Engineering Doctoral Students' Not Sure Item Nonresponse Rates on the Departmental Climate Survey

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***Abstract* — This research full paper describes engineering doctoral students' nonresponse patterns on a departmental climate survey. As the U.S. engineering workforce does not reflect the diversity of the U.S. population, the departmental climate can be one lever that higher education leaders can use to identify specific policies, practices, and procedures in doctoral programs to increase the retention and success of students from historically excluded groups. During the summer and fall of 2023, 355 engineering doctoral students from 28 institutions in the U.S. responded to a climate scale that we developed to assess multiple climate factors associated with organizational commitment or member retention. Items included a six-point Likert-type response option and "not sure." While most students responded adequately to the climate scale items with the Likert scale, a significant number of students also responded to the "not sure" option. Based on the climate and survey research in the literature, we hypothesized that these item nonresponses may stem from (a) the contextual characteristics of climate constructs or items and/or (b) student characteristics. Descriptive and inferential statistical data analyses showed that "not sure" item nonresponse differed by climate constructs and items as well as student characteristics. Among the six climate factors, on average, authenticity climate had the highest item nonresponse rates, followed by performance climate and diversity climate. While the item nonresponse rates increased by student age, at the item level analysis, item nonresponse rates varied by residency, gender, and first-generation status. There were no significant differences in the item nonresponse rates on underrepresented minority (URM) status, student disability, and LGBTQIA+ status.**

Keywords—engineering doctoral students, departmental climate, item nonresponses

I. Introduction

Decades of climate research in higher education have been siloed from organizational climate advances and have had limited success in increasing the number of engineering doctorates obtained by women and people from other historically excluded groups. Research on "campus climate" has become commonplace (e.g., [1-3] Hurtado et al., 1998; Nightingale, 2022; Parker & Trolian, 2020), and the meteorological metaphor of climate continues to be used to explain disparities with research on improving diversity outcomes in higher education organizations pointing to a negative or "chilly" atmosphere that results in lower rates of retention to degree completion (e.g., Cross et al., 2018; Davis et al., 2023; Kim et al., 2023; Thomas et al., 2021).

Hence, the doctoral engineering pipeline still does not reflect the U.S. diversity. 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% (ASEE, 2023).

As part of a collaborative project investigating department climates associated with engineering doctoral student retention, we constructed an organizational climate survey. The survey includes a climate scale based on a systematic literature review 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 historically underserved groups (Aldridge et al., 2023).

During the summer and fall of 2023, 355 engineering doctoral students from 28 institutions in the U.S. responded to the climate scale that included 30 items with a six-point Likert-type response option as well as "not sure" (NS). While most students adequately responded to the climate scale items with the Likert scale, a significant number of students also expressed uncertainty about some items by responding to the NS option.

On one hand, according to organizational climate research, individual members go through the uncertainty phase before forming collective perceptions of climate (Beus et al., 2023). In detail, as a subjective phenomenon, uncertainty acts as a motivator for organization members to make sense of the social context, facilitating the formation of collective climate perceptions (Beus et al., 2023; Downey & Slocum, 1975). On the other hand, according to survey research, respondents' uncertainty about responses may stem from (a) contextual characteristics of constructs or items and/or (b) respondent characteristics (Montagni et al., 2019).

A. Purpose of the Study

Informed by the organizational climate and survey research, we hypothesized that engineering doctoral students' uncertainty on the climate scale items could be influenced by (a) the contextual characteristics of climate constructs or items in particular during their formation of collective climate perceptions (Beus et al., 2023), and/or (b) student characteristics in that diverse groups of students may understand and interpret items and respond to them differently (Montagni et al., 2019). Therefore, for this study, we aimed to explore any differences in the NS response patterns across climate factors and items and by student characteristics, such as gender, underrepresented minority group membership, residency (domestic vs. international), age, first-generation, disability, and LGBTQIA+ status.

II. Theoretical Backgrounds

A. Organizational Climate

Organizational climate is defined 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 (Ehrhart et al., 2014; Ehrhart & Schneider, 2016; Schneider & Reichers, 1983; Schneider et al., 2013). Contemporary climate research focuses on specific strategic goals or internal processes (Ehrhart & Schneider, 2016). Findings from focused climate studies have practical applications and can guide specific policies, practices, and procedures to achieve organizational goals, such as diversity efforts (Ehrhart & Schneider, 2016; Schneider et al., 2017). A systematic literature review revealed six climate factors associated with organizational commitment or member retention of engineering doctoral students (Aldridge et al., 2023). Table I lists the identified six climate factors along with their definitions.

TABLE I. Definitions of the Six Climates in the Scale

Climate	**Definition**	References
Perceived cultural diversity	Perception and accurate recognition of the degree and nature of group diversity including variety in cultural values, beliefs, and practices	Chuapetcharasopon et al., 2018; MacLeod, 2021
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	Dwertmann et al., 2016; Perry, 2019
Mastery climate	Perception that efforts, sharing, and collaboration are valued, and learning and skill development are emphasized in an organization	Han et al., 2020; Nerstad et al., 2017
Performance climate	Perception that competition with comparison to, and recognition from others are the standards for success.	Cerne et al., 2014 ; Zhang et al., 2022
Authenticity climate	Perception that the organization encourages and provides a safe environment to express personal identities at work.	Grandey et al, 2012; Ostermeier et al., 2022
Organizational support climate	Perception that the organization values their contributions and cares about their well-being	Eisenberger et al., 1986, 2020

B. Item Nonresponses

In survey research, responses, such as "I don't know," "I'm not sure," and "I don't want to answer" are classified as nonresponse options and each has its own nuanced usage within a survey to be distinguished (Montagni et al., 2019; Presser et al., 2004). The "don't know" (DK) option is typically integrated into knowledge-related questions, enabling respondents to indicate their lack of information to answer the questions. The "not sure" (NS) option is better suited for attitude-related questions. The NS option, subtly different from the DK option, enables respondents to indicate uncertainty about an issue where they have not yet reached a definitive conclusion. Both DK and NS are options not to force respondents, who lack knowledge or are not sure, to select an invalid response but to provide an alternative way to express their uncertainty. The "I don't want to answer" (DWA) option corresponds to respondents' strong refusal and is commonly incorporated in sensitive questions (Montagni et al., 2019).

Note that for any type of survey, the nonresponse options are closely tied to the nature of the questions being asked (Montagni et al., 2019). For example, when the NS option is unavailable, respondents most commonly select the DK option for their uncertainty (Graham, 2021; Groothuis & Whitehead, 2002). When nonresponse options are absent, respondents are induced to select an arbitrary option as they lack relevant knowledge, experiences, opinions, and/or confidence. In other words, the availability of nonresponse options can contribute to the validity of the responses (Dillman et al., 2002; Waters et al., 2022), and failing to provide those options could lower data quality (Luskin & Bullock, 2011; Tourangeau et al., 2016). In addition, as forced responses contradict the voluntary nature of survey data collection, the use of an appropriate nonresponse option on a survey is regarded as an ethical consideration (DeRouvray & Couper, 2002).

However, there are drawbacks to incorporating nonresponse options in a survey, which has generated considerable controversy for decades (Krosnick & Presser, 2010; Montagni et al., 2019). First, all three nonresponse options could result from respondents' lack of motivation as a way to quickly and easily complete the survey without exerting much effort (i.e., sacrificing) (Krosnick & Presser, 2010; Roberts et al., 2019). Second, the use of nonresponse options could reduce statistical power due to the decreased sample sizes that require definite responses for valid data. Therefore, either the inclusion or the exclusion of nonresponse options on a survey has the potential to threaten the validity of the results.

Accordingly, the occurrence of item nonresponse primarily depends on the survey's contextual factors, such as the domains of questions and the type of nonresponse options. Additionally, item nonresponse has a significant association with respondents' backgrounds or social identities, including gender, age, and field of study (Montagni et al., 2019). For example, using latent class analysis, Montagni et al. (2019) revealed that the high item nonresponse group students were more male, younger, and Humanities and Letters majors than the high item response group students. Consequently, item nonresponses might provide meaningful information about the item context and student characteristics if they are not randomly distributed across items

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within a sample. Hence, researchers are advised to understand the distribution of item nonresponse in their datasets to see how it is related to other variables, such as what characteristics of the population are associated with nonresponse options (Waters et al., 2019).

III. Method

A. 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 (Yoon et al., 2024). Students who completed the survey had an opportunity to receive a $25 gift card as an incentive after drawing. While 604 students responded to an online survey on SurveyMonkey, 355 engineering doctoral students completed the full survey. The mean age of the participants was 28.36 years (n = 355, M = 28.36, SD = 4.38). Students reported an average duration of 2.40 years in the doctoral program (n = 351, M = 2.40, SD = 1.55). Table II shows an overview of 355 participants' gender, race/ethnicity, residency, first-generation, disability, and LGBTQIA+ identities.

TABLE II. Demographic Characteristics of Participants

Category	**Subcategory**	***n***	***%***
Gender	Woman	123	34.65
	Man	217	61.13
	Trans, Genderqueer, Genderfluid, Nonbinary, or Unsure	15	4.23
Race/ Ethnicity (Domestic Students Only)	American Indian/Alaska Native/First Nations/Indigenous	0	0.00
	Asian	16	4.51
	Black or African American	7	1.97
	Multiracial	5	1.41
	Native Hawaiian or Other Pacific Islander	0	0.00
	Hispanic or Latino/Latina/Latine/Latinx	14	3.94
	White	115	32.39
Residency	Domestic (U.S. citizen or permanent resident)	158	44.51
	International	197	55.49
SES	First generation	115	32.39
	Continuing generation	238	67.04
Disability	Identifies as having a disability	40	11.27
	Does not identify as having a disability	308	86.76
LGBTQIA+	Identifies as LGBTQIA+	44	12.39
	Does not identify as LGBTQIA+	297	83.66
Total		355	100.00

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 355.

B. Measurement

Our organizational climate survey included a departmental climate scale to probe respondent perceptions of the six climates in our framework. The scale is assessed on a six-point Likert-type response (1 = strongly disagree to 6 = strongly agree) along with a not sure (NS) option and does not include a middle category to capture neutral responses. Respondents were not forced to answer each scale to proceed through the survey, which led to missing responses. An exploratory factor analysis revealed latent factor structure for six climate constructs indicated by 30 items as the first validity evidence of the climate scale (Yoon et al., 2024). Table III presents the number of items for each construct and internal consistency reliability evidence of six climate constructs.

TABLE III. Internal Consistency Reliability Evidence of the Six Climate Constructs

Constructs	**Items**	***n***	**Cronbach's *α***
Perceived cultural diversity	1, 2, 3, 4	4	0.972
Diversity climate	5, 6, 7, 8, 9	5	0.943
Mastery climate	10, 11, 12	3	0.914
Performance climate	13, 14, 15, 16, 17	5	0.897
Authenticity climate	18, 19, 20, 21	4	0.936
Organizational support climate	22, 23, 24, 25, 26, 27, 28, 29, 30	9	0.934
Total		30	0.928

Note. n = The number of items grouped for a latent factor resulting from exploratory factor analysis

C. Data Analysis

Using SPSS (IBM Corp., 2023), we employed descriptive and inferential statistics to examine any differences in engineering doctoral students' NS responses on climate factors and items based on their backgrounds, such as age, gender, underrepresented minority group membership, residency (domestic vs. international), first-generation, disability, and LGBTQIA+ status. For inferential statistics, we applied independent samples t-tests, multiple regressions, Chi-square, and Fisher's exact tests to explore item nonresponse patterns and rates by student characteristics.

IV. Results

A. Distribution of Not Sure Item Nonresponses Across Climate Factors and Items

Out of 355 participants, 190 (53.5%) selected the NS option for at least one of the 30 climate scale items. Figure 1 shows the frequency distribution of the NS responses on six climate factors indicated by 30 climate scale items. Among six climate factors, on average, authenticity climate had the highest number of students who responded to the NS option with an average number of 38.50 respondents per question (10.9%), followed by performance climate with 35.20 respondents per question (9.9%) and diversity climate with 17.40 respondents per question (4.9%). Among 30 items, item 28 ("My department would understand a long absence due to a doctoral student's illness") has the highest NS responses (67 students = 18.9%), followed by item 18 ("My department has policies in place to support doctoral students in expressing their true selves") with 54 respondents (15.2%) and item 16 ("My department sets up only the highest-achieving doctoral students as examples") with 50 respondents (14.1%).

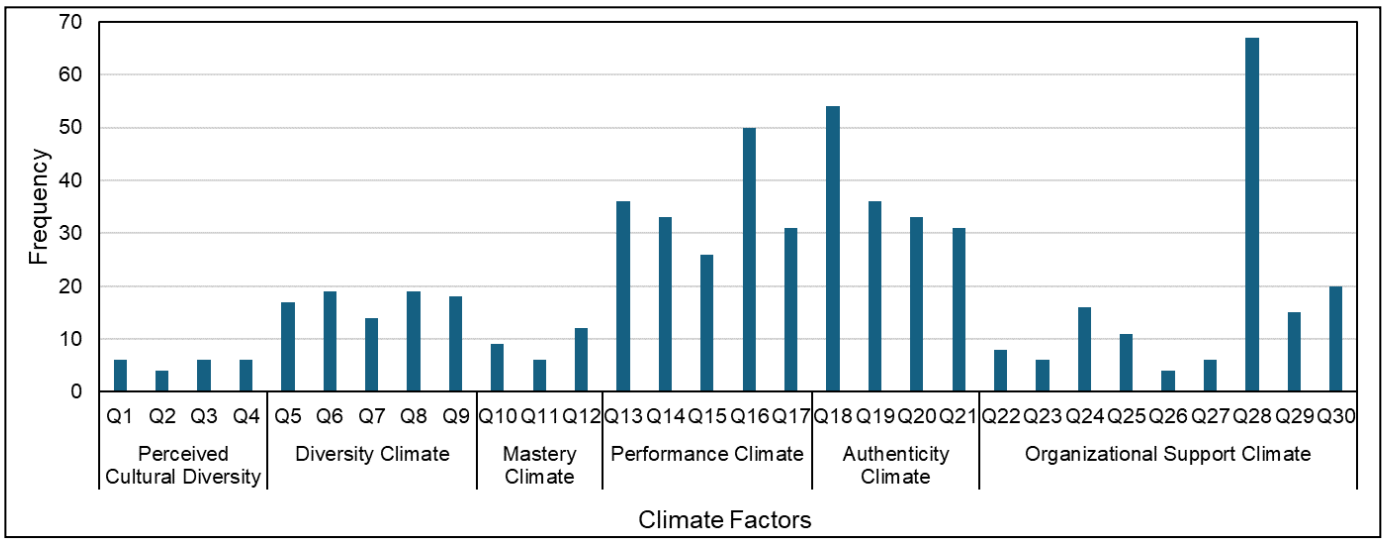

Fig. 1. Frequency distributions of students' not sure responses across six climate factors indicated by 30 items

B. *Total Numbers of Not Sure Responses on the Climate Scale by Student Characteristics*

According to the independent samples *t*-test, there was no statistically significant difference in the total number of NS item responses between domestic and international students, with $t(353) = -0.12$, $p = 0.909$. However, as shown in Table IV, when the data were disaggregated by student residence, multiple regression analysis revealed that student age was a positively significant predictor, and the duration of the doctoral program was a negatively significant predictor of the total number of NS responses for domestic students. However, none was a significant predictor of the total number of NS responses for international students.

TABLE IV. MULTIPLE REGRESSION MODEL TO PREDICT THE NUMBER OF NOT SURE ITEM NONRESPONSES FOR DOMESTIC STUDENTS

Predictors	**Unstandardized**		**Standardized**	***t***	***p***
	B	***S.E.***	***β***		
(Constant)	-3.93	1.72		-2.28	0.024
Gender (0 = female, 1 = male)	0.98	0.61	0.13	1.61	0.109
Race/Ethnicity (0 = non-White; 1 = White)	0.76	0.68	0.09	1.12	0.265
Age	0.20	0.06	0.29	3.27	0.001
Duration of Doctoral Program in Years	-0.48	0.19	-0.22	-2.56	0.011
First Generation (0 = no, 1 = yes)	0.62	0.76	0.07	0.81	0.417
Disability status (0 = no, 1 = yes)	-0.15	0.75	-0.02	-0.20	0.846
LGBTQIA+ (0 = no, 1 = yes)	-0.07	0.74	-0.01	-0.10	0.923

Note. $R^2 = 0.132$; Adjusted $R^2 = 0.086$

C. *Not Sure Response Rates on Climate Scale Items by Student Characteristics*

Table V shows significant differences in the NS response rates on three climate scale items by student residency (i.e., Domestic vs. International). While domestic students showed significantly higher item nonresponse rates on item 18, International students showed significantly higher item nonresponse rates on items 17 and 28.

TABLE V. DIFFERENCES IN ITEM NONRESPONSE RATES ON CLIMATE SCALE ITEMS BY STUDENT RESIDENCY

Constructs	**#**	**Items**	**Statistics**	**Not Sure**
Performance	17	My department encourages rivalry between doctoral students.	$\chi(1) = 6.69$, $p = 0.010$	Dom < Int
Authenticity	18	My department has policies in place to support doctoral students in expressing their true selves.	$\chi(1) = 5.61$, $p = 0.018$	Intl < Dom
Organizational Support	28	My department would understand a long absence due to a doctoral student's illness.	$\chi(1) = 4.54$, $p = 0.033$	Dom < Intl

Note. Dom = domestic students; Intl = international students

Table VI shows significant differences in the NS response rates on six climate scale items by student residency (i.e., Domestic vs. International) and student gender (i.e., women vs. men). Among domestic students, men showed significantly higher item nonresponse rates on items 5, 18, 19, 20, and 28 than women. For international students, women showed significantly higher item nonresponse rates on items 14 and 18 than men.

TABLE VI. DIFFERENCES IN ITEM NONRESPONSE RATES ON CLIMATE SCALE ITEMS BY STUDENT RESIDENCY

Constructs	#	Items	Domestic Students		International Students	
			Statistics	Gender	Statistics	Gender
Diversity	5	My department has open communication about diversity with doctoral students.	$\chi(1) = 4.39$, $p = 0.036$	F < M		
Performance	14	My department encourages internal competition among doctoral students to attain the best possible results.			$\chi(1) = 5.36$, $p = 0.021$	M < F
Authenticity	18	My department has policies in place to support doctoral students in expressing their true selves.	$\chi(1) = 4.48$, $p = 0.034$	F < M	$\chi(1) = 4.07$, $p = 0.044$	M < F
	19	My department encourages doctoral students to express their true selves.	$\chi(1) = 5.21$, $p = 0.022$	F < M		
	20	In my department, doctoral students can express their authentic selves without negative consequences.	$\chi(1) = 4.71$, $p = 0.030$	F < M		
Organizational Support	28	My department would understand a long absence due to a doctoral student's illness.	$\chi(1) = 4.26$, $p = 0.039$	F < M		

Note. F = female students; M = male students

Table VII shows significant differences in the NS response rates on two climate scale items by student residency (i.e., Domestic vs. International) and student first-generation status (i.e., Yes = first-generation vs. No = continuing-generation). Among domestic students only, first-generation students showed significantly higher item nonresponse rates on items, 20 and 29, than continuing-education students.

TABLE VII. DIFFERENCES IN NOT SURE RESPONSE RATES ON CLIMATE SCALE ITEMS BY DOMESTIC STUDENTS' FIRST-GENERATION STATUS

Constructs	#	Items	Statistics	Dom
Authenticity	20	In my department, doctoral students can express their authentic selves without negative consequences.	$\chi(1) = 7.10$, $p = 0.008$	No < Yes
Organizational Support	29	My department cares about doctoral student well-being.	*Fisher's exact test*, $p = 0.048$	No < Yes

Note. Dom = domestic students

There were no significant differences in the NS response rates on individual climate scale items by domestic students' underrepresented minority (URM) status, student disability, and LGBTQIA+ status, regardless of student residency (i.e., Domestic vs. International).

V. DISCUSSION

Based on the hypothesis that NS item nonresponses might be influenced by contextual factors related to climate constructs or items as well as student characteristics, we examined the NS response patterns on the climate scale among 355 engineering doctoral students from 28 institutions.

A. Distribution of Not Sure Responses Across Climate Factors

As shown in Fig. 1, the uneven distribution of NS responses across climate factors and items indicates that the item nonresponses are not random but might be associated with the context of climate factors or student characteristics, which was consistent with the findings in the literature (Montagani, 2019). According to the model of integrated climate theory, the higher NS responses on authenticity and performance climates imply that some individual group members might be still at the stage of uncertainty, prior to their sensemaking to format group-level collective climate perceptions (Beus et al., 2023).

The same interpretation may apply to individual climate scale items, such as item 28 ("My department would understand a long absence due to a doctoral student's illness"), item 18 ("My department has policies in place to support doctoral students in expressing their true selves"), and item 16 ("My department sets up only the highest-achieving doctoral students as examples"). If students have not experienced such specific climate contexts related to departmental policies, practices, and procedures in their doctoral programs, it is reasonable to expect that they would express uncertainty about those climate survey items (Beus et al., 2023).

B. Not Sure Responses on the Climate Scale by Student Characteristics

According to the integrated climate theory model, the formation of individual climate perceptions is influenced by individual differences and past experiences (Beus et al., 2023). However, in this study, we observed complex findings in that domestic students presented the total numbers of NS item nonresponses on the climate scale significantly increased by age but decreased by the duration of the doctoral programs in years. On one hand, it is reasonable to expect that the longer students remain in a doctoral program, the more aware they become of the departmental climate, leading to more accurate item responses. On the other hand, if student age is considered a proxy for maturity, more mature students might respond to climate scale items more cautiously, indicating uncertainty when they are unsure.

However, those interpretations did not apply to international students who might have different response behaviors. According to the survey research, Asian international students do not want to stand out and prefer to endorse middle points (Chen et al., 1995; Hoy, 1993). In addition, individuals from highly uncertainty avoidance and highly collective cultures like Asian international students tend to endorse socially or culturally desirable responses (Bernardi, 2006). Considering that the proportion of Asian international students was more than half (50.3%) in our international student sample, we might not

be able to identify age becoming a significant predictor of the number of NS responses like domestic students.

C. *Not Sure Response Rates on Climate Scale Items by Student Characteristics*

Even though at the climate scale level, we were not able to identify any differences in the total number of NS item nonresponses between domestic and international students, several climate scale items revealed significant differences in the response rates between domestic and international students. For example, regarding item 18 ("My department has policies in place to support doctoral students in expressing their true selves"), domestic students endorsed more uncertainty than international students, which could be explained by international students' uncertainty avoidance (Bernardi, 2006). However, item 17 ('My department encourages rivalry between doctoral students') and item 28 ('My department would understand a long absence due to a doctoral student's illness') showed opposite trends, with international students selecting the NS responses more frequently than domestic students. This trend may be explained by contextual features that are less familiar to international students.

In addition, some climate scale items presented gendered NS responses by student residency. For example, domestic male students endorsed more NS responses than female students on the five items, 5, 18, 19, 20, and 28, in which three items were about authenticity climate. Conversely, international female students endorsed more NS responses than male students on the two items, 14 and 18. While there was no difference in the NS response rates by international first-generation students, domestic first-generation students showed higher NS responses than domestic continuing education students on items, 20 ("In my department, doctoral students can express their authentic selves without negative consequences") and 29 ("My department cares about doctoral student well-being").

In sum, this study revealed that the NS item nonresponses could differ by contextual features of climate scale items and student characteristics, such as gender, residency, and first-generation status. The uneven distributions of the NS item nonresponse rates across certain student demographic backgrounds suggest (a) the inclusion of the NS option on the climate scale for engineering doctoral students and (b) a need for further discussion about climate scale items when a certain group of students presented higher NS responses than other groups.

D. *Limitations of the Study and Future Research*

Due to the small sample sizes for minorities for domestic students, we aggregated them into one group, such as non-White or underrepresented minorities (URM). As Grandy (1998) showed a cultural bias in the item responses by Asian American science and engineering students who favored middle points, future studies with larger sample sizes for minorities might reveal different item nonresponse trends from our findings. Similarly, due to the small sample sizes for the underrepresented groups, such as disability, first-generation, and LGBTQIA+ memberships, we might have low statistical power to detect any differences in the NS item nonresponse rates. Therefore, large sample sizes will be applicable for latent class analysis (Goodman, 1974; Lazarsfeld & Henry, 1968) that may detect item nonresponse patterns by a certain group with specific student characteristics (Montagni et al., 2019).

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