Exploring the Relationship Between Culture and Science, Engineering, and Mathematics Graduate Students' Mental Health (Full Paper)

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Abstract

In this paper, we explore the mental health of science, engineering, and math (SEM) graduate students using quantitative analysis on the survey data provided by the Healthy Minds Network (HMN): Research on Adolescent and Young Adult Mental Health group, coined the Healthy Minds Study (HMS). The aim of the study is to answer the following research questions:

(1) How has the mental health of SEM graduate students, measured by *depression*, *suicidal ideation*, *anxiety*, and *flourishing*, changed over the past three academic years?

(2) What role, if any, does the climate of SEM programs, measured by the proxies of *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration*, have on SEM graduate students' self-reported mental health measures of *depression*, *suicidal ideation*, *anxiety*, and *flourishing*, when accounting for students' *gender*, *race*, *international student status*, *degree*, and *discipline*?

Attention to the mental health of students in higher education has grown in recent years. Prior work has shown that several factors can influence an individuals' mental health, including, but not limited to, a students' demographics, social factors, available resources, values, motivation, and more. The purpose of this study, however, is to focus specifically on how the culture of SEM programs influences SEM graduate students' mental health. In this context, mental health refers to one's mental and emotional well-being. Therefore, this paper will leverage previous work that has indicated the role of academic disciplines' cultures on mental health.

SEM graduate students are of interest because they are understudied in the literature despite being more likely to report mental health problems. In addition, graduate students have a variety of academic and personal experiences that are different from undergraduate students due to their roles as students, instructors, and researchers, resulting in a different acculturation process. In addition, this process can impact students of diverse backgrounds inequitably, with minoritized students facing more negative mental health consequences and feeling like they are less supported than their non-marginalized peers. This study explored measures of program climate to assess how students' perceptions of diversity, equity, and inclusion efforts impact SEM students' self-reported mental health.

In this work, we performed a quantitative analysis on the Health Minds Network (HMN) data on SEM graduate students. We calculated bivariate statistics and developed regression models for each of the four outcome measures while accounting for relevant demographic measures. We first show that there have been changes in students' self-reported mental health, with the general trend of increasing mental health problems. In terms of program climate, our regressions found that students' beliefs about the climate had a statistically significant influence over their reported mental health measures, and that these experiences varied for different demographic groups.

The results from our work highlight areas of focus for future research. Furthermore, this work can help enable SEM graduate students, faculty, and staff to reflect on the changes in the past years and to use these results to promote change at individual, program, and systematic levels to improve SEM graduate students' mental health.

Introduction
There has been a growing crisis concerning students' mental health in the United States (U.S.) with mental health problems on the rise. A study lead by Sarah Lipson in 2019 highlighted rising mental health diagnoses (21.9% to 35.5%), services utilization (18.7% to 33.8%), and student-reported suicidal ideation (5.8% to 10.8%) over a ten-year span of 2007-17 [1]. This is over double to the national average in 2019, with roughly 4.7% of adults 18 or older reporting seriously considering suicide [2], [3]. In addition, a recent report by the National Academies of Science, Engineering, and Medicine (NASEM) titled *Mental Health, Substance Use, and Wellbeing in Higher Education: Supporting the Whole Student* highlighted three major concerns impacting students' mental health in the U.S.: the COVID-19 pandemic, the rise in unemployment and instability in the U.S. economy, and increased awareness of anti-Blackness and racism [4]. At the same time, higher education institutions have been struggling to keep up with this rise in demand [5], [6]. This collective evidence calls for concerted efforts to address mental health. However, most research has focused on an aggregate sample of undergraduate and graduate students despite research showing that graduate students are six times more likely to report mental health problems (i.e., depression and anxiety) [1], [7]–[9]. Research studies that do not separate out graduate students fail to account for the differences between students' mental health experiences in graduate degree programs and associate and baccalaureate programs, and the factors that can influence their mental health. Graduate students have different academic demands (e.g., more focus on independent research and communicating work), often inform their choices based on their past experiences in their undergraduate programs and tend to be older [10]. Furthermore, the social and cultural influence of graduate students' degree programs and discipline is stronger as a large focus of graduate programing is to indoctrinate students into this discipline [11], [12].

By analyzing data collected over the past three academic years on science, engineering, and mathematics (SEM) graduate students as part of the Healthy Minds Networks' (HMN) Healthy Minds Study, we hoped to add to the literature on SEM graduate student mental health [13]. Specifically, this study was driven by two goals. The first was to understand the state of SEM graduate student mental health over the past three academic years, measured through the proxies of *depression*, *suicidal ideation*, *anxiety*, and *flourishing*. The second goal was to understand what role the culture of SEM graduate students' program climates has on SEM graduate students' self-reported mental health. SEM programs' culture was measured using four proxies, selected by their wording to assess positive school climate: *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration*. Given the known systematic issues that lead to differences in mental health measures when assessed at the demographic level (detailed in the literature review section that follows), the demographics of *gender*, *race*, *international student status*, *degree*, and *discipline* were included. This culminated in two research questions, the first to understand the context of mental health over the past three years and the second to explore these relationships:

(1) How has the mental health of SEM graduate students, measured by *depression*, *suicidal ideation*, *anxiety*, and *flourishing*, changed over the past three academic years?

(2) What role, if any, does the climate of SEM programs, measured by the proxies of *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration*, have on SEM graduate students' self-reported mental health measures of *depression*, *suicidal ideation*, *anxiety*, and *flourishing*, when accounting for students' *gender*, *race*, *international student status*, *degree*, and *discipline*?

Literature Review
There are many ways mental health problems impact students. For this study, mental health was defined as anything related to a person's emotional or psychological welfare (i.e., their mental and emotional state) whereas well-being is a "holistic concept referring to both physical and mental health … [including] personal safety and security, emotional support and connection, mechanisms to cope with stressors, and access to services" [4, p. 3]. On a personal level, mental health problems can result in lowered satisfaction in life, with this impact showing to be greater as problems increase [14]–[16]. Given that many mood and substance disorders are known to be comorbid for those ages 18-35, this can have a drastic impact on quality of life [17]. Mental health problems have also been shown to impact students' academically. For example, lower grade point averages have been found in individuals with depression and anxiety [16]. Not surprisingly, mild forms of depression have also been linked to lowered cognitive function that can worsen the longer one experiences depression [18], [19]. This could be from depression's impact on an individual's executive function, memory, and attention, all of which have been shown to be present inside and outside of a depressive episode [20]. Furthermore, when considering attrition, research has shown that mental health concerns are highly cited among the reasons for students leaving before degree completion in both graduate and undergraduate populations, with one study showing that mental health problems doubled students' risk [4], [21]–[23].

However, these factors are not the only ones known to influence reported mental health outcomes. Research conducted by Berdanier et al. focusing on engineering graduate students' attrition highlighted how mental health concerns were sprinkled throughout the six main concerns students shared (i.e., advisor's role, perceptions of cost, existing support network, perceptions on how they are viewed, goals, and quality of both life and work) [24]. Furthermore, this work demonstrated how these concerns are interwoven and connected, as these core concerns are often cited collectively [24]. In addition to these concerns that can lead to attrition, a recent scoping literature review by Bork and Mondisa explored the mental health experiences of engineering graduate students [25]. Although only preliminary results were reported, this work found that of the limited research conducted, there has been an emphasis on engineering graduate students' mental health as it pertains to specific sub-groups, namely international, Black, female, and Black female students [25]. International graduate students' mental health was found to be impacted by language and cultural barriers they faced transitioning to life in the U.S. and the added isolating impact this could have [25], [26]. This work found that for Black, female, and Black female graduate students, racial-biases, gendered-biases, and both gendered- and racial-biases impacted these students' experiences. The compounding impacts of these biases is also evidenced in Kimberlé Crenshaw's intersectionality work [27]. The most common biases

were those where these students were considered less capable than their white male peers, whether they believed it about themselves or were told (implicitly or explicitly) by others in their programs [25].

Another area of interest when considering graduate students' mental health is the role of their programs' climate and culture. For this study, we intentionally delineated these terms. First, we defined culture to be normative behaviors, interactions, expectations, and dynamics that exist for a specific social group. Climate was then defined as how an individual (or groups of people) interacts with and assesses this culture. There is an inherent expectation of those who fit within that culture to have a stronger alignment with these normative behaviors and therefore are more likely to have positive experiences. For example, work led by Idalis Villanueva Alarcón has explored the normative behaviors expected for engineers training in graduate programs, with her work demonstrating how these norms are communicated explicitly and implicitly via aspects of the hidden curriculum [28], [29]. These norms would be considered part of engineering culture, whereas a new engineering graduate students' perspective of this culture (using evidence gained by their lived experiences interacting with and responding to this culture) would be considered the climate.

Students with mental health problems are often concerned with how others may perceive them. Many worry that others on campus will view them as lesser [30], [31]. This stigma concern is not unfounded. This research also reported that students requesting disability related accommodations, in which mood disorders are included, often encountered resistance and hostility as faculty and staff believed these students to be looking for an unfair advantage [30]. These experiences have an impact on students' perceptions of stigma and the climate of their school or program. This is evident by the 2021 HMN report, where despite only 6% of students reporting that they would think less of someone receiving treatment related to mental health, 45% reported that they think most people would think less of someone who has received mental health treatment [31].

Methodology
The following sections discuss the research approach we performed to answer our research questions.

Data and Sample
As aforementioned, data for this study comes from the Healthy Minds Network's (HMN) Healthy Minds Study [13]. This is a national survey that attempts to collect population level data from each institution participating in the study (i.e., by randomly surveying 4,000 students or the entire student population, whichever was smaller), in addition to applying weights to survey responses to get a representative sample (i.e., non-response weights estimated using a logistic multivariable regression from administrative data on gender, race/ethnicity, academic level, and grade point average and then applied to each students' responses). Students are recruited via email and completed a survey that asks them to reflect on experiences up to 12 months prior to the time the survey was administered. Participants received financial compensation for participating in the study. The survey itself is composed of 19 modules. Three of those modules are core modules and are presented to all study participants. The remaining modules are opted into where the institution working with the HMN group opts into the modules they want, with some restrictions based on

cost and total number of modules permitted [13]. As the covariates in this study come from one of the opt-in modules, we expect this to limit the data as opposed to the outcomes of interest, which are presented to all study participants in one of the three core modules.

For this study, our analysis used data provided from the academic years 2018-2019, 2019-2020, and 2020-2021. There was a total of 62,026, 89,888, and 115,163 survey responses for 2018-19, 2019-20, and 2020-21, respectively. As previously discussed, this study is focused on graduate students in science, engineering, and math (SEM) (technology was not an option). From the total samples, there were 2,945, 5,386, and 5,602 SEM graduate students included, respectively. However, participants may not have responded to all survey items and as discussed, not all participants were likely to have the opt-in module that these covariates were included in (i.e., in Table 1 the number of responses dropped from SEM graduate students compared to the number of SEM graduate students with completed covariate data). To account for this potentially missing data, any respondent that had missing data on any of the demographic measures used, the four outcomes of interest, or the four covariates were excluded from analysis for this study. The sample of SEM graduate students with complete responses for these measures was 661, 1,420, and 1,265 responses from 2018-19, 2019-20, and 2020-21, respectively, or a total of 3,346 responses across the three years (1.25% of all survey responses). The reduction of data to get to this final study sample is detailed in Table 1, where most of participant responses were eliminated when moving to SEM graduate students and when eliminating missing data for the covariates.

Table 1
Data Reduction to Final Responses Used

Data Groupings	2018-2019		2019-2020		2020-2021		2018-2021	
	N	%	N	%	N	%	N	%
All Responses	62,026	(100)	89,888	(100)	115,163	(100)	267,077	(100)
SEM Graduate Students	2,945	(4.75)	5,386	(8.68)	5,602	(4.86)	13,933	(5.22)
SEM Grad with Complete Demographics	2,938	(4.74)	5,376	(8.67)	5,599	(4.86)	13,913	(5.21)
SEM Grad with Complete Outcomes of Interest Data	2,040	(3.29)	4,955	(7.99)	5,083	(4.41)	12,078	(4.52)
SEM Grad with Complete Covariate Data	791	(1.28)	1,485	(2.39)	1,335	(1.16)	3,611	(1.35)
SEM Grads with Complete Demographics, Outcomes of Interest, and Covariate Data	661	(1.07)	1,420	(2.29)	1,265	(1.10)	3,346	(1.25)

*Note: SEM Grad means science, engineering, and mathematics graduate students

Demographics for participants for each academic year and collectively for the 3,346 respondents are presented in Table 2. As detailed in the table, we include the demographics of gender, race, international student status, degree, and discipline. For all demographic variables, any response categories that were less than 1% of the total data in aggregate form (i.e., 2018-21 data) were not presented to protect study participants from being identified. Due to this, categories in some of the variables were consolidated or removed. For example, the measure *gender* was coded to be female, male, or neither female nor male, which included all other gender identities. Likewise, American Indian/Alaskan Native and Pacific Islander were grouped into another category along with students

Table 2

Demographics for Study Participants by Academic Year and Aggregate

Demographic Measure		2018-2019 N (%)	2019-2020 N (%)	2020-2021 N (%)	2018-2021 N (%)
Gender		661 (100)	1,420 (100)	1,265 (100)	3,346 (100)
	Female	276 (41.8)	686 (48.3)	611 (48.3)	1,573 (47.0)
	Male	371 (56.1)	705 (49.6)	624 (49.3)	1,700 (50.8)
	Neither Female nor Male	14 (2.1)	29 (2.0)	30 (2.4)	73 (2.2)
Race		661 (100)	1,420 (100)	1,265 (100)	3,346 (100)
	African American/Black	21 (3.2)	53 (3.7)	47 (3.7)	121 (3.6)
	Asian/Asian-American	194 (29.3)	470 (33.1)	410 (32.4)	1,074 (32.1)
	Hispanic/Latino	29 (4.4)	91 (6.4)	52 (4.1)	172 (5.1)
	Middle Eastern, Arab, or Arab American	19 (2.9)	51 (3.6)	52 (4.1)	122 (3.6)
	White or Caucasian	345 (52.2)	712 (50.1)	577 (45.6)	1,634 (48.8)
	Multi-Racial or Other	53 (8.0)	43 (3.0)	127 (10.0)	223 (6.7)
International Student		661 (100)	1,420 (100)	1,265 (100)	3,346 (100)
	No	423 (64.0)	877 (61.8)	795 (62.8)	2,095 (62.6)
	Yes	238 (36.0)	543 (38.2)	470 (37.2)	1,251 (37.4)
Degree		661 (100)	1,420 (100)	1,265 (100)	3,346 (100)
	Master's	291 (44.0)	583 (41.1)	540 (42.7)	1,414 (42.3)
	PhD	370 (56.0)	837 (58.9)	725 (57.3)	1,932 (57.7)
Discipline		661 (100)	1,420 (100)	1,265 (100)	3,346 (100)
	Science and Mathematics	365 (55.2)	676 (47.6)	647 (51.1)	1,688 (50.4)
	Engineering	276 (41.8)	703 (49.5)	589 (46.6)	1,568 (46.9)
	Selected Multiple Disciplines	20 (3.0)	41 (2.9)	29 (2.3)	90 (2.7)

who selected multiple races. As has been pointed out elsewhere, aggregating students may obscure important distinctions between groups [32], [33]. For students who responded to the degree being both a master's and doctoral degree, they were recoded as doctoral degrees given embedded master's degrees in doctoral programs are common in the U.S.

Measures

For this study, we used four categorical independent variables (covariates) and four dependent variables (outcome of interest). We discuss the details for these measures below, in addition to their summaries presented in Table 3.

The four covariates were used to measure the culture for SEM students' programs. These measures served as proxies by asking students how much they agreed with statements pertaining to four concepts of mental health climate: *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration* [13]. These items were each scored on a scale of one to six, from one being strongly disagree and six being strongly agree. As noted in the table and in subsequent analysis, the measure *campus environment* is used in its reverse coded form; that is, for this study, we are interpreting this measure to mean: "*At my school, **I do not** feel that the campus environment has a negative impact on students' mental and emotional health.*"

Table 3
Measures used in Study

Measure	Measure Details	Scale
Outcomes		
Anxiety (GAD-7)	General Anxiety Disorder (GAD-7) score; self-reported measure for severity of anxiety; summative score across 7 items scored 0 (not at all) to 3 (nearly every day)*	0–4: minimal anxiety 5–9: mild anxiety 10–14: moderate anxiety 15–21: severe anxiety
Depression (PHQ-9)	Raw Patient Health Questionnaire (PHQ-9) score; self-reported measure for severity of depression; summative score across 9 items scored 0 (not at all) to 3 (nearly every day)*	0-4: minimal depression 5-9: mild depression 10-14: moderate depression 15-19: moderately severe depression 20-27: severe depression
Flourishing (Positive Mental Health)	Psychological Well-Being (PWB) scale; self-reported views on areas including relationships, self-esteem, purpose/meaning, and optimism; summative score across 8 items scored 1 (strongly disagree) to 7 (strongly agree)*	Scores range from 8 (lowest) to 56 (highest); A higher score indicates a person with many psychological resources and strengths
Suicidal Ideation	In the past year, did you ever seriously think about attempting suicide?	0=No 1=Yes
Covariates		
Campus Environment	At my school, I *do not* feel that the campus environment has a negative impact on students' mental and emotional health.	1=strongly disagree 2=disagree 3=slightly disagree 4=slightly agree 5=agree 6=strongly agree
Encouraging Dialogue	At my school, I feel that the campus climate encourages free and open discussion about mental and emotional health.	
Prioritizing Mental Health	At my school, I feel that students' mental health and emotional well-being is a priority.	
Receptive Administration	At my school, the administration is listening to the concerns of students when it comes to health and wellness.	

*Notes: See Appendix A for detailed survey scales; The Campus Environment measure was used in its reverse coded form for this study and all analysis/presentation - the wording here presents the item with added words (italicized) to show how it is being interpreted for this study/analysis.

The four dependent variables were used to assess self-reported mental health of participants. *Anxiety* was measured using self-reported responses to the General Anxiety Disorder 7 (GAD-7) scale [34], [35]. *Anxiety* for this study was used as a composite score, summing responses to seven items on the GAD-7 scale, scored from zero (not at all) to three (nearly every day). This score can then be grouped into severity of anxiety: 0-4 minimal anxiety, 5–9 mild anxiety, 10–14 moderate

anxiety, and 15–21 severe anxiety. *Depression* was measured using the Raw Patient Health Questionnaire score (0-27) from the Patient Health Questionnaire (PHQ) [36]–[38]. This score comes from totaling the score of nine items scaled zero (not at all) to three (nearly every day), asking participants at the time of the survey to reflect on the past two weeks as they pertain to depressive symptoms. The PHQ-9 score is grouped based on depressive symptom severity: 0-4 minimal depression, 5-9 mild depression, 10-14 moderate depression, 15-19 moderately severe depression, and 20-27 severe depression [38]. *Flourishing* was measured using the Psychological Well-Being scale given the intent to assess measures of positive mental health [39], [40]. This scale is created by totaling eight items, each with a total from one to seven (strongly disagree to strongly agree) for a cumulative range of 8 to 56. Unlike the previous instruments, this scale does not have categories; simply, the higher the reported composite number, the higher demonstrated positive mental health. *Suicidal ideation* was used to measure if the respondent has ever seriously considered suicide in the past year at the time of the survey using a dichotomous yes/no question.

Analytical Procedure
There were three stages of analysis completed: (1) obtaining descriptive statistics and central tendencies for each measure, (2) determining trends in the measures over the past three academic years, and (3) determining what relationships, if any, exist between the covariates and each outcome of interest. The remainder of this section details these three stages of analysis. As these results and methods build upon one another, the following section will present a brief overview of the procedure followed to generate the results with the Results section detailing the findings.

Descriptive Statistics The first step before analyzing the data was to explore the data by generating descriptive statistics and central tendency for each of the outcomes of interest and explanatory variables. To do so, we determined the range of values, mean, standard deviation, and variance for the measures, both for the individual academic years and collectively, as detailed in Table 4. Furthermore, given prior research discussing a potential relationship between certain demographics and reported mental health outcomes, we also provide a breakdown of the degree program, discipline, the outcomes of interest, and covariates by these demographics (i.e., gender, race, international student status, degree program, and discipline) for the complete 3,346 data responses for the aggregate data (i.e., 2018-21) in Table 5. It is important to note, however, that for this study, our goal was not to determine whether there were differences in the reported demographics, but rather to validate our use of these measures as demographic covariates in our regression models. Due to this, we did not perform t-tests to determine any difference in means, but rather included these measures as demographic covariates in our regression models.

Trends Over Past Three Academic Years To assess trends in the data over the 3 years, we ran an analysis to test whether there was a statistically significant difference in means via Welch's two-sided t-tests (using Equations 1a, 1b, and 1c). This was done as we did not want to assume directionality of the trends. A Welch's t-test was elected as the assumption of equal variances was not met for all measures (see Table 4). The t-tests were used to compare each academic year against the other two for each of the eight measures, or 24 t-tests. Results from these t-tests are detailed in Table 6.

$$\hat{\sigma}_{\bar{y}_1 - \bar{y}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} \ , \quad \hat{t} = \frac{(\bar{y}_1 - \bar{y}_2) - H_0}{\hat{\sigma}_{\bar{y}_1 - \bar{y}_2}} \ , \quad df_t = n_1 + n_2 - 2 \qquad \text{(1a, 1b, \& 1c)}$$

Additionally, as a two-sided t-test was used, we also calculated the difference in means for each t-test done to help show insight into the possible directionality of the difference. To do so, we subtracted the mean of the chronologically earlier academic year from the mean of the chronological later academic year (Equation 2).

$$difference\ in\ means < measure >_{Year2-Year1}\ = \overline{< measure >}_{Year2} - \overline{< measure >}_{Year1} \quad (2)$$

Relationships Between Outcomes of Interest and Covariates Following examining trends in the data, we then ran analysis to determine the relationships, if any, between the covariates and outcomes of interest using the aggregate data from 2018-2021, controlling for demographics. The reported value for the three interval outcomes of interest were used (i.e., depression, anxiety, and flourishing scale scores), with suicidal ideation being coded as dichotomous. The covariates and demographic measures were used in either categorical or dichotomous forms. As a result, four models were run, each focusing on a different outcome of interest (i.e., Model 1 for *anxiety*, Model 2 for *depression*, Model 3 for *flourishing*, and Model 4 for *suicidal ideation*), with the model type varying based on the outcome of interests' variable type.

For each model in this study, the baseline group was decided based on whatever response would be expected to strongly endorse the statement. For Model 1 (*anxiety*), Model 2 (*depression*), and Model 4 (*suicidal ideation*), this meant the option of "strongly disagree" was elected as the baseline as this option would be expected to be endorsed with higher levels of *depression*, *anxiety*, and *suicidal ideation.* As Model 3 dealt with *flourishing*, a metric of positive mental health, the option "strongly agree" was selected as the baseline as this would be the expected endorsement for someone experiencing a higher level of *flourishing*. In terms of the demographic variables, a White male domestic student in a science and mathematics master's program was elected as the baseline group (i.e., gender = male, race = White, international student = no, degree = master's, discipline = science and mathematics). The discipline and degree program were chosen arbitrarily as the variables were either dichotomous (degree) or close to it (discipline, a small portion of SEM graduate students in multiple disciplines). We acknowledge that these choices are arbitrary though previous analysis of older Health Minds Network data has used similar choices [41].

Before running any models, we first calculated the correlations between the nine covariates to determine if any were highly correlated, therefore breaking the assumption of independence in the measures. When looking first at the measures, there seemed to be some high correlations in the measures. However, once the covariates were broken down into their respective dummy variables, we saw that these higher correlations (i.e., above 0.4) were mostly present in response 6, or strongly agree (correlation tables Appendix B). Given this, we chose to keep the covariates as is and move forward with the models.

Models 1, 2, and 3 had outcomes of interests that were interval measures (i.e., *anxiety*, *depression*, and *flourishing* scores). As a result, ordinary least squares regression (i.e., multiple linear regression) models were estimated to understand the difference between the covariates and the respective outcomes of interest for each model. For each categorical covariate or demographic measure, each response option category was run as dummy dichotomous variables in the linear regression model, omitting the baseline option as detailed above. Equations 3a, 3b, and 3c detail the regression equations used for modeling against the covariates for outcomes of interest: *anxiety*,

$$\widehat{anxiety}_\iota = \; a + b_{CE2}(campus\ environment)_i + \cdots + \; b_{CE6}(campus\ environment)_i \hspace{2cm} (3a)$$
$$+ \, b_{ED2}(encouraging\ dialogue)_i + \cdots + \; b_{ED6}(encouraging\ dialogue)_i$$
$$+ \, b_{PMH2}(prioritizing\ mental\ health)_i + \cdots + \; b_{PMH6}(prioritizing\ mental\ health)_i$$
$$+ \, b_{RA2}(receptive\ administration)_i + \cdots + \; b_{RA6}(receptive\ administration)_i$$
$$+ \, b_{GEN1}(gender)_i + b_{GEN3}(gender)_i$$
$$+ \, b_{RACE1}(race)_i + \cdots + \; b_{RACE4}(race)_i + \; b_{RACE6}(race)_i$$
$$+ \, b_{INT1}(international\ student)_i$$
$$+ \, b_{DEG1}(degree)_i$$
$$+ \, b_{DISC2}(discipline)_i + b_{DISC3}(discipline)_i$$
$$+ \, error$$

$$\widehat{depression}_\iota = \; a + b_{CE2}(campus\ environment)_i + \cdots + \; b_{CE6}(campus\ environment)_i \hspace{2cm} (3b)$$
$$+ \, b_{ED2}(encouraging\ dialogue)_i + \cdots + \; b_{ED6}(encouraging\ dialogue)_i$$
$$+ \, b_{PMH2}(prioritizing\ mental\ health)_i + \cdots + \; b_{PMH6}(prioritizing\ mental\ health)_i$$
$$+ \, b_{RA2}(receptive\ administration)_i + \cdots + \; b_{RA6}(receptive\ administration)_i$$
$$+ \, b_{GEN1}(gender)_i + b_{GEN3}(gender)_i$$
$$+ \, b_{RACE1}(race)_i + \cdots + \; b_{RACE4}(race)_i + \; b_{RACE6}(race)_i$$
$$+ \, b_{INT1}(international\ student)_i$$
$$+ \, b_{DEG1}(degree)_i$$
$$+ \, b_{DISC2}(discipline)_i + b_{DISC3}(discipline)_i$$
$$+ \, error$$

$$\widehat{flourishing}_\iota = a + b_{CE1}(campus\ environment)_i + \cdots + \; b_{CE5}(campus\ environment)_i \hspace{2cm} (3c)$$
$$+ \, b_{ED1}(encouraging\ dialogue)_i + \cdots + \; b_{ED5}(encouraging\ dialogue)_i$$
$$+ \, b_{PMH1}(prioritizing\ mental\ health)_i + \cdots + \; b_{PMH5}(prioritizing\ mental\ health)_i$$
$$+ \, b_{RA1}(receptive\ administration)_i + \cdots + \; b_{RA5}(receptive\ administration)_i$$
$$+ \, b_{GEN1}(gender)_i + b_{GEN3}(gender)_i$$
$$+ \, b_{RACE1}(race)_i + \cdots + \; b_{RACE4}(race)_i + \; b_{RACE6}(race)_i$$
$$+ \, b_{INT1}(international\ student)_i$$
$$+ \, b_{DEG1}(degree)_i$$
$$+ \, b_{DISC2}(discipline)_i + b_{DISC3}(discipline)_i$$
$$+ \, error$$

depression, and *flourishing*, respectively.

In Model 4, the outcome of interest was whether the individual had experienced *suicidal ideation* in the past year, measured as a dichotomous variable. To assess this, a binomial logistic regression model (logit model) was used [42]–[44]. Probabilities are the basis for these models. The odds that an event occurring is calculated by figuring out the probability of an event occurring (p) and dividing this by (1-p), or the probability of the event *not* occurring (Equation 4). An example for this study would be the probability that an SEM graduate student experiences any level of *suicidal ideation* in the past year.

$$\text{odds} = \frac{p}{1-p} \hspace{4cm} (4)$$

A logit model is expressed as a linear combination of the independent (explanatory) variables, where a unit change in an independent variable is related to a change in the log-odds of the dependent variable (Equation 5).

$$\ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots \tag{5}$$

To interpret these results, we transform this equation of log-odds to be expressed in terms of off ratios (Equation 6).

$$\frac{p}{1-p} = e^\alpha + e^{\beta_1 x_1} + e^{\beta_2 x_2} + e^{\beta_3 x_3} + \cdots \tag{6}$$

The large benefit from doing this is that odds ratios are simpler to interpret. That is, an odds ratio less than one represents a decrease in the odds of an outcome relative to the baseline outcome and an odds ratio greater than one represents an increase in the odds of an outcome relative to the baseline outcome. For more information about logistic regression and how to interpret results in the context of discipline-based education research (DBER), we direct the reader to Theobald et al. [45].

Limitations
There are several limitations for this study. The first is that there is a possibility for a student to be represented up to three times. This is because students may have taken the survey in each offering as institutions may offer the survey more than once. However, we chose to include the data given the increase in responses across years, the use of randomized sampling at institutions (i.e., those with more than 4,000 students), and time between surveys and potential change in responses from individuals. Furthermore, there was no way for us to determine participant duplication or institution duplication without restricting the data to the final year, which was not desirable for this study.

The measures we used to assess mental health and program climate are also limitations. Because we used an existing survey instrument, we were unable to create questions tailored to the desired outcomes. For example, the question framing for the covariates ask students to reflect on their school. In this case, students could also be thinking about their school at large, their program, or a combination of both. For these instances, given that the graduate student population tends to spend a significant time inside their program while at school, this wording would have a non-significant impact.

Directly related to this is the second limitation, in that the Covid-19 pandemic's onset began and was in full-effect during the second and third academic years when data was being collected (i.e., 2019-2020, 2020-2021). This could mean that the differences found between academic years or increased severity in self-reported mental health concerns could be a result of the pandemic, not other factors. This would also be backed by existing work that has shown the rise of mental health problems amidst the pandemic in student populations [46]. However, we argue that the root causes of mental health problems are unlikely to change, with the pandemic serving to agitate and exacerbate these conditions as opposed to generating uniquely new mental health problems. Furthermore, we assume that in the state of the pandemic, it is unlikely that students experiencing severe mental health problems are likely to complete the survey for this study.

Related to both, because the data was anonymous, we were unable to conduct any longitudinal assessment of students and how their mental health may have been affected by the pandemic.

Having such data would allow us to determine if students are repeated in the data and if the measures included in this study showed variation before and after the pandemic.

Finally, because the survey is opt-in, there is likely response bias in who answers the survey. That is, those who experience mental health symptoms may be more likely to respond to a survey than those who experience no symptoms in the hopes that the inclusion of their data might lead to institutional change or improvements in support [47]. In addition, because students are asked about the previous year when answering the survey, bias can exist based on what students recall and how they interpret those events (see [48] for possible examples).

Findings
Descriptive Statistics
The descriptive statistics in Table 4 show that for SEM graduate students from 2018-2021, 43.8% reported minimal anxiety, 31.5% reported mild anxiety, 14.7% reported moderate anxiety, and 9.9% reported severe anxiety. The average anxiety score was 6.41, which coincides with mild anxiety. In terms of *depression*, 34.6% reported mild depression, 16.8% reported moderate depression, 8.2% reported moderately severe depression, and 4.5% reported severe depression. The average *depression* score was a 7.55, which coincides with mild depression. On the other hand, 35.9% reported no depression. SEM graduate students reported an average *flourishing* score of 43.01, which corresponds to an average score of 5.38 on the individual items, or between somewhat agree and agree. In terms of *suicidal ideation*, 8.5% of the population, or 285 SEM graduate students, reported having some form of suicidal ideation in over these three academic years. The covariates were used as proxies for program culture via questions on positive program climate (scale of strongly disagree to strongly agree). Students reported an average of 3.75 for *campus environment*, with the score being between somewhat disagree and somewhat agree. The other covariates had reported averages of 4.15 (*encouraging dialogue*), 4.04 (*prioritizing mental health*), and 4.05 (*receptive administration*), which corresponds to scores just above somewhat agree.

As detailed in Table 5, we found there to be some differences in the reported means of the outcomes of interest and covariates based on demographic measures of *gender*, *race*, and *international student status*. This table can provide more context on the study participants and provide validation of past existing literature for us to include these measures as demographic covariates in the regression models. Although no tests of significance were run, looking at the means it seems that for gender, females and neither females nor males have higher reported levels of *anxiety*, *depression*, and *suicidal ideation*, and lower levels of *flourishing*. Looking at race, students' identifying as multi-racial or other reported higher levels of *anxiety*, *depression*, and *suicidal ideation*, and lower levels of *flourishing* (outside of African American/Black students higher scores on reported *suicidal ideation*). For all outcomes of interest, international students reported lower scores than domestic students.

Trends Over Past Three Academic Years
The results from the t-tests in Table 6 include several statistically significant differences in means. Focusing first on comparing academic years 2018-19 to 2019-20, *anxiety, prioritizing mental health*, and *receptive administration* had a statistically significant difference in means, with each showing that these measures increased from 2018-19 to 2019-20. Looking at the

Table 4

Descriptive Statistics of Outcomes of Interest and Covariates

Measures	Range Min	Max	2018-2019 N (%)	Mean	Std. Dev.	Variance	2019-2020 N (%)	Mean	Std. Dev.	Variance	2020-2021 N (%)	Mean	Std. Dev.	Variance	2018-2021 N (%)	Mean	Std. Dev.	Variance
Outcomes																		
Anxiety	0	21	661 (100)	5.78	4.79	22.94	1,420 (100)	6.26	5.13	26.32	1,265 (100)	6.91	5.52	30.47	3,346 (100)	6.41	5.24	27.46
Minimal	0	4	315 (47.7)	-	-	-	635 (44.7)	-	-	-	517 (40.9)	-	-	-	1,467 (43.8)	-	-	-
Mild	5	9	212 (32.1)	-	-	-	451 (31.8)	-	-	-	392 (31.0)	-	-	-	1,055 (31.5)	-	-	-
Moderate	10	14	92 (13.9)	-	-	-	196 (13.8)	-	-	-	204 (16.1)	-	-	-	492 (14.7)	-	-	-
Severe	15	21	42 (6.4)	-	-	-	138 (9.7)	-	-	-	152 (12.0)	-	-	-	332 (9.9)	-	-	-
Depression	0	27	661 (100)	6.83	5.17	26.73	1,420 (100)	7.26	5.60	31.36	1,265 (100)	8.25	6.02	36.24	3,346 (100)	7.55	5.71	32.60
None	0	4	257 (38.9)	-	-	-	546 (38.5)	-	-	-	397 (31.4)	-	-	-	1,200 (35.9)	-	-	-
Mild	5	9	246 (37.2)	-	-	-	492 (34.6)	-	-	-	421 (33.3)	-	-	-	1,159 (34.6)	-	-	-
Moderate	10	14	99 (15.0)	-	-	-	209 (14.7)	-	-	-	254 (20.1)	-	-	-	562 (16.8)	-	-	-
Moderately Severe	15	19	42 (6.4)	-	-	-	115 (8.1)	-	-	-	118 (9.3)	-	-	-	275 (8.2)	-	-	-
Severe	20	27	17 (2.6)	-	-	-	58 (4.1)	-	-	-	75 (5.9)	-	-	-	150 (4.5)	-	-	-
Flourishing	8	56	661 (100)	43.73	8.59	73.79	1,420 (100)	43.16	8.77	76.91	1,265 (100)	42.47	9.08	82.45	3,346 (100)	43.01	8.86	78.50
Suicidal Ideation	0	1	661 (100)	0.083	0.28	0.08	1,420 (100)	0.09	0.29	0.08	1,265 (100)	0.081	0.27	0.07	3,346 (100)	0.085	0.28	0.08
Yes	1	1	55 (8.3)	-	-	-	128 (9.0)	-	-	-	102 (8.1)	-	-	-	285 (8.5)	-	-	-
Covariates																		
Campus Environment*	1	6	661 (100)	3.79	1.32	1.74	1,420 (100)	3.7	1.36	1.85	1,265 (100)	3.79	1.31	1.72	3,346 (100)	3.75	1.33	1.77
Encouraging Dialogue	1	6	661 (100)	4.23	1.04	1.08	1,420 (100)	4.14	1.17	1.37	1,265 (100)	4.12	1.20	1.44	3,346 (100)	4.15	1.16	1.35
Prioritizing Mental Health	1	6	661 (100)	4.16	1.11	1.23	1,420 (100)	4.00	1.24	1.54	1,265 (100)	4.00	1.22	1.49	3,346 (100)	4.04	1.21	1.46
Receptive Administration	1	6	661 (100)	4.24	1.1	1.21	1,420 (100)	4.01	1.26	1.59	1,265 (100)	3.99	1.28	1.64	3,346 (100)	4.05	1.24	1.54

Note: *Campus Environment* was reverse coded for this project and subsequent data analysis

Table 5

Detailed Descriptive Statistics by Selected Demographics for Study Sample (n=3,346)

Demographic Measures	Degree (n = 3,346) Master's	PhD	Discipline (n = 3,346) Science and Mathematics	Engineering	Multiple	Outcomes of Interest (Means) Anxiety	Depression	Flourishing	Suicidal Ideation	Campus Environment	Covariates (Means) Encouraging Dialogue	Prioritizing Mental Health	Receptive Administration
Gender													
Female	636	937	1005	540	28	7.13	8.12	43.13	0.091	3.74	4.09	3.97	3.98
Male	751	949	632	1010	58	5.64	6.88	43.06	0.072	3.80	4.24	4.14	4.15
Neither Female nor Male	27	46	51	18	4	8.93	10.77	39.27	0.274	2.97	3.30	3.12	3.16
Race													
African American/Black	56	65	71	46	4	5.75	7.14	44.79	0.140	3.80	4.36	4.23	4.26
Asian/Asian-American	474	600	327	717	30	5.86	7.08	42.64	0.071	4.03	4.42	4.34	4.37
Hispanic/Latino	53	119	111	56	5	6.73	7.65	44.13	0.052	3.86	3.96	3.89	3.91
Middle Eastern, Arab, or Arab American	28	94	42	76	4	6.80	7.52	42.30	0.066	3.75	4.14	4.00	4.10
White or Caucasian	719	915	1009	584	41	6.64	7.71	43.28	0.092	3.57	4.00	3.85	3.84
Multi-Racial or Other	84	139	128	89	6	7.28	8.81	41.39	0.108	3.65	3.99	3.94	4.00
International Student													
No	947	1148	1290	750	55	6.79	7.94	43.10	0.097	3.55	4.00	3.85	3.85
Yes	467	784	398	818	35	5.78	6.89	42.86	0.066	4.09	4.40	4.35	4.38

Note: The table presents the number of students in the *degree* or *discipline*, and then the average score for the selected demographics for each outcome of interest and covariate.

Table 6
T-tests for Measures Across Academic Years

Measures	2018-19 v 2019-20			2019-20 v 2020-21			2018-19 v 2020-21		
	Difference in Means	t	p-value	Difference in Means	t	p-value	Difference in Means	t	p-value
Outcomes									
Anxiety	0.48	2.086	0.0371*	0.65	3.173	<0.0001***	1.13	4.687	0.0015**
Depression	0.43	1.697	0.0900	0.99	4.425	<0.0001***	1.42	5.408	<0.0001***
Flourishing	-0.57	1.406	0.1600	-0.69	2.014	0.0441*	-1.26	3.016	0.0026**
Suicidal Ideation	0.007	0.527	0.5986	-0.009	0.881	0.3783	-0.002	0.195	0.8454
Covariates									
Campus Environment	-0.09	1.384	0.1667	0.09	1.787	0.0740	0.00	0.087	0.9310
Encouraging Dialogue	-0.09	1.854	0.0639	-0.02	0.243	0.8083	-0.11	2.008	0.0448*
Prioritizing Mental Health	-0.16	2.976	0.0030**	0.00	0.008	0.9940	-0.16	2.942	0.0033**
Receptive Adnimistration	-0.23	4.209	<0.0001***	-0.02	0.514	0.6076	-0.25	4.528	<0.0001***

Notes: ***p<0.001, ** p<0.01, *p<0.05; Difference in Means was calculated by following the equation: Year2 - Year1, with Year1 being the chronologically earlier academic year (e.g., for 2018-19 v 2019-20, the difference in means = 2019-20 mean - 2018-19 mean).

comparison of academic years 2019-20 to 2020-21, *anxiety*, *depression,* and *flourishing* had a statistically significant difference in means. For the difference in means, this shows a trend of increasing mental health problems (i.e., *anxiety* and *depression*) and decreasing in positive mental health (i.e., *flourishing*). The statistically significant difference in means found comparing 2018-19 to 2019-20 and 2019-20 to 2020-21 also held in the t-tests done comparing 2018-19 to 2020-21, with the same trends of increasing means for *anxiety* and *depression* and decreasing means for *flourishing*, *prioritizing mental health*, and *receptive administration*. In addition, the covariate *encouraging dialogue* also showed a statistically significant decrease between the years. The measures *suicidal ideation* and *campus environment* were the only two that seemed to fluctuate in non-statistically significant ways between the survey years.

Relationships Between Outcomes of Interest and Covariates
Tables 7 through 9 present the first, second, and third multiple regression models, which focus on predicting relationships with the outcomes of interest *anxiety*, *depression*, and *flourishing*, respectively. Each of these models were interpreted in terms of their standardized coefficients, beta. Table 10 presents the fourth logit model, which focuses on predicting the odds of self-reporting suicidal ideation. This model was interpreted based on the reported odds ratios, as discussed previously.

Model 1: Anxiety (Table 7) This model had several significant results. In terms of the covariates (i.e., *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration*), *prioritizing mental health* and *campus environment* had strong beta values, indicating the strongest relationship with the *anxiety* score. In addition, generally as the covariate responses went up the scale from "disagree" to "strongly agree", signaling increased agreement with positive indicators for climate, the beta values increased in negative magnitude (i.e., lower *anxiety* scores; outside of "strongly agree" which begins to reverse the trend). Also, once the strength of agreement for any of these covariates reached "somewhat agree," they had a significant influence on the resulting *anxiety* score. When looking at demographic covariates, compared to the baselines of being a White male domestic student in a science and mathematics master's program, there were statistically significant influences in the *anxiety* score for the demographics of gender (both female and neither male nor female), race (multi-racial or other), and discipline (engineering), with all but discipline having positive beta values.

Table 7

Model 1 Predicting Relationship with Anxiety (GAD-7) Score

	Raw Coefficient	Standard Error	t	p	beta
Disagree					
Campus Environment	-0.097	0.434	-0.224	0.8228	-0.006
Encouraging Dialogue	-1.066	0.649	-1.643	0.1004	-0.048
Prioritizing Mental Health	-1.755	0.590	-2.975	0.0029 **	-0.087
Receptive Administration	-0.318	0.540	-0.589	0.5561	-0.015
Somewhat Disagree					
Campus Environment	-0.893	0.421	-2.124	0.0337 *	-0.069
Encouraging Dialogue	-1.628	0.645	-2.526	0.0116 *	-0.107
Prioritizing Mental Health	-1.895	0.604	-3.137	0.0017 **	-0.130
Receptive Administration	-0.090	0.523	-0.173	0.8629	-0.006
Somewhat Agree					
Campus Environment	-1.388	0.416	-3.335	<0.001 ***	-0.119
Encouraging Dialogue	-2.360	0.639	-3.694	<0.001 ***	-0.215
Prioritizing Mental Health	-1.876	0.603	-3.110	0.0019 **	-0.172
Receptive Administration	-1.181	0.516	-2.289	0.0221 *	-0.107
Agree					
Campus Environment	-2.048	0.422	-4.855	<0.001 ***	-0.171
Encouraging Dialogue	-2.141	0.658	-3.254	0.0011 **	-0.192
Prioritizing Mental Health	-2.253	0.628	-3.588	<0.001 ***	-0.195
Receptive Administration	-2.014	0.542	-3.719	<0.001 ***	-0.179
Strongly Agree					
Campus Environment	-2.362	0.501	-4.716	<0.001 ***	-0.116
Encouraging Dialogue	-1.190	0.742	-1.604	0.1089	-0.065
Prioritizing Mental Health	-2.287	0.701	-3.263	<0.001 ***	-0.123
Receptive Administration	-2.445	0.638	-3.835	<0.001 ***	-0.130
Demographics					
Gender - Female	1.148	0.178	6.451	<0.001 ***	0.110
Gender - Neither Female nor Male	1.630	0.594	2.745	0.0061 **	0.045
Race - African American/Black	-0.268	0.466	-0.575	0.5655	-0.010
Race - Asian/Asian-American	0.238	0.264	0.903	0.3664	0.021
Race - Hispanic/Latino	0.267	0.398	0.670	0.5028	0.011
Race - Middle Eastern, Arab, or Arab American	0.814	0.478	1.702	0.0889	0.029
Race - Multi-Racial or Other	0.779	0.353	2.205	0.0275 *	0.037
International Student - Yes	0.062	0.247	0.249	0.8032	0.006
Degree - PhD	-0.135	0.179	-0.754	0.4511	-0.013
Discipline - Engineering	-0.589	0.191	-3.092	0.0020 **	-0.056
Discipline - Selected Multiple	-0.651	0.532	-1.224	0.2209	-0.020
Total Observations	3,346				
F-Value (3,345 DOF)	18.33				
R-Squared	0.1464				
Adjusted R-Squared	0.1384				

Notes: ***p<0.001, ** p<0.01, *p<0.05

Table 8

Model 2 Predicting Relationship with Depression (PH9) Score

	Raw Coefficient	Standard Error	t	p		beta
Disagree						
Campus Environment	-0.175	0.472	-0.370	0.7111		-0.010
Encouraging Dialogue	-1.520	0.706	-2.152	0.0315	*	-0.063
Prioritizing Mental Health	-0.579	0.642	-0.902	0.3671		-0.026
Receptive Administration	-0.557	0.587	-0.948	0.3430		-0.024
Somewhat Disagree						
Campus Environment	-1.369	0.458	-2.991	0.0028	**	-0.097
Encouraging Dialogue	-1.714	0.702	-2.443	0.0146	*	-0.103
Prioritizing Mental Health	-1.349	0.657	-2.052	0.0403	*	-0.085
Receptive Administration	-0.835	0.570	-1.466	0.1427		-0.051
Somewhat Agree						
Campus Environment	-1.691	0.453	-3.731	<0.001	***	-0.133
Encouraging Dialogue	-2.564	0.695	-3.687	<0.001	***	-0.215
Prioritizing Mental Health	-1.362	0.657	-2.075	0.0380	*	-0.114
Receptive Administration	-1.557	0.562	-2.772	0.0056	**	-0.130
Agree						
Campus Environment	-2.619	0.459	-5.703	<0.001	***	-0.201
Encouraging Dialogue	-2.567	0.716	-3.586	0.0003	***	-0.211
Prioritizing Mental Health	-1.844	0.684	-2.698	0.0070	**	-0.146
Receptive Administration	-2.300	0.590	-3.901	<0.001	***	-0.187
Strongly Agree						
Campus Environment	-2.828	0.545	-5.187	<0.001	***	-0.128
Encouraging Dialogue	-1.835	0.808	-2.272	0.0232	*	-0.092
Prioritizing Mental Health	-2.322	0.763	-3.042	0.0024	**	-0.114
Receptive Administration	-2.693	0.694	-3.880	<0.001	***	-0.131
Demographics						
Gender - Female	0.870	0.194	4.492	<0.001	***	0.076
Gender - Neither Female nor Male	1.877	0.646	2.904	0.0037	**	0.048
Race - African American/Black	0.171	0.508	0.336	0.7366		0.006
Race - Asian/Asian-American	0.620	0.287	2.157	0.0311	*	0.051
Race - Hispanic/Latino	0.203	0.434	0.468	0.6399		0.008
Race - Middle Eastern, Arab, or Arab American	0.650	0.520	1.249	0.2118		0.021
Race - Multi-Racial or Other	1.306	0.384	3.397	<0.001	***	0.057
International Student - Yes	-0.030	0.269	-0.111	0.9119		-0.003
Degree - PhD	-0.490	0.194	-2.521	0.0118	*	-0.042
Discipline - Engineering	-0.686	0.207	-3.305	<0.001	***	-0.060
Discipline - Selected Multiple	-0.581	0.579	-1.003	0.3162		-0.016
Total Observations	3,346					
F-Value (3,345 DOF)	18.72					
R-Squared	0.1490					
Adjusted R-Squared	0.1411					

Notes: ***p<0.001, ** p<0.01, *p<0.05

Table 9

Model 3 Predicting Relationship with Flourishing (Positive Mental Health) Score

	Raw Coefficien	Standard Error	t	p	beta
Strongly Disagree					
Campus Environment	-3.725	0.855	-4.359	<0.001 ***	-0.106
Encouraging Dialogue	-3.291	1.266	-2.600	0.0094 **	-0.066
Prioritizing Mental Health	-6.867	1.196	-5.740	<0.001 ***	-0.157
Receptive Administration	-1.527	1.088	-1.403	0.1606	-0.040
Disagree					
Campus Environment	-2.125	0.755	-2.813	0.0049 **	-0.077
Encouraging Dialogue	-2.786	1.005	-2.771	0.0056 **	-0.075
Prioritizing Mental Health	-3.539	0.958	-3.696	<0.001 ***	-0.104
Receptive Administration	-2.289	0.987	-2.319	0.0204 *	-0.062
Somewhat Disagree					
Campus Environment	-1.260	0.716	-1.759	0.0786	-0.057
Encouraging Dialogue	-2.860	0.852	-3.358	<0.001 ***	-0.111
Prioritizing Mental Health	-2.546	0.819	-3.109	0.0019 **	-0.103
Receptive Administration	-2.134	0.848	-2.517	0.0119 *	-0.084
Somewhat Agree					
Campus Environment	-1.797	0.687	-2.617	0.0089 **	-0.091
Encouraging Dialogue	-2.041	0.755	-2.703	0.0069 **	-0.110
Prioritizing Mental Health	-2.058	0.729	-2.823	0.0048 **	-0.111
Receptive Administration	-0.918	0.767	-1.197	0.2314	-0.049
Agree					
Campus Environment	0.130	0.661	0.196	0.8446	0.006
Encouraging Dialogue	-0.808	0.705	-1.146	0.2521	-0.043
Prioritizing Mental Health	-1.339	0.692	-1.935	0.0531	-0.068
Receptive Administration	-0.423	0.712	-0.595	0.5519	-0.022
Demographics					
Gender - Female	0.445	0.304	1.465	0.1430	0.025
Gender - Neither Female nor Male	-1.301	1.013	-1.285	0.1990	-0.021
Race - African American/Black	0.673	0.796	0.845	0.3980	0.014
Race - Asian/Asian-American	-1.645	0.450	-3.653	<0.001 ***	-0.087
Race - Hispanic/Latino	1.031	0.680	1.517	0.1293	0.026
Race - Middle Eastern, Arab, or Arab American	-1.122	0.816	-1.376	0.1690	-0.024
Race - Multi-Racial or Other	-1.835	0.603	-3.045	0.0023 **	-0.052
International Student - Yes	-0.846	0.422	-2.004	0.0452 *	-0.046
Degree - PhD	-0.480	0.305	-1.575	0.1154	-0.027
Discipline - Engineering	0.704	0.325	2.164	0.0305 *	0.040
Discipline - Selected Multiple	0.820	0.908	0.903	0.3667	0.015
Total Observations	3,346				
F-Value (3,345 DOF)	16.28				
R-Squared	0.1322				
Adjusted R-Squared	0.1240				

Notes: ***p<0.001, ** p<0.01, *p<0.05

Table 10

Model 4 Predicting Odds of Suicidal Ideation

	Raw Coefficient	Standard Error	Odds Ratio	Standard Error O.R.	z	p
Disagree						
Campus Environment	-0.176	0.255	0.839	0.214	-0.689	0.4906
Encouraging Dialogue	-0.319	0.355	0.727	0.258	-0.898	0.3694
Prioritizing Mental Health	-0.076	0.326	0.927	0.302	-0.232	0.8164
Receptive Administration	0.383	0.320	1.466	0.469	1.196	0.2318
Somewhat Disagree						
Campus Environment	-0.555	0.260	0.574	0.149	-2.134	0.0328 *
Encouraging Dialogue	-0.610	0.368	0.543	0.200	-1.661	0.0967
Prioritizing Mental Health	-0.443	0.356	0.642	0.228	-1.247	0.2124
Receptive Administration	0.335	0.334	1.397	0.467	1.000	0.3172
Somewhat Agree						
Campus Environment	-0.590	0.261	0.554	0.144	-2.267	0.0234 *
Encouraging Dialogue	-0.509	0.362	0.601	0.217	-1.408	0.1592
Prioritizing Mental Health	-0.535	0.357	0.585	0.209	-1.499	0.1339
Receptive Administration	0.304	0.332	1.355	0.450	0.915	0.3604
Agree						
Campus Environment	-0.883	0.279	0.414	0.115	-3.169	0.0015 **
Encouraging Dialogue	-0.463	0.385	0.629	0.242	-1.203	0.2292
Prioritizing Mental Health	-0.636	0.388	0.529	0.205	-1.639	0.1012
Receptive Administration	0.187	0.361	1.206	0.435	0.519	0.6035
Strongly Agree						
Campus Environment	-0.662	0.359	0.516	0.185	-1.841	0.0656
Encouraging Dialogue	-0.058	0.473	0.943	0.446	-0.123	0.9018
Prioritizing Mental Health	-0.860	0.481	0.423	0.203	-1.788	0.0737
Receptive Administration	-0.052	0.468	0.950	0.445	-0.110	0.9121
Demographics						
Gender - Female	0.148	0.136	1.159	0.158	1.084	0.2784
Gender - Neither Female nor Male	1.117	0.300	3.054	0.917	3.720	<0.001 ***
Race - African American/Black	0.648	0.287	1.911	0.549	2.254	0.0242 *
Race - Asian/Asian-American	0.099	0.197	1.104	0.217	0.502	0.6154
Race - Hispanic/Latino	-0.480	0.362	0.619	0.224	-1.327	0.1846
Race - Middle Eastern, Arab, or Arab American	-0.057	0.393	0.944	0.371	-0.146	0.8838
Race - Multi-Racial or Other	0.231	0.244	1.260	0.308	0.948	0.3432
International Student - Yes	-0.076	0.189	0.927	0.175	-0.403	0.6871
Degree - PhD	-0.203	0.134	0.816	0.109	-1.518	0.1290
Discipline - Engineering	-0.341	0.146	0.711	0.104	-2.335	0.0196 *
Discipline - Selected Multiple	0.046	0.365	1.047	0.382	0.125	0.9005
Total Observations	3,346					
Null Deviance (3345 DOF)	1,948.9					
Residual Deviance (3314 DOF)	1,845.2					
AIC/Psuedo R	1,909.2					

Notes: ***p<0.001, ** p<0.01, *p<0.05; O.R. = Odds Ratio

Model 2: Depression (Table 8) When looking at the covariates, *encouraging dialogue* had a statistically significant influence on the *depression* score for all responses. As with Model 1, there were statistically significant influences on the covariates for almost all response strengths, with all being significant once passing the "somewhat agree" threshold. These covariates followed a similar trend as with *anxiety*. That is, as students agreed more strongly with the covariates being positive indicators for climate, the beta values increased in negative magnitude (i.e., lower *depression* scores; outside of "strongly agree" which begins to reverse the trend). Looking again at the demographic covariates, compared to the baselines of being a White male domestic student in a science and mathematics masters' program, there were statistically significant influences in the *depression* score for the demographics of gender (both female and neither male nor female), race (Asian/Asian-American and multi-racial or other), degree (PhD), and discipline (engineering), with all but degree and discipline indicating positive beta values (degree and discipline had negative betas).

Model 3: Flourishing (Table 9) When taking into consideration that this model was indicative of increasing self-reported positive mental health compared to increasing mental health problems, this model seems to follow the trends of Models 1 and 2. That is, for responses "strongly disagree" to "somewhat agree," most covariates have a statistically significant influence on the *flourishing* score, with trends showing betas decreasing in negative magnitude. This means that as students agree more with indicators of positive climate, their respective *flourishing* score decreases less compared to the baseline of "strongly agree" (i.e., their *flourishing* scores went up as students agreed more with the positive climate measures). For individual covariates, *encouraging dialogue* and *prioritizing mental health* both had strong statistically significant influences on the *flourishing* scores across all responses while *campus environment* and *receptive administration* had a less consistent pattern. In terms of demographics, compared to the baselines of being a White male domestic student in a science and mathematics master's program, race (Asian/Asian-American and multi-racial or other), international student status (yes), and discipline (engineering) all had significant influences on the *flourishing* score, with all but degree indicating negative beta values (again, compared to the baseline of "strongly agree").

Model 4 Odds of Suicidal Ideation (Table 10) This table shows that when the covariate *campus climate* had an increase in agreement for positive climate (past disagree), there was a statistically significant decreased odds of self-reporting *suicidal ideation* in the past year. No other covariate was found to have statistically significant odds, although these trends were generally followed by the covariates *prioritizing mental health* and *receptive administration*. The trends for *encouraging dialogue*, again although not statistically significant, showed the reverse trend (i.e., increasing odds of self-reporting *suicidal ideation* in the past year). When looking at demographics, compared again to the baseline of being a White male domestic student in a science and mathematics master's program, having a gender of neither female nor male or being African American/Black had a statistically significant increased odds of self-reporting *suicidal ideation* in the past year, whereas being in engineering had a statistically significant decreased odds of self-reporting *suicidal ideation* in the past year.

Discussion
Looking back at the research questions guiding this study, there were two goals in mind. The

first was to determine how the mental health of SEM graduate students has changed over the past three academic years. The second goal was to investigate the roles of *campus environment*, *encouraging dialogue*, *prioritizing mental health*, and *receptive administration* on the self-reported mental health measures of *anxiety*, *depression*, *flourishing*, and *suicidal ideation* when accounting for the demographics of *gender*, *race*, *international student status*, *degree*, and *discipline*.

The descriptive statistics and t-test results presented in Tables 4, 5, and 6 achieve our first goal. These findings show that mental health problems are on the rise (i.e., *anxiety* and *depression* increasing with *flourishing decreasing*). It is important though to consider the practical implications of these increases. For example, the *anxiety* and *depression* scores are increasing by an average of 1.13 and 1.42 points, respectively. Although these may seem small, this data is supported by other researchers who have reported increased mental health problems among student populations in recent years [4], [46]. Although a 1.13- or 1.42-point increase in these scores may seem minimal, the growing trend depicts an average shift from a diagnosis of mild symptomology to moderate symptomatology. This could happen for one of two reasons. Either individuals experiencing mental health problems are having their symptoms exacerbated such that they are now reporting higher levels of these measures, or there are more people reporting these mental health problems. Both are likely causes. Furthermore, although there has not been statistically significant difference in *suicidal ideation* between the years, 8.5% of this population reporting suicidal ideation is almost double that of Americans 18 or older [2], [3]. Finally, Table 5 details potentially significant trends in differences for mental health measures by various demographics. Although only counts and means were presented, these results show differences in these measures that exist for subsets of interest. Unfortunately, given the small number of responses we were unable to provide data for intersections of demographics (e.g. African American/Black domestic males).

Our second goal was met through our regression analysis. For *anxiety* and *depression,* we saw that three of the explanatory covariates had a statistically significant relationship with a decrease in mental health problems and therefore less severe reporting of *anxiety* and *depression* (*encouraging dialogue* only statistically significant with depression). For anxiety, c*ampus environment* and *prioritizing mental health* had strong relationships, whereas with *depression*, *encouraging dialogue* had the strongest relationship. On the other hand, with the *flourishing* score we saw this by the explanatory covariates having a statistically significant relationship with increasing positive mental health scores, and therefore increase *flourishing* scores. For this measure, *encouraging dialogue* and *prioritizing mental health* were the stronger influences on the *flourishing* score. When considering *suicidal ideation*, it seemed that students reporting outside of the extremes for *campus environment* led to a decreased odds in suicidal ideation. These trends were also seen in *encouraging dialogue*, *prioritizing mental health*, and *receptive administration*, although not statistically significant.

In terms of demographic covariates for the first three models, all were found to have an impact on the mental health measures. *Gender*, *race*, and *discipline*, however, had a consistent impact on these measures, with general trends showing that *females*, *neither males nor females*, *Asian/Asian-Americans*, *multi-racial or other races*, and those in *science and mathematics disciplines* all had higher scores for measures of mental health problems (and conversely lower

scores for positive mental health) compared to white male domestic students in an engineering program. When looking at *international students*, the only statistically significant trend was a lowered flourishing score compared to domestic students.

These results do show that the culture of SEM programs has an influence on SEM graduate students' self-reported mental health in which students' endorsement of positive program climate measures results in a decreased severity of mental health problems (*i.e., anxiety*, *depression*, and *suicidal ideation)* and increased scores for positive mental health (i.e., *flourishing*).

Conclusions and Future Work

Taken in a large context, our results suggest that SEM graduate student mental health is not improving, and that the institutional and SEM program culture has a role to play in that. As researchers, we play a role in creating and maintaining that culture. We are expected to observe the principle of beneficence and secure the wellbeing of our research participants, yet, there's no reason our obligation to securing wellbeing should not also extend to those in our labs, departments, and field.

However, much work remains to be done. As said in the recent NASEM report, "[T]he research on wellbeing and mental health for graduate students remains limited in comparison to undergraduate students … effective support for graduate students would benefit from increased research and program evaluation" [4, p. 83]. We as a research community need to further examine the role our institutions and their cultures play in influencing graduate student mental health as well as how institutions can use their power, influence, and resources to ensure all graduate students have a positive experience.

To guide this process, we suggest several areas of future work. First, researchers can examine how institutional and departmental characteristics might influence climate and hence, mental health outcome measures. While Posselt presents results by institution and includes perception of competitiveness in her analysis, she also calls for measures of observational competitiveness and support [41]. In this case, considering perceptions and rankings of institutions might provide a useful avenue for understanding larger trends in how institutions may affect students' mental health. For example, characterizing the institutions by their Carnegie Classification or research output could provide useful information about the expectations placed on students. In addition, for studies that focus on specific disciplines, discipline specific rankings or measures of the department could be used to provide additional contextual information that might influence the mental health of their students (e.g., the completion rate of the program, the size and prestige of the program, and stipend and employment benefits information). Finally, this work did not include a central part of the student experience for graduate students: their advisor and the relationship that exists. There is an abundance of literature discussing the importance of this relationship [25], [49]–[52]. Work exploring the advisor's role in socializing and indoctrinating their graduate students into their discipline and the role of power dynamics in play and their effects on SEM graduate students' mental health would expand these findings.

Thinking more on this study, we could also reconsider how best to handle missing data to ensure our results are generalizable but also robust. In our study, we removed participants who did not complete all questions of interest given their relatively low numbers. However, a reasonable

alternative approach could be to impute the missing data [53], [54]. Yet, for some items with many of the students not responding (e.g., GPA in Posselt's study), such approaches might not be valid or useful. Future work should therefore focus on how best to analyze such data given the increased interest in studying student mental health. As other discipline-based education researchers have noted, we make ontological assumptions and epistemological commitments based on the approach we take to analyze our data and answer our questions and differing commitments and assumptions might lead to different analysis approaches and questions [55]. How those may affect the results we find should be further explored.

In addition, future work can examine alternative methods of analysis and provide best practices going forward around analyzing data from this annual data set. For example, when analyzing outcome measures such as *depression*, *anxiety*, *flourishing*, etc., how best should be model them? Should we use linear regression approaches on the value itself as we have done here for some of the measures, should we consider categories like minimal, mild, moderate, severe, or use a binary outcome measure (positive/negative screen)? Having an agreed upon analysis and data handling approach will allow results from different studies to be compared easily.

Finally, there are other considerations researchers can take to greatly expand these results. First, considering quantitative methods, researchers can conduct a longitudinal study on SEM graduate students' mental health using stratified sampling techniques. This would allow for us to see how students' mental health changes as they progress through their program, opening possible analysis for contextual factors and concerns SEM graduate students' face (e.g., milestone of candidacy, intentions to persist and possible attrition, etc.). Use of stratified sampling techniques would allow for more intentional recruitment of minoritized SEM graduate students, which would then allow for a richer analysis to be completed. However, along the same vein, researchers should also expand their methodological framing to include qualitative and mixed-methods research in this area (e.g., using mixed methods to develop targeted surveys as in [56]). Leveraging the richness found in qualitative research can provide insight into findings that survey data is not capable of providing, both due to its intent as well as the reality of there being small sample sizes for these minority populations.

References

[1] S. K. Lipson, E. G. Lattie, and D. Eisenberg, "Increased rates of mental health service utilization by U.S. College students: 10-year population-level trends (2007-2017)," *Psychiatric Services*, vol. 70, no. 1, pp. 60–63, 2019, doi: 10.1176/appi.ps.201800332.

[2] Substance Abuse and Mental Health Services Administration, "Results from the 2019 National Survey on Drug Use and Health," 2020. [Online]. Available: https://www.samhsa.gov/data/external

[3] U.S. Department of Commerce, "National Population by Characteristics: 2010-2019", [Online]. Available: https://www.census.gov/data/tables/time-series/demo/popest/2010s-national-detail.html

[4] NASEM, "Mental Health, Substance Use, and Wellbeing in Higher Education: Supporting the Whole Student," Washington, DC: The National Academies Press., 2021. doi: 10.17226/26015.

[5] P. Leviness, K. Gorman, L. Braun, and L. Koenig, "The Association for University and College Counseling Center Directors Annual Survey: 2019," 2019. [Online]. Available: https://www.medican-health.com/wp-content/uploads/2021/03/201920AUCCCD20Survey-2020-05-31-PUBLIC.pdf

[6] P. LeViness, C. Bershad, K. Gorman, L. Braun, and T. Murray, "The Association for University and College Counseling Center Directors Annual Survey: 2017," 2017. [Online]. Available: http://files.cmcglobal.com/AUCCCD_2013_Monograph_Public.pdf

[7] J. Hunt and D. Eisenberg, "Mental Health Problems and Help-Seeking Behavior Among College Students," *Journal of Adolescent Health*, vol. 46, no. 1, pp. 3–10, 2010, doi: 10.1016/j.jadohealth.2009.08.008.

[8] J. Hefner and D. Eisenberg, "Social Support and Mental Health Among College Students," *American Journal of Orthopsychiatry*, vol. 79, no. 4, pp. 491–499, 2009, doi: 10.1037/a0016918.

[9] T. M. Evans, L. Bira, J. B. Gastelum, T. Weiss, and N. L. Vanderford, "Evidence for a mental health crisis in graduate education," *NATURE BIOTECHNOLOGY*, vol. 36, 2018, Accessed: Nov. 01, 2021. [Online]. Available: http://ga.berkeley.

[10] T. W. Wyatt and S. B. Oswalt, "Comparing mental health issues among undergraduate and graduate students," *American Journal of Health Education*, vol. 44, no. 2, pp. 96–107, 2013, doi: 10.1080/19325037.2013.764248.

[11] J. K. Hyun, B. C. Quinn, T. Madon, and S. Lustig, "Graduate Student Mental Health: Needs Assessment and Utilization of Counseling Services," *Development*, vol. 47, no. 3, p. 36, doi: 10.1353/csd.2006.0030.

[12] K. Levecque, F. Anseel, A. de Beuckelaer, J. van der Heyden, and L. Gisle, "Work organization and mental health problems in PhD students," *Research Policy*, vol. 46, no. 4, pp. 868–879, 2017, doi: 10.1016/j.respol.2017.02.008.

[13] The Healthy Minds Network, "The Healthy Minds Study - Student Survey," 2022. https://healthymindsnetwork.org/hms/

[14] D. M. Fergusson, G. F. H. McLeod, L. J. Horwood, N. R. Swain, S. Chapple, and R. Poulton, "Life satisfaction and mental health problems (18 to 35 years)," *Psychological Medicine*, vol. 45, no. 11, pp. 2427–2436, May 2015, doi: 10.1017/S0033291715000422.

[15] P. E. Jenkins, I. Ducker, R. Gooding, M. James, and E. Rutter-Eley, "Anxiety and depression in a sample of UK college students: a study of prevalence, comorbidity, and

quality of life," *Journal of American College Health*, pp. 1–7, 2020, doi: 10.1080/07448481.2019.1709474.

[16] D. Eisenberg, E. Golberstein, and J. B. Hunt, "Mental health and academic success in college," *The BE Journal of Economic Analysis & Policy*, vol. 9, no. 1, 2009, doi: 10.2202/1935-1682.2191.

[17] J. L. Tanner, "Mental Health in Emerging Adulthood," 2015. doi: 10.1093/oxfordhb/9780199795574.013.30.

[18] V. M. Dotson, S. M. Resnick, and A. B. Zonderman, "Differential association of concurrent, baseline, and average depressive symptoms with cognitive decline in older adults," *American Journal of Geriatric Psychiatry*, vol. 16, no. 4, pp. 318–330, 2008, doi: 10.1097/JGP.0b013e3181662a9c.

[19] E. J. Laukka, D. Dykiert, M. Allerhand, J. M. Starr, and I. J. Deary, "Effects of between-person differences and within-person changes in symptoms of anxiety and depression on older age cognitive performance," *Psychological Medicine*, vol. 48, no. 8, pp. 1350–1358, 2018, doi: 10.1017/S0033291717002896.

[20] P. L. Rock, J. Roiser, W. J. Riedel, and A. Blackwell, "Cognitive impairment in depression: a systematic review and meta-analysis," *Psychol Med*, vol. 44, no. 10, pp. 2029–2040, 2014, doi: 10.1017/S0033291713002535.

[21] National Alliance on Mental Illness (NAMI), "College Students Speak: A Survey Report on Mental Health.," 2012. [Online]. Available: https://www.nami.org/getattachment/About-NAMI/Publications-Reports/Survey-Reports/College-Students-Speak_A-Survey-Report-on-Mental-Health-NAMI-2012.pdf

[22] H. Anttila, S. Lindblom-Ylänne, K. Lonka, and K. Pyhältö, "The Added Value of a PhD in Medicine - PhD Students' Perceptions of Acquired Competences," *International Journal of Higher Education*, vol. 4, no. 2, 2015, doi: 10.5430/ijhe.v4n2p172.

[23] M. Schmidt and E. Hansson, "Doctoral students' well-being: a literature review.," *Int J Qual Stud Health Well-being*, vol. 13, no. 1, p. 1508171, Dec. 2018, doi: 10.1080/17482631.2018.1508171.

[24] C. G. P. Berdanier, C. Whitehair, A. Kirn, and D. Satterfield, "Analysis of social media forums to elicit narratives of graduate engineering student attrition," *Journal of Engineering Education*, vol. 109, no. 1, pp. 125–147, Jan. 2020, doi: 10.1002/JEE.20299.

[25] S. J. Bork and J.-L. Mondisa, "A Scoping Literature Review of Engineering Graduate Students' Mental Health.," *Journal of Engineering Education*, 2020.

[26] E. A. Erichsen and D. U. Bolliger, "Towards understanding international graduate student isolation in traditional and online environments," *Educational Technology Research and Development*, vol. 59, no. 3, pp. 309–326, Jun. 2011, doi: 10.1007/S11423-010-9161-6.

[27] K. Crenshaw, "Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory, and antiracist politics," *The University of Chicago Legal Forum*, pp. 139–168, 1989, doi: 10.4324/9780429500480-5.

[28] I. Villanueva, L. Gelles, K. Youmans, and M. di Stefano, "Hidden curriculum awareness: A comparison of engineering faculty, graduate students, and undergraduates," *World Engineering Education Forum*, pp. 1–6, 2018, [Online]. Available: https://digitalcommons.usu.edu/ete_facpub/242/

[29] I. Villanueva *et al.*, "What Does hidden curriculum in engineering look like and how can it be explored?," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 2018-June, 2018, doi: 10.18260/1-2--31234.

[30] C. Zongrone, C. McCall, M. Paretti, A. Shew, D. Simmons, and L. McNair, "'I'm Looking at You, You're a Perfectly Good Person': Describing Non-Apparent Disability in Engineering," 2021. Accessed: Nov. 08, 2021. [Online]. Available: https://peer.asee.org/i-m-looking-at-you-you-re-a-perfectly-good-person-describing-non-apparent-disability-in-engineering

[31] The Healthy Minds Network (HMN), "The Healthy Minds Study: 2021 Winter/Spring Data Report," 2021. [Online]. Available: https://healthymindsnetwork.org/wp-content/uploads/2021/09/HMS_national_winter_2021.pdf

[32] R. T. Teranishi, "Race, ethnicity, and higher education policy: The use of critical quantitative research," *New Directions for Institutional Research*, vol. 2007, no. 133, pp. 37–49, 2007.

[33] D. Shafer, M. S. Mahmood, and T. Stelzer, "Impact of broad categorization on statistical results: How underrepresented minority designation can mask the struggles of both Asian American and African American students," *Physical Review Physics Education Research*, vol. 17, no. 1, p. 10113, Mar. 2021, doi: 10.1103/PhysRevPhysEducRes.17.010113.

[34] R. L. Spitzer, K. Kroenke, J. B. W. Williams, and B. Löwe, "A brief measure for assessing generalized anxiety disorder: The GAD-7," *Archives of Internal Medicine*, vol. 166, no. 10, pp. 1092–1097, 2006, doi: 10.1001/archinte.166.10.1092.

[35] R. L. Spitzer, J. B. W. Williams, and K. Kroenke, "GAD-7 Anxiety." https://adaa.org/sites/default/files/GAD-7_Anxiety-updated_0.pdf

[36] K. Kroenke, R. L. Spitzer, and J. B. W. Williams, "The PHQ-9.pdf," *Journal of General Internal Medicine*, vol. 16, pp. 606–613, 2001.

[37] R. L. Spitzer, K. Kroenke, J. B. Williams, and Patient Health Questionnaire Primary Care Study Group, "Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study," *Jama*, vol. 282, no. 18, pp. 1737–1744, 1999, doi: 10.1001/jama.282.18.1737.

[38] Pfizer Inc., "Patient Health Questionnaire (PHQ-9)," 1999. https://med.stanford.edu/fastlab/research/imapp/msrs/_jcr_content/main/accordion/accordion_content3/download_256324296/file.res/PHQ9 id date 08.03.pdf

[39] E. Diener *et al.*, "New Measures of Well-Being," *Social Indicators Research Series*, vol. 39, 2009, doi: 10.1007/978-90-481-2354-4.

[40] S. Oishi and R. Biswas-Diener, "New Measures of Well-Being When examining the standard scales for assessing well-being, we were impressed with the need for measurement scales in several domains-positive and negative feelings, positive thinking, and a brief scale of psychological well-being (PWB)," *Social Indicators Research Series*, vol. 39, 2009, doi: 10.1007/978-90-481-2354-4.

[41] J. Posselt, "Discrimination, competitiveness, and support in US graduate student mental health," *Studies in Graduate and Postdoctoral Education*, vol. 12, no. 1, pp. 89–112, 2021, doi: 10.1108/SGPE-07-2020-0042.

[42] S. J. Bork and J.-L. Mondisa, "Science, Engineering, and Mathematics Graduate Student Mental Health: Insights from the Healthy Minds Network Dataset." doi: 10.18260/1-2--33255.

[43] T. S. Henderson, "Exploring the post-graduation benefits of high-impact practices in engineering: Implications for retention and advancement in industry," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 2017-June, 2017.

[44] T. S. Henderson, K. A. Shoemaker, P. Ed-, and L. Lattuca, "Early-career Plans in Engineering : Insights from the Theory of Planned Be- havior Early Career Plans in Engineering : Insights from the Theory of".

[45] E. J. Theobald, M. Aikens, S. Eddy, and H. Jordt, "Beyond linear regression: A reference for analyzing common data types in discipline based education research," *Physical Review Physics Education Research*, vol. 15, no. 2, p. 20110, Jun. 2019, doi: 10.1103/PhysRevPhysEducRes.15.020110.

[46] T. Healthy Minds Network & American College Health Association, "The Impact of COVID-19 on College Student Wellbeing," 2020. [Online]. Available: https://healthymindsnetwork.org/wp-content/uploads/2020/07/Healthy_Minds_NCHA_COVID_Survey_Report_FINAL.pdf

[47] R. Telford and A. Faulkner, "Learning about service user involvement in mental health research," *Journal of Mental Health*, vol. 13, no. 6, pp. 549–559, Feb. 2004, doi: 10.1080/09638230400017137.

[48] A. Durayappah, "The 3P Model: A General Theory of Subjective Well-Being," *Journal of Happiness Studies*, vol. 12, no. 4, pp. 681–716, Feb. 2011, doi: 10.1007/s10902-010-9223-9.

[49] M. J. Amon, "Looking through the glass ceiling: A qualitative study of STEM women's career narratives," *Frontiers in Psychology*, vol. 8, no. FEB, 2017, doi: 10.3389/fpsyg.2017.00236.

[50] B. A. Burt, K. L. Williams, and W. A. Smith, "Into the Storm: Ecological and Sociological Impediments to Black Males' Persistence in Engineering Graduate Programs," *American Educational Research Journal*, vol. 55, no. 5, pp. 965–1006, 2018, doi: 10.3102/0002831218763587.

[51] J. Posselt, "Normalizing Struggle: Dimensions of Faculty Support for Doctoral Students and Implications for Persistence and Well-Being," *Journal of Higher Education*, vol. 89, no. 6, pp. 988–1013, 2018, doi: 10.1080/00221546.2018.1449080.

[52] K. G. Rice *et al.*, "International Student Perspectives on Graduate Advising Relationships," *Journal of Counseling Psychology*, vol. 56, no. 3, pp. 376–391, 2009, doi: 10.1037/a0015905.

[53] M. Pampaka, G. Hutcheson, and J. Williams, "Handling missing data: analysis of a challenging data set using multiple imputation," *International Journal of Research & Method in Education*, vol. 39, no. 1, pp. 19–37, Feb. 2016, doi: 10.1080/1743727X.2014.979146.

[54] J. Nissen, R. Donatello, and B. van Dusen, "Missing data and bias in physics education research: A case for using multiple imputation," *Physical Review Physics Education Research*, vol. 15, no. 2, p. 20106, Feb. 2019, doi: 10.1103/PhysRevPhysEducRes.15.020106.

[55] L. Ding, "Theoretical perspectives of quantitative physics education research," *Physical Review Physics Education Research*, vol. 15, no. 2, p. 20101, Jun. 2019, doi: 10.1103/PhysRevPhysEducRes.15.020101.

[56] E. Crede and M. Borrego, "From Ethnography to Items: A Mixed Methods Approach to Developing a Survey to Examine Graduate Engineering Student Retention," *Journal of Mixed Methods Research*, vol. 7, no. 1, pp. 62–80, 2013, doi: 10.1177/1558689812451792.

[57] Healthy Minds Network (2022). *Healthy Minds Study among Colleges and Universities, year (2018-19, 2019-20, & 2020-21)* [Data sets]. Healthy Minds Network, University of Michigan, University of California Los Angeles, Boston University, and Wayne State University. https://healthymindsnetwork.org/reserach/data-for-researchers.

Appendix A

Detailed Survey Items for Measures of Anxiety, Depression, and Flourishing

GAD-7 Anxiety

Over the last two weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid, as if something awful might happen	0	1	2	3

Column totals _____ + _____ + _____ + _____ =

Total score _____

If you checked any problems, how difficult have they made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all ☐   Somewhat difficult ☐   Very difficult ☐   Extremely difficult ☐

Figure A1: Screenshot of full GAD-7 [34], [35].

Over the last 2 weeks, how often have you been bothered by any of the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

(For office coding: Total Score _____ = _____ + _____ + _____)

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all ☐   Somewhat difficult ☐   Very difficult ☐   Extremely difficult ☐

Figure A2: Screenshot of full PHQ-9 from [36]–[38].

Below are 8 statements with which you may agree or disagree. Using the 1–7 scale below, indicate your agreement with each item by indicating that response for each statement.

7 Strongly agree
6 Agree
5 Slightly agree
4 Mixed or neither agree nor disagree
3 Slightly disagree
2 Disagree
1 Strongly disagree

    I lead a purposeful and meaningful life.
    My social relationships are supportive and rewarding.
    I am engaged and interested in my daily activities
    I actively contribute to the happiness and well-being of others
    I am competent and capable in the activities that are important to me
    I am a good person and live a good life
    I am optimistic about my future
    People respect me

Scoring: Add the responses, varying from 1 to 7, for all eight items. The possible range of scores is from 8 (lowest possible) to 56 (highest PWB possible). A high score represents a person with many psychological resources and strengths.

Figure A3: Screenshot of full Psychological Well-Being Scale (PWB) [39], [40].

Appendix B

Correlation Matrices for all Measures and for Detailed Covariates (demographics included)

	Measures	Anxiety	Depression	Flourishing	Suicidal Ideation	Campus Environment	Encouraging Dialogue	Prioritizing Mental Health	Receptive Administration	Gender - Female	Gender - Male	Gender - Neither Female nor Male	Race: African American/Black	Race: Asian/Asian-American	Race: Hispanic/Latino	Race: Middle Eastern, Arab, or Arab American	Race: White or Caucasian	Race: Multi-Racial or Other	International Student (No=0; Yes=1)	Degree (Master's=0; PhD=1)	Discipline: Science and Mathematics	Discipline: Engineering	Discipline: Selected Multiple Disciplines
Outcomes	Anxiety	1.00	0.75	-0.40	0.28	-0.26	-0.26	-0.27	-0.30	0.13	-0.15	0.07	-0.02	-0.07	0.01	0.01	0.04	0.04	-0.09	0.04	0.11	-0.11	0.00
	Depression		1.00	-0.53	0.36	-0.28	-0.28	-0.29	-0.30	0.09	-0.12	0.08	-0.01	-0.06	0.00	0.00	0.03	0.06	-0.09	0.01	0.10	-0.10	0.01
	Flourishing			1.00	-0.29	0.23	0.28	0.29	0.27	0.01	0.01	-0.06	0.04	-0.03	0.03	-0.02	0.03	-0.05	-0.01	-0.07	-0.04	0.04	-0.02
	Suicidal Ideation				1.00	-0.11	-0.10	-0.12	-0.10	0.02	-0.05	0.10	0.04	-0.03	-0.03	-0.01	0.02	0.02	-0.05	-0.01	0.06	-0.06	0.02
Covariates	Campus Environment					1.00	0.41	0.46	0.46	-0.01	0.04	-0.09	0.01	0.14	0.02	0.00	-0.13	-0.02	0.20	-0.07	-0.07	0.08	-0.04
	Encouraging Dialogue						1.00	0.71	0.69	-0.05	0.08	-0.11	0.03	0.16	-0.04	0.00	-0.13	-0.04	0.17	-0.08	-0.08	0.10	-0.06
	Prioritizing Mental Health							1.00	0.70	-0.05	0.09	-0.11	0.03	0.18	-0.03	-0.01	-0.15	-0.02	0.20	-0.09	-0.08	0.10	-0.04
	Receptive Administration								1.00	-0.05	0.08	-0.11	0.03	0.18	-0.03	0.01	-0.16	-0.01	0.21	-0.10	-0.09	0.11	-0.06
	Gender - Female									1.00	-0.96	-0.14	-0.02	-0.07	0.02	-0.02	0.07	-0.01	-0.14	0.03	0.25	-0.24	-0.05
	Gender - Male										1.00	-0.15	0.01	0.09	-0.02	0.03	-0.08	-0.01	0.16	-0.04	-0.27	0.26	0.05
	Gender - Neither Female nor Male											1.00	0.00	-0.05	-0.01	-0.03	0.04	0.05	-0.09	0.02	0.06	-0.07	0.03
	Race: African American/Black												1.00	-0.13	-0.05	-0.04	-0.19	-0.05	0.00	-0.02	0.03	-0.03	0.01
	Race: Asian/Asian-American													1.00	-0.16	-0.13	-0.67	-0.18	0.63	-0.03	-0.28	0.27	0.00
	Race: Hispanic/Latino														1.00	-0.05	-0.23	-0.06	0.00	0.05	0.07	-0.07	0.00
	Race: Middle Eastern, Arab, or Arab American															1.00	-0.19	-0.05	0.10	0.08	-0.06	0.06	0.01
Demographics	Race: White or Caucasian																1.00	-0.26	-0.61	-0.03	0.22	-0.22	-0.01
	Race: Multi-Racial or Other																	1.00	-0.04	0.02	0.04	-0.04	0.00
	International Student (No=0; Yes=1)																		1.00	0.08	-0.29	0.29	0.01
	Degree (Master's=0; PhD=1)																			1.00	0.18	-0.21	0.07
	Discipline: Science and Mathematics																				1.00	-0.95	-0.17
	Discipline: Engineering																					1.00	-0.16
	Discipline: Selected Multiple Disciplines																						1.00

Figure B1

Correlation Matrix Between All Measures

Figure B2 — Correlation Matrix for All Covariates (Detailed)

Column key (38 measures, in order):
- Campus Environment 1–6 = CE1…CE6
- Encouraging Dialogue 1–6 (labeled "Campus Environment") = ED1…ED6
- Prioritizing Mental Health 1–6 = PMH1…PMH6
- Receptive Administration 1–6 = RA1…RA6
- GF = Gender – Female; GM = Gender – Male; GN = Gender – Neither Female nor Male
- AfAm = Race: African American/Black; Asn = Race: Asian/Asian-American; His = Race: Hispanic/Latino; ME = Race: Middle Eastern, Arab, or Arab American; Wht = Race: White or Caucasian; MR = Race: Multi-Racial or Other
- Intl = International Student (No=0; Yes=1); Deg = Degree (Master's=0; PhD=1)
- SciM = Discipline: Science and Mathematics; Eng = Discipline: Engineering; Mult = Discipline: Selected Multiple Disciplines

Measure	CE1	CE2	CE3	CE4	CE5	CE6	ED1	ED2	ED3	ED4	ED5	ED6	PMH1	PMH2	PMH3	PMH4	PMH5	PMH6	RA1	RA2	RA3	RA4	RA5	RA6	GF	GM	GN	AfAm	Asn	His	ME	Wht	MR	Intl	Deg	SciM	Eng	Mult
Campus Environment 1	1.00	-0.10	-0.14	-0.17	-0.16	-0.08	0.34	0.12	0.02	-0.09	-0.13	0.03	0.41	0.15	-0.01	-0.14	-0.14	0.04	0.37	0.11	0.00	-0.12	-0.15	0.05	0.00	-0.01	0.05	-0.01	-0.06	-0.01	0.01	0.06	-0.04	-0.08	0.02	0.02	-0.03	0.02
Campus Environment 2		1.00	-0.19	-0.23	-0.22	-0.10	0.04	0.11	0.07	-0.08	0.00	-0.08	0.06	0.17	0.05	-0.10	-0.02	-0.06	0.15	0.06	-0.11	0.00	-0.08	-0.03	0.01	0.07	0.02	-0.02	-0.07	-0.02	-0.02	0.08	0.01	-0.09	0.04	0.00	-0.01	-0.02
Campus Environment 3			1.00	-0.32	-0.30	-0.14	-0.05	0.01	0.13	0.17	-0.18	-0.11	-0.06	0.02	0.12	0.14	-0.17	-0.09	-0.03	0.03	0.13	0.14	-0.17	-0.11	0.04	-0.04	0.01	0.00	-0.06	-0.02	0.02	0.05	0.03	-0.08	0.04	0.05	-0.06	0.03
Campus Environment 4				1.00	-0.37	-0.17	-0.11	-0.06	0.03	0.16	-0.05	-0.09	-0.12	0.06	0.18	-0.07	-0.11	-0.08	0.05	0.20	-0.07	-0.12	-0.02	-0.02	-0.02	-0.02	-0.03	0.04	0.03	-0.03	0.01	0.02	-0.01	0.02	0.02	0.02	-0.03	0.03
Campus Environment 5					1.00	-0.16	-0.09	-0.07	-0.15	-0.12	0.28	0.02	-0.10	-0.11	-0.15	-0.08	0.30	0.02	-0.12	-0.09	-0.16	-0.09	0.30	0.03	-0.03	-0.03	-0.04	0.01	0.10	-0.01	0.01	-0.08	-0.01	0.11	-0.06	0.07	-0.06	-0.03
Campus Environment 6						1.00	0.03	-0.05	-0.10	-0.15	0.01	0.36	-0.01	-0.05	-0.10	-0.12	0.03	0.34	0.00	-0.06	-0.10	-0.15	0.03	0.39	-0.01	0.02	-0.03	0.01	0.11	0.03	0.00	-0.10	-0.04	0.15	-0.05	-0.05	0.06	-0.04
Encouraging Dialogue 1							1.00	-0.05	-0.07	-0.14	-0.13	0.01	0.56	0.10	-0.06	-0.13	-0.11	-0.04	0.50	0.08	-0.04	-0.12	-0.11	-0.04	0.05	-0.02	-0.05	0.01	0.00	0.03	0.03	-0.07	0.01	0.05	-0.06	0.01	-0.06	0.03
Encouraging Dialogue 2								1.00	-0.10	-0.19	-0.18	-0.08	0.13	0.38	0.06	-0.12	-0.15	-0.07	0.20	0.28	0.03	-0.09	-0.13	-0.07	0.01	-0.03	0.05	-0.02	-0.05	-0.02	-0.02	0.08	0.01	-0.09	0.04	0.00	-0.01	0.04
Encouraging Dialogue 3									1.00	-0.30	-0.28	-0.13	-0.02	0.10	0.33	-0.04	-0.21	-0.10	0.03	0.07	0.30	0.03	-0.22	-0.12	0.04	-0.05	0.02	-0.02	-0.09	-0.04	0.01	0.05	0.05	-0.07	0.07	0.04	-0.05	0.04
Encouraging Dialogue 4										1.00	-0.51	-0.23	-0.10	-0.09	0.03	0.38	-0.23	-0.17	-0.13	0.06	0.03	0.38	-0.22	-0.17	-0.02	0.02	0.02	-0.03	0.01	0.01	0.01	-0.02	-0.02	0.01	0.02	0.02	-0.02	-0.01
Encouraging Dialogue 5											1.00	-0.22	-0.12	-0.16	-0.22	-0.14	0.51	-0.06	-0.16	-0.12	-0.18	-0.19	0.51	-0.06	-0.04	0.07	-0.08	-0.01	0.08	-0.02	-0.01	-0.05	-0.03	0.08	-0.03	-0.03	0.04	-0.03
Encouraging Dialogue 6												1.00	-0.06	-0.08	-0.12	-0.18	-0.01	0.59	-0.05	-0.08	-0.11	-0.18	-0.03	0.60	-0.02	0.03	-0.03	0.03	0.10	0.04	0.00	-0.09	-0.07	0.10	-0.07	-0.06	0.07	-0.02
Prioritizing Mental Health 1													1.00	-0.06	-0.09	-0.16	-0.14	-0.07	0.54	0.10	-0.04	-0.12	-0.13	-0.06	0.06	-0.07	0.03	-0.01	0.04	0.00	-0.01	0.04	0.03	-0.08	0.02	0.03	-0.03	0.02
Prioritizing Mental Health 2														1.00	-0.12	-0.21	-0.18	-0.09	0.17	0.32	0.07	-0.10	-0.16	-0.07	0.08	-0.04	0.08	-0.01	-0.07	0.00	0.00	0.06	0.00	-0.08	0.06	0.06	-0.04	0.03
Prioritizing Mental Health 3															1.00	-0.32	-0.27	-0.13	-0.02	0.07	0.32	0.03	-0.22	-0.12	0.06	-0.07	0.03	-0.01	-0.09	0.00	0.08	-0.01	-0.08	0.04	0.04	-0.03	0.00
Prioritizing Mental Health 4																1.00	-0.48	-0.23	-0.15	-0.11	-0.03	0.39	-0.16	-0.17	-0.03	-0.02	-0.04	0.01	0.04	0.00	-0.01	-0.04	-0.01	0.03	-0.04	0.05	-0.04	0.02
Prioritizing Mental Health 5																	1.00	-0.20	-0.14	-0.14	-0.19	-0.23	0.51	0.00	-0.04	0.06	-0.05	0.00	0.10	0.00	-0.01	-0.09	-0.01	0.11	-0.04	-0.03	0.05	-0.04
Prioritizing Mental Health 6																		1.00	-0.03	-0.06	-0.09	-0.17	-0.04	0.55	-0.04	0.06	-0.04	0.06	0.11	-0.04	0.00	-0.10	-0.02	0.13	-0.06	-0.08	0.08	-0.01
Receptive Administration 1																			1.00	-0.06	-0.10	-0.18	-0.17	-0.07	0.06	-0.04	0.10	-0.01	-0.06	0.00	-0.01	0.04	0.03	-0.09	0.01	0.04	-0.03	0.05
Receptive Administration 2																				1.00	-0.06	-0.10	-0.15	-0.17	0.08	-0.04	0.00	-0.01	-0.07	0.00	0.02	0.06	0.00	-0.08	0.06	0.04	-0.03	0.00
Receptive Administration 3																					1.00	-0.29	-0.27	-0.12	0.04	-0.01	0.02	0.00	0.08	0.00	-0.01	-0.08	0.04	0.03	-0.03	0.03	-0.03	0.02
Receptive Administration 4																						1.00	-0.49	-0.22	0.02	-0.01	-0.03	-0.01	-0.06	0.00	-0.01	0.06	-0.06	0.03	0.06	0.06	-0.06	0.02
Receptive Administration 5																							1.00	-0.20	-0.05	0.06	0.01	0.11	0.00	0.02	-0.10	-0.02	0.12	-0.04	0.07	0.09	-0.05
Receptive Administration 6																								1.00	-0.02	0.03	-0.02	0.03	0.11	-0.03	0.01	-0.10	0.01	0.13	-0.07	-0.06	0.07	-0.05
Gender – Female																									1.00	-0.96	-0.14	-0.02	-0.07	0.02	-0.02	0.07	-0.01	-0.14	0.03	0.25	-0.24	-0.05
Gender – Male																										1.00	-0.15	0.01	0.09	-0.02	0.03	-0.08	-0.01	0.16	-0.04	-0.27	0.26	0.05
Gender – Neither Female nor Male																											1.00	0.00	-0.05	-0.01	-0.03	0.04	0.05	-0.09	0.02	0.06	-0.07	0.03
Race: African American/Black																												1.00	-0.13	-0.05	-0.04	-0.19	-0.05	0.00	-0.02	0.03	-0.03	0.01
Race: Asian/Asian-American																													1.00	-0.16	-0.13	-0.67	-0.18	0.63	-0.03	-0.28	0.27	0.00
Race: Hispanic/Latino																														1.00	-0.05	-0.23	-0.06	0.00	0.05	0.07	-0.07	0.00
Race: Middle Eastern, Arab, or Arab American																															1.00	-0.19	-0.05	0.10	0.08	-0.06	0.06	0.01
Race: White or Caucasian																																1.00	-0.26	-0.61	-0.03	0.22	-0.22	-0.01
Race: Multi-Racial or Other																																	1.00	-0.04	0.02	0.04	-0.04	0.00
International Student (No=0; Yes=1)																																		1.00	0.08	-0.29	0.29	0.01
Degree (Master's=0; PhD=1)																																			1.00	0.18	-0.21	0.07
Discipline: Science and Mathematics																																				1.00	-0.95	-0.17
Discipline: Engineering																																					1.00	-0.16
Discipline: Selected Multiple Disciplines																																						1.00

Figure B2

Correlation Matrix for All Covariates (Detailed)