjoyment. The survey also included a demographics section, which included questions about students' race, gender, academic status, and academic major.

Caring Climate.

The 13-item Caring Climate Scale (CCS; Newton et al., 2007) was employed to assess students' perceptions of the extent the environment within the laboratory was perceived as caring, a place where students feel valued, comfortable, and treated with kindness and respect. A sample item is "The instructor cares about the students in this lab." Students responded using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). **Results of Newton and colleagues' (2007) confirmatory factor analysis found the 13-item CCS to have acceptable model fit (SRMR = .035, CFI = .97, TLI = .97, and RMSEA = .04) with youth physical activity participants. In addition, they reported that the 13-item CCS displayed adequate internal reliability (α = .92) and variability (*M* = 3.86, *SD* = .77).**

Perceived Motivational Climate.

The 12-item Perceived Motivational Climate in Exercise Questionnaire-Abbreviated (PMCEQ-A; Moore et al., 2015) was developed to assess individuals' **perceptions** of the motivational climate in exercise settings, but was easily adapted for a laboratory setting. The stem was adapted from "In this physical activity course…" to read "In this physiology lab …". Sample items include "the instructor encouraged students to help each other" (TI) and "students feel embarrassed if they don't know how to perform a skill" (EI). Students responded to the items using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Moore and colleagues (2015) have provided support for the psychometric properties and reliability of employing the PMCEQ-A in the exercise setting.

Effort.

The 4-item effort subscale of the Intrinsic Motivation Inventory (IMI; McAuley et al., 1989) was modified and used to assess students' perceptions of their personal effort during laboratory sessions throughout the semester. Students responded using a 5-point Likert scale with responses ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I put a lot of effort into learning the material presented in each lab." The effort subscale of the IMI has proven to have acceptable internal reliability and psychometric properties for use with college physical activity participants (Boyd et al., 2002) and college exercise classes (Brown & Fry, 2014), which provides great potential for investigating effort levels in the college academic class setting.

Enjoyment.

The 5-item enjoyment subscale of the Academic Satisfaction Instrument (**ASI; Duda & Nicholls, 1992**) was developed to assess the degree of fun youths reported in academic settings. Students responded to the items using a 5-point Likert scale with responses ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I enjoyed lab session activities." The ASI has demonstrated strong internal reliability in multiple studies ranging from $\alpha = .84$ to .94, and has been used as a measure of enjoyment in classroom settings with adolescents (Duda & Nicholls, 1992).

Statistical Procedures

Initial checks of data quality were conducted in IBM SPSS version 26 (IBM Corp., Armonk, N.Y., USA) as well as calculating descriptive statistics and percentages of missing data for Study 1 and Study 2. Criterion for checks of normality were conducted in RStudio, version 3.5.1 (RStudio Team, 2015). Confirmatory factor analyses (CFA) to assess measurement quality of the constructs in the novel laboratory setting were conducted in the lavaan 0.6-5 (Rosseel, 2012) software package. The CFAs for Study 1 and Study 2 included five latent constructs: C climate, TI climate, EI climate, effort, and enjoyment. To account for missing data, the parameters' values and standard errors were estimated with full-information maximum likelihood (FIML) (Little, 2013). The fixed-factor method of setting the scale was used in all analyses to obtain standardized, unit-free estimates (Little, 2013).

Measurement Invariance of the Measures (Study 1)

Configural invariance was tested to assess the overall fit of the item-level model for Study 1 (Figure 1). Both absolute (Root Mean Square Error of Approximation [RMSEA]; Standardized Root Mean Square Residual [SRMR]) and relative (Comparative Fit Index [CFI]; Tucker-Lewis Index [TLI]) fit statistics were utilized to determine model fit. CFI and TLI values above .90 and below .08 for the RMSEA and SRMR are considered acceptable fit statistics (Cheung & Rensvold, 2002; Little, 2013).

Parceling was only completed with the constructs that had their measurement model quality supported and parceled in previously published articles (Moore et al., 2015). To parcel the TI and EI climate constructs; items were grouped by feature and followed the same procedure as Moore and colleagues (2015) to decrease the impact of non-common variance and avoid contaminating the latent constructs (Little, 2013; Little et al., 2002). In contrast, the C climate construct required parceling the constructs' items into three parcels as equally as possible based upon the item-level model factor loadings and using the counter-balance method (i.e., stronger and weaker loading items were combined to generate the three parcels) (Little, 2013). Parceling was not implemented for the effort and enjoyment constructs, due to their fewer items and respective factor loadings. Meaningful parameter estimates, such as the factor loadings, intercept values, and residuals are presented for the item-level model (see Table 2) and parceled models (see Figures 2 and 3). The covariance matrices for both models can be found in the supplemental documents.

In order to further assess the survey measures' acceptability in the college academic setting, the measurement reliabilities of each construct were calculated by using the composite reliability (CR) value. According to Hair and colleagues (1998) the criterion value for a measures' CR is .60. Analyses indicated that all constructs, except for the EI climate construct demonstrated satisfactory levels of reliability. Based on parameter estimates and reliabilities of the EI climate construct, the wording for two of the EI climate construct items – item 5 and item 6 – were changed to read more naturally for the academic environment. Thus, Study 2 data was collected with the revised EI climate items and assessed to validate the usage of these measures in the college academic setting.

Validating the Measures (Study 2)

A follow-up study was conducted in the same laboratory courses, except with a **different** sample of students to further investigate invariance and validate the usage of these measures in the college academic setting. In order to identify the most effective measure, the wording for items 5 and 6 within the EI climate construct were slightly modified to better relate to the academic setting. The TI and EI climate constructs were originally developed in the exercise setting, so it was important to ensure that all items were tailored for the academic setting. Again, an item-level CFA was conducted (Figure 1), followed by a parceled CFA model to reach a final model (Figure 3).

Results

Preliminary findings indicated that there was 0.24% and 0.62% missing data in Study 1 and Study 2, respectively. Across both samples, the majority of the students perceived the laboratory course climate as being **highly caring, moderately task-involving,** and not EI (See

Table 1). Most also reported giving **moderate** effort in and **moderately** enjoying the laboratory course.

Measurement Invariance of the Measures (Study 1)

***Item-level measurement model 1*.**

The initial CFA conducted to assess the quality of the item-level model had poor model fit ($\chi^2_{(517,\ n=249)}$ = 1645.41, CFI = .80, TLI = .78, RMSEA = .09, SRMR = .06). The subsequent, parceled configural model had acceptable model fit ($\chi^2_{(125,\ n=249)}$ = 245.60, CFI = .95, TLI = .94, RMSEA = .06, SRMR = .05). The reliabilities of each construct were calculated and all constructs, except for the EI climate construct (CR = .46) met satisfactory levels of reliability. Specifically, the other constructs reliability values were: C climate (CR = .97), TI climate (CR = .81), effort (CR = .78), and enjoyment (CR = .84). In addition, the correlations for all the constructs were significant ($p < .001$), and in hypothesized directions and magnitudes (See Figure 2).

Validating the Measures (Study 2)

Compared to Study 1, the participants in Study reported experiencing laboratory course climates that were slightly less CTI, and a bit more ego-involving (Table 1). The range of their climate perceptions was greater, as was their reported effort and enjoyment.

***Item-level measurement model 2*:**

To validate the usage of the survey measures, a CFA was conducted with sample 2 at the item-level (Figure 1). The item-level model, like in Study 1, resulted in inadequate model fit ($\chi^2_{(517,\ n=199)}$= 1615.19, CFI = .82, TLI = .80, RMSEA = .10, SRMR = .06). Table 2 provides the factor loadings, intercepts, and variances. Results indicated that the revisions to the two EI climate items resulted in an improved factor loading for item 5, while item 6 remained low.

Revised measurement model:

Parceling the climate construct items resulted in acceptable model fit ($\chi^2_{(125, n=199)}$= 367.48, CFI = .92, TLI = .90, RMSEA = .10, SRMR = .07). See Figure 3 for the factor loadings, intercepts, and variances. Each construct's reliability met acceptable CR criterion and improved from Study 1: C climate (CR = .98), TI climate (CR = .90), EI climate (CR = .69), effort (CR = .81), and enjoyment (CR = .87). Correlations for all the constructs were again significant (p < .001) and were theoretically sound in direction and magnitudes (See Figure 3).

The improved factor loadings and model fit suggest the modified wording of the EI climate items improved the reliability of the measure to an acceptable standard. It can be deduced that the survey measures evaluating C climate, TI climate, EI climate, effort, and enjoyment are reliable, valid, and tenable for use in the college laboratory setting.

Discussion

The purpose of this study was to determine if measures of motivational climate, effort, and enjoyment that have previously been validated and utilized in the college exercise class domain could be appropriately used in the college biology laboratory setting to assess students' perceptions of these variables. Results from Study 1 and Study 2 provide support for the utility and validity of employing these measures in college biology laboratory courses. Specially, results from Study 1 provided strong evidence for the psychometric properties of the adapted C climate, TI climate, enjoyment, and effort measures and Study 2 provided evidence to support the use of the revised EI climate items in the biology laboratory setting. In addition, the correlations between the constructs were theoretically consistent and the reliabilities of each measure were determined to be acceptable, as previously found in the physical domain (Moore et al, 2015; Brown et al., 2013; Duda & Nicholls, 1992).

While the motivational climate measures used have been validated in the exercise domain, it is important to note that the wording is somewhat generic and relevant to classroom situations, since the features of the climate (e.g., emphasizing effort and improvement, treating mistakes as opportunities for learning) are somewhat consistent across achievement contexts. It should be noted that the climate measures were parceled in this study, as has been a recommended procedure by Little (2013), and utilized by researchers in previous studies with these same measures in the exercise domain (Moore & Fry, 2014; Moore et al., 2015). The EI climate scale was the only measure that failed to demonstrate an adequate reliability value (CR > .60) in Study 1. However, when two problematic items (i.e., low factor loadings) were reworded to be more appropriate for the classroom setting and used in the survey for Study 2, the reliability of the EI climate scale improved. Specifically, EI climate item 5 – "Students are encouraged to do better than other students" – was first adapted from the exercise version of the PMCEQ-A (Moore, et al., 2015; "Members are encouraged to do better than other members"). In the physical domain, exercise leaders often encourage participants to compete against one another in cycling classes, etc. However, in the laboratory setting, instructors are less likely to outwardly tell students to outperform each other. They may use a more subtle approach and, for example, describe the kind of students who will receive As and/or excel in the course. Thus, the wording of EI climate item 5 was changed for Study 2 to, "The instructor is pleased when some students do better than others", suggesting that the instructor is concerned with identifying the best students in the course. The original adaptation of EI climate item 6 was "Students are excited when they do better than their peers." This wording suggests that perhaps students show their excitement outwardly in the course, as is the case often in the physical domain when individuals outperform others. Again, in the laboratory setting, the excitement may be more internal, and so

EI climate item 6 was reworded for Study 2 to read, "Students feel good when they do better than other students." This wording, while slightly adapted, maintained the essence of the EI climate items.

The primary purpose of this study was to validate measures for use in the college biology laboratory. These measures are central to understanding students' experiences in biology laboratory courses, and lay a foundation for promoting and sustaining students' motivation over time. Considerable research has outlined the benefits of individuals perceiving a CTI climate in the physical domain. Clearly, participants' perceptions of a positive and supportive environment is associated with enhanced levels of effort and enjoyment, which has led to optimal exercise and physical activity experiences (Fry & Hogue, 2018; Fry & Gano-Overway, 2010; Hall et al., 2017; Newland et al., 2017). Results from this study in the laboratory setting align with previous research in the physical domain, as students reported exerting greater effort and experiencing heightened enjoyment the more they perceived their biology laboratory course as reflecting a CTI climate. College students are in the midst of a key developmental period where they are gaining greater responsibility over their lives and setting the groundwork for their futures (Committee on Improving Health, 2015). Though this is a period of tremendous growth, there can be struggles with anxiety, depression, and relationships (American Psychological Association, 2013). If college instructors can establish a positive environment in biology laboratory courses, students may find themselves **better equipped to manage their struggles and engage and focus on their academic pursuits**. In their qualitative work, Enghag and Niedderer (2008) present the need in the academic domain to enhance student engagement and identify optimal levels of ownership in order to improve student learning and teaching effectiveness in physics teaching. Moore and Fry (2014) **expanded on ownership** in the physical domain and found that college students in physical education classes who perceived a CTI climate reported feeling greater ownership within that course and promoted participants' exercise empowerment. **As a result, educating instructors on how to create CTI climates with their students may play a key role in improving teaching effectiveness and enhancing student engagement and ownership in STEM educational settings.**

Universities have much to gain from having access to reliable, relatively brief, and easy to administer measures that provides feedback from students in a timely and convenient manner regarding their course experiences. Of all the student educational outcomes that universities desire their students demonstrate, effort and enjoyment may be the two most important to measure in terms of students' **experiences** (Smith et al., 2016). Evidence from previous studies suggest that effort and enjoyment are related to higher levels of intrinsic motivation and commitment, and this is good news for students in the biology and other STEM fields, particularly those more susceptible to discontinuing their education. For example, Griffith (2010) conducted a review of literature and found that female and minority students are less likely to continue a STEM degree than both male and non-minority students. Griffith went on to report that students' educational experiences (i.e., grades, instructor-student connection, institution characteristics) highlight some of the crucial factors that impact student retention and dropout rates between groups and merit further investigation. Examining minority, underserved, and at-risk college students' perceptions of the climate in their college laboratory courses may provide college instructors, faculty, and administrators with valuable information about how to optimize student learning.

Future Research

This study provided foundational work to validate measures for the academic domain that assess college students' experiences in biology laboratory courses. These results open the door for future research. It would be interesting, for example, to have students identify the behaviors and strategies their instructors used to create a CTI climate, as well as the behaviors and strategies instructors use that reinforce an EI climate. While creating a CTI climate may lead to more students having fun, developing a true love for the course material, and feeling empowered to continue in their STEM education, students who experience an EI climate in their laboratory courses may be more likely to feel discouraged, less competent, and less likely to continue their educational journey in a STEM degree. However, research is needed to identify the precise behaviors that instructors utilize to create the CTI and EI climate features in the college laboratory setting.

Based on the results of this study and previous research on the deficiency in teaching effectiveness and training of GTAs, it may be beneficial to employ training interventions for instructors to help them develop the capacity to create a more CTI climate. This would involve assisting them with identifying strategies to emphasize effort and improvement of each student, foster cooperation among peers in the course, reinforce mistakes are part of learning, and grow a spirit of mutual caring and respect for everyone in the laboratory classroom setting. It seems likely that beneficial increases in students' learning and motivational outcomes may be even more apparent if students are fortunate to complete courses with instructors trained to establish a CTI climate. Differences might likely be seen in not only effort and enjoyment levels, but grades, retention, and overall commitment to their field of study.

To include variables such as grades and retention, it would be important to be able to identify students and track their progress across the college years. In the present study, the surveys were anonymous, so there is no way to link students' responses to their continued performance and progress in the course and major. This is an important future direction, though it comes with pros and cons. The participation rate of students completing this survey was over 95%, which is excellent. Students were assured that instructors and administrators would not have access to the individual survey responses, which a number of students indicated was important to them and influenced their willingness to complete the survey. Although instructors were outside the room when students completed the surveys, it was not unusual for students to ask, "You're sure my instructor won't see my answers?" This suggests that students appreciate the opportunity to provide feedback, but also want to feel confident that their responses will remain confidential. Requiring students to provide an identifier would be beneficial for advancing this line of research to examine students' experiences over time in biology courses, but might result in some students declining to complete the survey. It would be important to assure students that even though they are providing a personal identifier, their responses would be kept confidential.

While this study provided insights to important areas of future inquiry, it was not without limitations. First, students were surveyed one time at the end of the semester. Students' course experiences are dynamic and it will be important in future work to include more than one assessment point across the semester. Adding a midpoint survey along with the end of the semester survey would allow researchers to have a better indication of students' experiences as they progress through the course.

In addition, the study included student self-report measures, and future research may include an observational tool that could be utilized to help instructors see their interactions with students, and to continue to identify best practices for creating a CTI climate. In addition, though the measures of climate, effort, and enjoyment were validated in this study and received strong initial support for their use in biology laboratory courses at a Research 1 university, it will be important to continue to validate the measures and examine whether they hold strong across gender, race/ethnicity, **socio-economic status (SES),** and a variety of STEM laboratories as well as other university STEM courses.

In conclusion, research suggests and this study provides additional support for the benefits students experience from their exposure to a CTI climate. Students taught in a CTI climate may enjoy and be better equipped to succeed in their academic studies. As coaches' behaviors are influenced by the coaching behaviors they experienced as an athlete (Moore, 2017), professionals' behaviors may also be influenced by the behaviors of their teachers **(Oleson & Hora, 2014).** Thus, college students who experience a CTI climate may be more likely to develop the skills to foster the same CTI climate with their future clients, patients, and coworkers. This study sets the stage for continued research in this area of improving the learning experiences of students in STEM fields.

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