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Development of a Climate Survey for Engineering Doctoral Students from an Intersectional Approach: First-Round Validity Evidence

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Joseph Roy has over 15 years of data science and higher education expertise. He currently directs three national annual data collections at the ASEE of colleges of engineering and engineering technology that gather detailed enrollment, degrees awarded, research expenditures, faculty headcounts, faculty salary and retention data for the engineering community. He is PI of a NSF Advanced Technological Education funded grant to build a national data collection for engineering-oriented technician degree and certificate programs at 2-year institutions. Prior to joining the ASEE, he was the senior researcher at the American Association of University Professor and directed their national Faculty Salary Survey. He also developed a technical curriculum to train analysts for a national survey of languages in Ecuador while he was at the University of Illinois as a linguistic data analytics manager and member of their graduate faculty. He has a B.S. in Computer Science & Mathematics, a M.S. in Statistics from the University of Texas at San Antonio and a Ph.D. in Linguistics from the University of Ottawa.

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Abstract

This study reported on the development procedures for a multi-factor organizational climate survey for engineering doctoral student retention. Engineering doctoral programs are a type of organization, and the perceptions of program members can be understood through organizational climate science. From this perspective, organizational climate measurement can guide researchers and leaders in better understanding the specific climates affecting the experiences of students from underrepresented populations, such as women of color and members of the LGBTQIA+ community, through degree completion. Using an intersectional approach, we developed a scale to assess multiple climate factors associated with organizational commitment or member retention, many of which are particularly salient to the experiences of students from marginalized or minoritized identities. We took several steps to create the scale, including face/content validity analysis, exploratory factor analyses for validity evidence, and internal consistency for reliability evidence. The survey also includes demographic items to capture the respondents' complex social identities. During the summer and fall of 2023, we collected our first pilot study data of 287 engineering doctoral students from 28 institutions in the U.S. We identified the scale's latent factor structure for construct validity evidence and evaluated internal consistency reliability evidence. Results from studies using the finalized survey are expected to indicate specific policies, practices, and procedures that may serve as interventions to enhance organizational performance specifically in the strategic area of doctoral student retention at the department level.

I. Introduction

The long-term vitality of the U.S. workforce relies on the full range of science, technology, engineering, and mathematics (STEM) career pathways being available to all Americans [1]. The increased participation of women and members of racially minoritized and marginalized groups, including Black, Hispanic/Latinx, and Indigenous students in STEM, is imperative to maintain the U.S. standing as a global leader in innovation.

We reported on the development procedure for a multi-factor organizational climate survey for engineering doctoral student retention. Engineering doctoral graduates account for a large share of the innovation workforce [2], but the engineering doctoral pipeline does not reflect the diversity of the U.S. population. For example, in 2022, women earned 26.2% of the engineering doctoral degrees awarded in the U.S., with fewer than half of those women being U.S. residents. Of those degrees, American Indian women earned 0.1%, Black women earned 5.0%, multiracial women earned 5.3%, Latina women earned 9.7%, Asian American women earned 18.5%, and White women earned 61.3% [3]. In turn, the American Council on Education [4] has delineated a need for academic leaders to develop policies and best practices to promote diversity in STEM. Engineering doctoral programs are a type of organization, and the continuation of students in these programs through Ph.D. completion can be viewed as an issue of organizational commitment or member retention. From this perspective, an organizational climate measurement can guide researchers and leaders in better understanding the climates affecting the experiences of students from underrepresented populations, such as members of women of color and the LGBTQIA+ community.

Therefore, we used an intersectional approach to develop an organizational climate survey including a scale to assess multiple climate factors associated with organizational commitment or member retention, many of which may be particularly salient to the experiences of students from marginalized or minoritized identities. This paper describes the procedure for developing the scale using an intersectional approach to probe the climate factors that may affect a doctoral student's commitment. We took several steps to create the scale, including face/content validity analysis, exploratory factor analyses for validity evidence, and internal consistency for reliability evidence.

Purpose of the Study

As part of a multi-year, mixed-methods research project funded by the National Science Foundation (NSF) to understand factors contributing to the attrition and retention of students from racially minoritized and marginalized groups in engineering doctoral programs, we developed a survey to assess engineering doctoral students' experience of department-level organizational climate. We aimed to survey engineering doctoral students using a valid and reliable instrument that focuses on the climate constructs that contribute to the retention or attrition of students from historically excluded or underrepresented groups. Here, *climate constructs, in general,* refer to the theoretical concepts or dimensions as organization members' shared perceptions of climates. This paper describes the first stages of that scale development process using the following research questions:

1. *What organizational climate constructs are most **relevant to engineering doctoral student retention**, particularly for students from historically excluded or underrepresented groups?*
2. *To what extent does the **construct validity** evidence of the scale hold for engineering doctoral students?*
3. *What is the level of **internal consistency reliability** for engineering doctoral student data from the survey's scale?*

II. Theoretical Framework

A. **Organizational Climate**

We are interested in organizational climates that may impact the degree completion of engineering doctoral students from diverse groups. Organizational climate is one of the most studied aspects of the social context of organizations [5]. Climate arises from shared, socially derived perceptions of the meanings attached to an organization's norms and expectations [6] and is understood as a group, or a collective phenomenon [7]. For our work, we rely on the decades-long accepted definition of organizational climate as the shared meaning organizational members attach to the events, policies, practices, and procedures they experience and the behaviors they see being rewarded, supported, and expected [8-10].

Ehrhart and Schneider [9] noted that contemporary climate research tends to have a focus on specific strategic goals or internal processes. That is, *focused climate* refers to a climate for a specific outcome or process, such as climate for diversity or climate for psychological safety. This focused approach has continued successfully since 1980 [10-12]. Findings from focused climates studies "have important useful practical applications because they identify the policies, practices, and behaviors that make up the climate that has been shown to be valid for important outcomes" [13, p. 477]. While general measures of organizational climate that lack clearly defined constructs framed by a strategic interest have been foundational to the study of climate in higher education, they have been criticized as "useless for anything but the most gross description of the range of variation in organizations" [14, p. 22]. In other words, because data from general measures of organizational climate cannot provide clear guidance about policies, practices, or behaviors that construct climate, those data cannot guide higher education leaders in their decision-making.

We conducted a literature review of climate and student retention in engineering doctoral programs and searched papers produced by the engineering education community for any indications of the focused climates in our framework [15]. The focused climates in our framework have been investigated across a variety of organizations. In other words, none of the climates in our framework are organization-specific and we would expect them in studies of doctoral engineering student retention.

We focus on organizational climate at the department level because disciplinary, institutional, and professional contexts converge at the department level to shape graduate student experiences [16-18]. Without a frame of reference, climate survey respondents are left to interpret questions and may describe perceptions of any part of their work environment at any level and not necessarily what is being studied. Levels within an organization are complex, and respondents exist simultaneously in various subgroups within the larger organization, but members can distinguish what happens in their subunit from the larger organization as a whole [8].

Organizational climate is driven by formal leadership, and members work in a climate but do not create it [8, 9]. In higher education organizations, formal leadership is delineated by a hierarchy of administrators, such as deans and provosts as well as assistant and associate administrators, and department chairs who are positioned between higher-level administrators and faculty [19-21]. Faculty are organizational members who are responsible for supervising and advising doctoral students. The relationship between a doctoral student and their faculty supervisor/advisor is addressed by a different construct from organizational science, perceived supervisor support [22, 23]. While perceived supervisor support may contribute to climate perceptions, the level of contribution depends on the degree to which the individual identifies their supervisor with the organization [24] and the supervisor's status within the organization [25]. Other climate contributors include organization size and individual characteristics, such as personality [26, 27]. Climate contributors, or antecedents, are beyond the scope of this funded project. We are interested in focused climates in doctoral engineering. *Therefore, we seek to develop a scale that assesses specific organizational climate constructs relevant to member retention, using an intersectional approach, at the department level.* Hereafter, climate constructs refer to the focused climates we assess in the multi-factor climate scale.

B. Intersectionality

An intersectional approach guided our scale development process in several ways. *Intersectionality theory* is typically credited to Crenshaw [28, 29], who noted that analysis of race or gender alone or in isolation fails to capture the experiences of women of color as members of a group constructed by multiple, intersecting systems of oppression. However, the concept of intersectionality has a rich history originating in 19^{th}-century Black feminist activism [30-33]. Today, the reach of intersectionality theory extends beyond the study of Black women, offering an approach to understanding complex inequities tied to multiple social categories. Synthesizing diverse multidisciplinary scholarship in intersectionality, Else-Quest and Hyde [34] noted shared assumptions that intersectionality 1) *attends to the experience and meaning of belonging to multiple social categories (e.g., gender, race/ethnicity, social class) simultaneously*; 2) *includes an examination of power and inequality*; and 3) *attends to social categories as properties of the individual as well as to the social context and thus considers those categories and their significance or salience as potentially fluid and dynamic*. Thus, as both a critical theory and approach, intersectionality is fundamentally concerned with social inequality, including access to and full participation in engineering doctoral education.

An intersectional approach is essential when considering engineering doctoral student retention and attrition and organizational climate. At this stage of the project, intersectionality guided the identification of climate constructs and the creation of items for the constructs. This included identifying climate constructs most related to processes and outcomes of inclusion/exclusion, and inclusively and respectfully assessing demographic characteristics. In future stages, when the sample size is larger and statistical power permits, intersectionality will inform the methodological approach to analyze data based on respondents' multiple social categories (especially gender, race/ethnicity, sexuality, and disability) and include describing intersectional group variations in climate assessment.

III. Method

A. Identifying Climate Constructs

To answer the first research question, *What organizational climate constructs are most relevant to engineering doctoral student retention?*, we undertook several steps during the scale development process as guided by Clark and Watson [35]. First, we reviewed the organizational climate literature and identified focused climates found to be associated with organizational member retention. Next, we examined how scholars have approached the problem of organizational climate and STEM doctoral student retention. We found that the specific area is understudied. In particular, our review demonstrated that when there are studies of climate, constructs were not defined, ill-defined, or derived from literature outside of organizational science [15]. STEM doctoral student climate perceptions were often inadvertently captured in studies of phenomena other than climate. We also noted that studies purportedly of climate utilized survey instruments that are not validated either for the climate constructs they claim to measure or for assessment across multiple intersectional groups of students. Therefore, it is difficult to draw reliable conclusions from these studies or translate their results meaningfully to inform policy or practice.

Based on our intersectional approach and the literature review, we selected seven climate constucts that seem most relevant to engineering doctoral student retention. Table 1 presents the seven constructs, and how each is defined in the context of our study and supporting literature. Each construct reflects a process or outcome relevant to all doctoral students but especially to students from groups that have been historically excluded, marginalized, or otherwise underrepresented. For example, authenticity climate captures the perception that one can safely express their social identities (e.g., sexual orientation) in that setting, and organizational support climate captures the perception that one's department values each student's contributions and well-being.

Table 1. *Definitions of the Seven Climates in the Scale*

Climate	Definition	References
Cultural mosaic beliefs climate: Perceived cultural diversity	Perception and accurate recognition of the degree and nature of group diversity including variety in cultural values, beliefs, and practices	[36, 37]
Diversity climate	Perceptions about the extent to which their organization values diversity as evident in the organization's formal structure, informal values, and social integration of underrepresented members	[38, 39]
Psychological safety climate	Perception of how others in the workplace will respond to risk-taking behaviors, such as taking initiative or speaking up about problems in the workplace	[40, 41]
Mastery climate	Perception that efforts, sharing, and collaboration are valued, and learning and skill development are emphasized in an organization	[42, 43]
Performance climate	Perception that competition with comparison to, and recognition from others are the standards for success.	[44, 45]
Authenticity climate	Perception that the organization encourages and provides a safe environment to express personal identities at work.	[46, 47]
Organizational support climate	Perception that the organization values their contributions and cares about their well-being	[48, 49]

B. Organizational Commitment

We identified two constructs relevant to student retention to serve as measures for concurrent and divergent validity evidence during the climate scale validation process. *Organizational commitment* is defined as a psychological state that characterizes the member's relationship with the organization and has implications for their decision to continue [50-52]. There are three commitment styles: affective, continuance, and normative. We focus here on the constructs of Affective commitment and Continuance commitment. Affective commitment stems from firsthand experience that the organization supports its members, treats them fairly, and enhances their sense of competence [50, 51, 53]. By contrast, continuance commitment is a cost-based form of attachment that stems from a belief that leaving the relationship would incur great personal sacrifice and/or options are limited [50-53]. Instead of being motivated to stay, members with high continuance commitment remain because they believe they have no other choice and will satisfy the minimum requirements for maintaining their role [50].

In higher education, student commitment is recognized as a key driver to degree completion [54]. In an early study of the relationship between graduate student attrition and commitment, Cooke et al. [55] found that students with higher levels of affective commitment were more likely to continue with their degree program, and variables such as feelings of alienation and lack of social support were not predictive of attrition. More recently, a study of undergraduate students found affective commitment results from a positive attachment based on feelings of inspiration, belonging, caring, and pride, whereas continuance commitment undermined affective commitment toward the institution [56].

C. Item Construction

We reviewed the literature for existing scales that measure the climate constructs. We collected item examples from validated scales found in organizational climate literature and noted none of the scales have been used in studies of engineering doctoral students. Therefore, we generated a pool of items based on existing scale items, modifications of existing ones, and adding new items for use specifically with engineering doctoral students. The pool of items was judged by a panel of professors and engineering graduate students to confirm face and content validity, which resulted in 41 items for seven climate constructs and 9 items for two commitment constructs using six-point Likert-type responses (1 = strongly disagree to 6 = strongly agree).

D. Capturing Social Identities

To capture the complex social identities of diverse students, we identified demographic items from the literature to add to our climate survey. For example, gender identity and sexual orientation questions are based on the APA Resolution on Data About Sexual Orientation and Gender Identity [57]. We also included items regarding racial/ethnic group identification, disability, and country of residence.

E. Participants

Following IRB approval, an invitation to participate in a survey was sent to students in engineering doctoral programs at 28 universities in the summer and fall of 2023 [58]. Students who completed the survey had an opportunity to receive a $25.00 gift card as an incentive after drawing. While 604 students responded to an online survey on SurveyMonkey, 287 engineering doctoral students completed the full survey. The mean age of the participants was $M = 28.01$ years ($n = 279$, $SD = 3.77$). Students reported an average of $M = 2.44$ ($n = 284$, $SD = 1.50$) years in the doctoral program, with a range of 1 to 11 years. Table 2 shows an overview of gender identity, race/ethnicity, first-generation status, disability status, and residence of the sample.

Table 2. *Demographic Characteristics of Participants* (*N* = 287)

Category	**Subcategory**	***n***	**%**
Gender identity	Woman	108	37.6
	Man	174	60.6
	Trans, Genderqueer, Genderfluid, Nonbinary, or Unsure	9	3.1
Race/ Ethnicity (Domestic Students Only)	American Indian/Alaska Native/First Nations/Indigenous	0	0.0
	Native Hawaiian or Other Pacific Islander	0	0.0
	Asian	10	3.5
	East Asian (e.g., Chinese, Japanese, Korean, Taiwanese)	3	1.0
	South Asian (e.g., Indian, Pakistani, Sri Lankan)	5	1.7
	Southeast Asian (e.g., Filipino, Vietnamese, Cambodian, Laotian, Hmong)	2	0.7
	Black or African American	5	1.7
	Caribbean (e.g., Jamaica, Cuba, Martinique, etc.)	3	1.0
	African (i.e., East Africa, Central or Middle Africa, Southern Africa, or Western Africa)	0	0.0
	Middle Eastern or North African	6	2.1
	Mexican or Chicano/a	4	1.4
	Puerto Rican	4	1.4
	Central or South American (e.g., Costa Rican, Brazilian, Argentinian)	7	2.4
	White	99	34.5
	Unsure	0	0.0
	Prefer not to answer	2	0.7
Residence	Domestic (U.S. citizen or permanent resident)	135	47.0
	International	152	53.0
SES	First generation	70	24.4
	Continuing generation	198	69.0
Disability	Identifies as having a disability	19	6.6
	Does not identify as having a disability	247	86.1
LGBTQIA+		38	13.2

Note. SES = socioeconomic status; Due to the multiple responses and non-responses, the total number of the responses in each category may not add up to 287.

F. Data Analysis

To answer the second research question, *To what extent does construct validity of the scale hold for engineering doctoral students?*, we conducted an exploratory factor analysis (EFA) using 287 engineering doctoral student data to identify underlying factor structure and irrelevant items that did not fit into any factors in the scale. Before conducting an EFA, Pearson correlation coefficients among the 50 items were calculated to check whether the coefficients were positively or negatively correlated, meaning that putative factors identified through an EFA are not independent. In addition, we checked multicollinearity (strong correlations over .85) between two items, implying that those items tend to measure the same aspect of the constructs [59].

For the EFA, eigenvalues and factor loadings after an oblique rotation of GEOMIN, which is the default rotation of the M*plus,* were calculated to judge the number of factors and items for each factor. We extracted the number of factors underlying the data based on parallel analysis and the point of inflection of the curve in the scree plot [60]. According to Stevens' [61] (2002) guideline about the relationship between the sample size and cutoff factor loading, we considered items with a factor loading greater than 0.40 significant for the designated factor. This cutoff functioned to suppress any irrelevant items that did not fit well into the designated factor. M*plus* performed full information maximum-likelihood estimation for missing responses under the assumption of missing at random.

To answer the third research question, *What level of internal consistency reliability exists for engineering doctoral student data from the survey's scale?*, we calculated the reliability coefficient of internal consistency, Cronbach's α, using SPSS Statistics 25 [62], and investigated how items are inter-related within each factor, sub-factor, and the overall instrument.

IV. Results

A. Identification of the Latent Factor Structure

Pearson correlation coefficients among the 50 items, which are continuous variables, revealed that the coefficients ranged from -0.438 to 0.921, meaning that some items showed multicollinearity. We extracted the eight factors underlying the data based on the criteria to determine the optimal number of factors.

As shown in Table 3, the exclusion criteria for cutoff factor loading yielded 39 items, excluding 11 items. Based on the constructs named in Table 1, we matched the constructs to the factors clustered with a group of items. Note that the first four items designated for Perceived cultural diversity showed multicollinearity with correlations over 0.85 each other. This implies the four items (Q1 to Q4) grouped for perceived cultural diversity, seemed to capture almost the same aspect of the construct. In addition, Q9 and Q10 for Diversity climate, Q17 and Q18 for Mastery Climate, Q21 and Q22 for Performance climate, Q28 and Q29 for Authenticity climate, Q37 and Q38 for Organization support, and Q42 and Q43 for Affective commitment were the items presenting multicollinearity.

Table 3. *Results from Exploratory Factor Analysis (n = 287) on the Climate and Commitment Scales*

Construct	Sample Item	Item #	Factor Loadings							
			1	2	3	4	5	6	7	8
Perceived cultural diversity	*My department is made up of members with different cultural backgrounds.*	1	**0.931***	-0.036	0.003	0.038	0.005	0.02	-0.028	0.011
		2	**0.925***	0.050	0.024	0.001	-0.01	-0.012	-0.02	0.040
		3	**0.938***	0.041	-0.013	0.029	-0.028	0.003	0.019	-0.015
		4	**0.917***	0.048	-0.031	-0.096*	0.047	0.021	0.032	0.010
Diversity climate	*My department is committed to supporting doctoral students from diverse backgrounds.*	5	0.164*	**0.478***	0.109*	0.111	0.018	0.118	0.006	0.045
		6	0.134*	**0.764***	0.021	0.087	0.052	-0.062	-0.033	0.031
		7	0.192*	**0.648***	-0.016	0.014	0.064	0.087	0.005	0.014
		8	**0.428***	**0.520***	0.008	0.046	-0.033	-0.019	0.044	-0.001
		9	-0.015	**0.904***	-0.024	-0.005	0.043	0.03	-0.007	0.016
		10	0.043	**0.858***	0.014	0.017	0.014	0.021	0.042	0.026

Psychological safety climate	*It is safe for doctoral students to take a risk in my department.*	11	0.054	**0.425***	0.02	0.313*	0.085	0.035	0.014	0.005
		12	0.117	0.256*	**-0.317***	-0.146	0.032	0.161	-0.099	-0.006
		13	0.053	0.151	0.025	**0.327***	0.034	0.351*	0.068	-0.134
		14	-0.059	0.257*	-0.085	**0.363***	-0.039	0.242*	-0.078	-0.015
		15	-0.028	0.118	-0.036	**0.385***	0.087	0.275*	-0.066	-0.028
Mastery climate	*In my department, doctoral students are encouraged to exchange ideas with each other.*	16	0.006	0.213*	0.014	**0.486***	0.222*	0.131*	0.038	-0.08
		17	-0.023	0.079	-0.035	0.047	**0.755***	0.077	-0.027	0.08
		18	0.046	0.023	-0.024	0.006	**0.870***	-0.022	-0.017	0.134
		19	-0.017	0.048	0.018	**0.326***	**0.536***	0.077	0.025	0.026
Performance climate	*My department encourages doctoral students to strive to outperform each other.*	20	-0.014	-0.003	**0.707***	-0.11	0.094	0.026	-0.052	-0.018
		21	-0.003	0.002	**0.890***	0.062	-0.001	0.083	0.012	0.041
		22	0.056	-0.008	**0.927***	0.036	0.014	0.139*	0.040	-0.034
		23	0.094	0.013	**0.718***	-0.097	-0.002	-0.031	-0.042	0.006
		24	-0.015	0.057	**0.745***	-0.052	-0.072	-0.008	0.00	-0.005
Authenticity climate	*My department supports doctoral students to be their true selves.*	25	0.050	0.079	0.086	0.297*	0.006	**0.400***	-0.03	0.114
		26	0.018	0.068	**-0.470***	**-0.131**	-0.027	0.187	0.057	0.092
		27	-0.030	-0.003	0.021	0.059	0.074	**0.699***	-0.006	0.234
		28	0.020	0.048	-0.029	-0.004	-0.001	**0.785***	0.002	0.176
		29	0.026	-0.002	-0.018	0.063	0.019	**0.792***	0.008	0.167
Organizational support climate	*My department considers doctoral students' goals and values.*	30	0.094	-0.082	-0.025	**0.745***	0.077	0.065	0.052	-0.001
		31	0.107*	-0.137	0.039	**0.784***	0.065	-0.022	0.013	0.006
		32	0.013	0.022	0.010	**0.857***	0.126*	-0.094	0.01	0.023
		33	-0.035	0.065	0.033	**0.681***	0.069	0.007	0.027	0.01
		34	-0.010	-0.03	0.026	**0.714***	0.110	-0.105	-0.045	0.102
		35	-0.014	0.189	-0.127*	**0.366***	-0.077	0.108	-0.083	0.048
		36	0.107	0.13	-0.093	**0.494***	-0.074	0.092	-0.044	0.054
		37	-0.049	0.173*	-0.091*	**0.720***	-0.108*	0.028	-0.031	0.09
		38	0.021	0.162	-0.044	**0.675***	-0.137*	0.081	-0.054	0.067
		39	-0.076	0.013	0.01	0.261*	0.099	0.128	0.13	0.133
		40	0.034	0.030	**-0.346***	0.043	0.132	0.172	-0.169*	-0.261*
		41	0.075	-0.067	**-0.379***	0.080	0.108	0.109	-0.234*	-0.192*
Affective Commitment	*I feel a sense of belonging to my department.*	42	0.035	0.056	-0.018	0.081	0.03	0.071	0.054	**0.783***
		43	0.024	0.104	-0.005	0.034	0.038	0.036	-0.024	**0.799***
		44	0.054	-0.028	0.008	0.155*	0.085*	0.029	-0.081*	**0.742***
Continuance Commitment	*Too much in my life would be disrupted if I decided to leave my doctoral program now.*	45	0.084	0.042	0.007	-0.05	-0.064	-0.031	**0.707***	-0.055
		46	0.080	-0.191*	0.029	0.004	-0.029	0.099	**0.773***	0.045
		47	-0.024	0.005	-0.049	0.068	-0.018	-0.012	**0.852***	-0.024
		48	-0.022	-0.063	0.048	0.001	0.029	-0.01	**0.758***	0.110
		49	-0.025	0.025	0.016	-0.188*	0.046	0.060	**0.744***	-0.028
		50	0.016	0.014	-0.037	0.015	0.044	-0.058	**0.780***	-0.072

Note. $^{*}p < 0.05$.

B. Reliability Evidence

Data from the $n = 287$ engineering doctoral students were utilized for the reliability analysis. The overall reliability of the scale with 39 items was Cronbach's $\alpha = 0.928$. Each construct housed in the scale appeared to have good internal consistency as shown in Table 4. Cronbach's α values of the constructs ranged from 0.897 to 0.972. All items of the scale were worthy of inclusion because the removal of any items would not increase the score reliability for any construct and the scale as a whole [63]. Table 4 shows the initial numbers of items in the constructs and the numbers of items grouped for latent factors resulting from EFA.

Table 4. *Number of Items and Internal Consistency Reliability Evidence of the Climate and Commitment Constructs*

Constructs	**Items**	n_i	n_{EFA}	**Cronbach's** α
Perceived cultural diversity	1, 2, 3, 4	4	4	0.972
Diversity climate	5, 6, 7, 9, 10	6	5	0.943
Psychological safety climate	N/A	5	0	N/A
Mastery climate	17, 18, 19	4	3	0.914
Performance climate	20, 21, 22, 23, 24	5	5	0.897
Authenticity climate	25, 27, 28, 29	5	4	0.936
Department support climate	16, 30, 31, 32, 33, 34, 36, 37, 38	12	9	0.934
Affective commitment	42, 43, 44	3	3	0.945
Continuance commitment	45, 46, 47, 48, 49, 50	6	6	0.899
Total		50	39	0.928

Note. n_i = The initial number of the items in the construct; n_{EFA} = The number of items grouped for a latent factor resulting from EFA; N/A = Not applicable

Need to include factor correlations

C. Engineering Doctoral Student Intention to Persist

Table 5 shows the frequency data on engineering doctoral students' intention to persist on the six-point Likert-type responses. The correlation coefficient between the two single indicators below (*complete my degree* vs. *considered leaving*) was negative and statistically significant with $r = -0.410, p < 0.05$.

Table 5. *Engineering Doctoral Students' Intention to Persist*

Response	**I intend to complete my graduate degree in my department.**		**I have considered leaving the graduate program in my department.**	
	n	%	*n*	%
Strongly Disagree (= 1)	**2**	**0.7**	**109**	**38.0**
Moderately Disagree (= 2)	**4**	**1.4**	33	11.5
Slightly Disagree (= 3)	**3**	**1.0**	22	7.7
Slightly Agree (= 4)	15	5.2	**43**	**15.0**
Moderately Agree (= 5)	42	14.6	**25**	**8.7**
Strongly Agree (= 6)	**220**	**76.7**	**50**	**17.4**
N	286	99.7	282	98.3
M	5.63		2.97	
SD	0.84		1.94	

D. Engineering Doctoral Students' Social Identity and Intention to Persist

Table 6 shows a correlation matrix between students' social identities, their intention to get the Ph.D., and their consideration of leaving the graduate program. Regardless of their social identity, most students demonstrated a relatively higher agreement to complete their graduate program. However, students who reported having negative experiences related to their social identity showed a negative correlation (*r* = -0.165) with their intention to complete the graduate program, which is lower than their counterparts. Domestic students, students in the LGBTQIA+ community, students with negative experiences, and students without any support network more frequently reported consideration of leaving their graduate program. These small effect sizes were statistically significant. Sample sizes were too small to examine the intention to persist across intersectional social identities.

Table 6. *Correlation Between Social Identity and Intention to Persist*

Category	**Complete Ph.D.**	**Leave Ph.D.**
Gender identity (0 = woman; 1 = man)	-0.059	0.022
Residency (0 = domestic; 1 = international);	-0.004	**-0.233****
First generation (0 = continuing generation; 1 = first generation)	-0.060	-0.063
Disability status (0 = no disability; 1 = at least one disability);	0.058	0.093
LGBTQIA+ (0 = not LGBTQIA+; 1 = LGBTQIA+)	0.064	**0.163***
Negative experience related to social identity	**-0.165***	**0.196***
Support network	0.139*	**-0.135***

Note. $^{*}p < 0.05$. Negative experience related to social identity (0 = none reported; 1 = reported negative experiences); Support network (0 = no support network; 1 = support network present).

V. Discussion

This study is the first step to developing a survey as a valid measure of department-level organizational climate for engineering doctoral student retention informed by intersectionality. We sought to develop a scale to measure climate constructs that are differentially associated with student retention or attrition, particularly about students from underrepresented or marginalized groups, including women and students from racially minoritized and marginalized groups. To do so, we deployed an intersectional approach at each stage of the survey development process. An intersectional approach requires attention to the dimension of power and inequality that is embedded within social categories of gender, race/ethnicity, disability, etc. [33]. Thus, we began by including thoughtful and inclusive demographic items from the literature to capture respondents' diverse and complex social identities. Most climate research in higher education fails to capture or analyze students' membership in multiple social categories [64]. Next, we reviewed the literature on organizational climate constructs associated with student retention and appropriate for doctoral students and identified specific climate constructs relevant to students from underrepresented or marginalized groups.

First Round of Validity Evidence

Based on our intersectional approach, we reviewed the literature on climate in higher education and identified seven climate constructs relevant to the retention of diverse students in engineering doctoral programs. Our items were evaluated for content and face validity, and we tested 50 items in our first pilot study. The EFA with the data from 287 engineering doctoral students revealed the latent factor structure of the climate scale for 6 climate and 2 commitment constructs indicated by 39 items. Internal consistency was excellent. These data were used to inform qualitative interviews on climate with a subsample of engineering doctoral students from multiply-marginalized groups, an important next step in the broader process of developing a useful and valid climate survey for student retention in engineering doctoral programs [65].

Strengths, Limitations, and Suggestions for Future Research

Like all studies, there are both strengths and limitations to note. Our intersectional approach sets this project apart from existing climate research in higher education. Intersectionality informed every step of our research process. For example, we sought to recruit students from a diverse sample of engineering doctoral programs and also to maximize our sample of students from multiply-marginalized groups. Importantly, as a result of these targeted efforts, our sample is not representative of the population of engineering doctoral students in the U.S. For example, women are overrepresented in our sample, which supports our intersectional approach by amplifying the voices of a historically excluded group within engineering education.

Our selection of focused climates is not exhaustive. Our intersectional approach guided our climate construct selection process, such that we focused on climates that are relevant to student retention, particularly for students from historically excluded or underrepresented groups. Because our research goal is not to produce comprehensive or exhaustive cataloging of climates that exist in engineering doctoral education, the selection of seven focused climates is best understood as a strength rather than a limitation.

As items were not grouped to indicate Psychological safety climate, we planned to revise the items and add new items for the second round of data collection. In addition, items presenting multicollinearity, such as four items in Perceived cultural diversity, two items each in Diversity climate, Mastery Climate, Performance climate, Authenticity climate, Organization support, and Affective commitment, will be revised to capture slightly different aspects of the designated climate and commitment constructs, while avoiding multicollinearity.

Once the second round of data collection is completed, an EFA will be conducted to reveal the latent factor structure for climate constructs that we intended to assess. When there is no need for item revisions, a confirmatory factor analysis will be followed. When our sample size is large enough, we will have the statistical power to examine interactions between multiple social categories in climate constructs or student outcomes. Future data collection efforts in this line of research will warrant larger samples that are sufficiently diverse and also oversample low-frequency groups (e.g., Native American students, and students with disabilities) to facilitate complex group comparisons within an intersectional approach. In addition, testing for measurement invariance will warrant identifying any potential bias in items toward a certain group.

An additional strength of this project Is our interdisciplinary collaborative approach. Our project is informed by scholarship and expertise in organizational psychology, engineering education, educational measurement, and feminist science. We caution against a siloed approach to climate research in engineering doctoral departments. In particular, studies of organizational climate require an interdisciplinary team approach that includes organizational psychology experts in the climate area of interest. The engineering education community should not simply incorporate climate scales into their research. Likewise, research projects aiming to study or compare historically excluded or underrepresented groups require a reflexive, critical approach that attends to the social context of intersecting systems of oppression without essentializing race and gender.

Conclusion

The finalized survey is expected to contribute to understanding needed actions to enhance departmental climates for a more diverse workforce in doctoral engineering. Future higher education climate research must be grounded in and guided by contemporary organizational climate science to provide actionable results. Our work differs from existing approaches to climate and/or student persistence in doctoral engineering. The foundation for our work is organizational science, and we are introducing focused climates found to be associated with organizational member retention into doctoral engineering.

The focused organizational climate approach would facilitate intervention efforts aimed at improving specific department policies, practices, and procedures, such as student recruitment, instructional practices, professional development offerings, the process to change advisors, and grievance and non-retaliation policies to name a few. Viewing engineering doctoral student retention as an organizational science issue would also shift the responsibility from the faculty advisor-advisee relationship, which is often considered pivotal from a student-persistence perspective to higher education leadership. Organizational leaders, such as deans and chairs, are positioned to drive organizational change.

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