Science, Engineering, and Mathematics Graduate Student Mental Health: Insights from the Healthy Minds Network Dataset

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Abstract

This paper explores the mental health of science, engineering, and mathematics (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 this study is to answer the following research question: *How does the presence of (a) self-sufficiency, (b) sense of belonging, and/or (c) social self-efficacy impact an SEM graduate student's mental health?*

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 academic discipline. The purpose of this study is to focus specifically on how social aspects can influence graduate students' mental health, or mental and emotional well-being. Therefore, this paper will pull on past work that has found several factors that have improved students' mental health in social contexts.

The current literature shows trends between a student's need for both independence and ownership of their work while having some level of personal support. There have been multiple concepts used to explore this, including *self-sufficiency*, *sense of belonging*, and *social self-efficacy*. *Social self-efficacy* is defined as one's confidence to employ social skills to initiate social contact and develop new friendships, whereas *self-sufficiency* refers to one's ability to independently complete their day-to-day tasks. How connected one feels to their communities is represented by *sense of belonging*. This study will determine how, if at all, these concepts impact a student's mental health, measured by proxy through *depression* and *suicidal ideation*.

The focus of this paper is specific to the graduate student population as the experiences and needs of students in graduate programs are different from those in associates or baccalaureate programs. Although current literature has been showing an increase in work surrounding mental health for students in higher education, there seems to be a lack of research specific to SEM graduate students' mental health.

To do so, this paper presents the quantitative data analysis that was performed using data collected from 2007-2013 by the HMN. Of the 89,486 student responses from this timeframe, roughly 2,439 students responded as United States graduate students in the natural sciences, mathematics, and engineering, with 1,201 responses being complete. Using these 1,201 responses, descriptive and bi-variant statistics were performed and reported with regards to the research question.

The anticipated results included how, if at all, the three concepts of *self-sufficiency*, *sense of belonging*, and *social self-efficacy* vary among different graduate student demographics, and if these demographics have an impact on the prevalence of mental health problems. The hope is that SEM graduate students, faculty, and staff can use these results to influence individual and programmatic changes to improve SEM graduate student mental health.

Introduction

Attention to mental health in young adults has increased over the years [1]. With enrollment increasing 28% in degree-granting postsecondary institutions between 2000 to 2016 [2], it is important to understand how mental health may influence the enrollment and retention for these students. Past studies, however, tend to focus on undergraduate and graduate student samples across a wide range of academic disciplines [1, 3], often resulting in information that cannot be transferred to specific departments or disciplines. This is unfortunate given that both degree program and academic discipline have been shown to influence students' reported mental health measures [4, 5]. One challenge in reporting on mental health measures is the lack of consistent data on mental health disorders or treatments over time for these student populations to analyze [1]. This paper hopes to address this by analyzing data provided by the Healthy Minds Network (HMN): Research on Adolescent and Young Adult Mental Health group's from 2007-2013 to study the mental health of science, engineering, and mathematics (SEM) graduate students [6-7].

Literature Review

If someone is suffering from mental health problems, it is important that they seek help as soon as possible as those who delay in seeking help and subsequent treatment can cause a longer period of illness in addition to an increased probability of relapse [1]. This is quite alarming when one considers previous studies on graduate students' mental health. Hyun, Quinn, Madon, and Lustig [4] reported that Ph.D. students are 8% less likely to self-report mental health needs than non-doctoral students. Hunt and Eisenberg [1] list unawareness of the resources or insurance coverage available, a lack of confidence in the effectiveness of treatment, and one's own perceptions around needing help as barriers of help seeking in student populations. In contrast, Hyun, Quinn, Madon, and Lustig [4] report gender and race as having an influence on help-seeking behavior (increased likelihood to seek help if self-reported as White or female). A study in 2009 showed that at one institution, 15% of graduate students seriously considered suicide with 4% reporting within the last twelve months; of those who had, 90% had considered how they would do so, and 28% had made some level of preparation for it [8]. Furthermore, 8% of those who seriously considered suicide in the past 12 months tried with 28% of those instances requiring medical attention, and 27% of those indicate that they are considering making another suicide attempt [8]. Although these statistics could carry over to other demographics, a recent Belgian publication helps to highlight the role that being in a graduate program (specifically doctoral) has on one's mental health [5]. When compared to a group of highly educated people in the general population, highly educated employees, and students in higher education (bachelor, masters, or doctoral degrees), PhD students consistently reported a higher number of mental health symptoms (e.g., felt worthless, unhappy and depressed) [5]. This clearly illustrates that the graduate student experience has unique negative influences on students' mental health.

Although there has been research exploring mental health for graduate student populations, existing literature has highlighted that an ideal study would be designed to study graduate student mental health in a specific discipline, independently from undergraduates. The academic experiences and social demands faced by graduate students differ from undergraduate students, with graduate students being more influenced by pressures surrounding research, teaching, publishing, finding employment, and unclear advisor expectations [4]. Furthermore, a recent study reported deadlines, problems with one's family, relationships, strained finances, time management and feeling a lack of control as key stressors in the doctoral process [9]. These stressors, in

combination with a lack of interest, exhaustion, and anxiety, contribute to 56% of PhD students consideration to drop out during their studies [9]. In terms of academic discipline, studies have shown that one's academic discipline, and therefore norms, work culture, and views towards mental health, influences one's reported mental health measures. Being enrolled as an engineering or science student significantly decreases one's likelihood to seek help for mental health problems when compared to other disciplines (e.g. arts, humanities) [4, 10] despite prior research showing that engineers exhibit higher stress levels and lower exercise rates [4]. For this reason, this study explicitly examines graduate students in SEM disciplines.

As graduate students' academic experiences differ, so do the sources of mental health problem. Past studies have shown that contributors to poor mental health include: social isolation [3], a lack of self-disclosure or attachment avoidance [11], low self-efficacy [12] in both social [11, 13] and research [14] contexts, a low sense of belonging [15], and a low sense of autonomy in one's work [14]. These trends show several key factors that influence graduate student mental health, many of which tie into social support. Social support as defined by House, Umberson, and Landis [16] is the positive aspects of relationships that can provide instrumental, emotional, and informational aid. It has been shown that social support, such as having regular contact with friends or having a higher functioning relationship with one's advisor, decreases graduate and professional students' needs [4]. This literature, overall, shows how social support can influence student mental health.

This paper, therefore, is focusing on graduate student's ability to engage in these social interactions. To do so, the three following measures are being pursued*: self-sufficiency*, *sense of belonging*, and *social self-efficacy. Self-sufficiency* for this study is being defined as an individual's ability to operate independently on a day-to-day basis. In this context, this could be perceived as a student's ability to perform their daily work duties as well as any social obligations they may have. *Sense of belonging* is defined as feeling like one belongs to a group or community [17]. In the graduate school context, this could pertain to one's research group, department, school, club, or another group. Self-efficacy, as defined by Bandura, is known to be the confidence an individual has in herself/himself to achieve a desired outcome [12, 18]. Therefore, when looking at self-efficacy in a social context, *social self-efficacy* is defined as one's confidence to use their social skills. More specifically, one's confidence to both initiate contact in social settings and to make new relationships, both on a personal and professional level [11]. For a graduate student, this could mean one's perceptions of how they handle social situations (i.e. meetings or conferences), create new professional contacts, or how they perceive their ability to make and maintain friends with peers in their degree program [19].

Methodology
Given the prior literature, this papers aim is to study to role of social support in SEM graduate student mental health. More specifically, we will be looking at the roles of *self-sufficiency*, *sense of belonging*, and *social self-efficacy* on the reported mental health measures of *depression* and *suicidal ideation*. This culminates into the following research question:

> How does the presence of (a) *self-sufficiency*, (b) *sense of belonging*, and (c) *social self-efficacy* impact an SEM graduate student's mental health, measured by *depression* and *suicidal ideation*?

Data and Sample
Data for this study was taken from a larger study from the Healthy Minds Network (HMN): Research on Adolescent and Young Adult Mental Health group [6]. From the larger study, data was collected at each participating school by randomly surveying 4,000 students (or the entire student population, whichever was smaller). Students were recruited over email with a cash incentive and asked to reflect on experiences two weeks to 12 months prior at the time of the survey. In order for the student responses that were recorded to be reflective of the full student population at each university, non-response weights were 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 [20].

For this study, our analysis used data provided from the years 2007, 2009, 2010, and 2011 due to the availability of the codebook specific to this timeframe, questions present in the survey, and available student responses [20]. Graduate students included in the analysis came from 56 of the 64 participating schools. As the factors that contribute to mental health related responses may vary greatly over cultures, the dataset was restricted to only domestic students. As aforementioned, academic discipline influences mental health measures; therefore, this study is restricted to graduate students in science, engineering, and math (SEM) (technology was not an option). From a dataset of 89,486 students, there were 17,273 SEM students, with 2,439 being domestic graduate (masters and doctoral) students. Finally, to account for missing data across the reported measures, any respondents that had missing data for any of the variables used in this analysis were removed, lowering the sample size to 1,201 respondents. Table 1 below details the demographics of the 1,201 respondents.

Table 1
Gender and Race Descriptive Statistics for the Sample

Gender	
Male	690 (57.45)
Female	511 (42.55)
Race	
African American/Black	27 (2.25)
American Indian/Alaskan Native	2 (.17)
Arab/Middle Eastern or Arab American	15 (1.25)
Asian/Asian-American	156 (12.99)
Hispanic/Latino	40 (3.33)
Pacific Islander	5 (.42)
White or Caucasian	857 (71.36)
Multi-Racial	69 (5.75)
Other/Not Applicable/Missing	30 (2.50)

Measures
For this study, there were three categorical independent variables (covariates) and two dependent variables (outcome of interest). These variables are detailed in Table 2 below.

Table 2
Survey Response Items

Measure	Question Text	Scale
Outcomes		
Depression	Raw Patient Health Questionnaire score	0-27
Suicidal Ideation	In the past year, did you ever seriously think about committing suicide?	0=No 1=Yes
Covariates		
Social Self-Efficacy	In the past month, how often did you feel confident to think or express your own ideas and opinions?	0=Never 1=Once or twice
Self-Sufficiency	In the past month, how often did you feel good at managing the responsibilities of your daily life?	2=About once a week 3=2 or 3 times a week
Sense of Belonging	In the past month, how often did you feel that you belonged to a community (like a social group, your neighborhood, your city)?	week 4=Almost Everyday 5=Everyday

The three covariates were meant to measure the frequency in the past month that the respondent felt in terms of *self-sufficiency*, *sense of belonging*, and *social self-efficacy*, respectively. The two dependent variables were used as mental health measures. *Depression* indicates the Raw Patient Health Questionnaire score (0-27) from the Patient Health Questionnaire (PHQ). This score can be grouped based on depressive symptom severity: 0-4 none, 5-9 mild depression, 10-14 moderate depression, 15-19 moderately severe depression, and 20-27 severe depression [21]. The composite score was used as an interval dependent variable that was broken down to categories when needed. *Suicidal ideation* was meant to measure if the respondent has ever seriously considered suicide in the past year at the time of the survey.

Analytical Procedure
The first step before analyzing the data was to measure the descriptive statistics and central tendency for the outcomes of interest and explanatory variables. These can be seen in Table 3 on the following page. As the covariates are all categorical data with both an interval and a dichotomous outcome variable, two models were run. The following section will go into details with regards to these two models.

In Model 1, the outcome of interest was the level of *depression*, measured via the raw patient health score. As this was interval, an ordinary least squared regression (i.e. multiple linear regression) model was estimated to understand the relationships between the covariates and the outcome of interest.

Table 3
Descriptive Statistics and Central Tendency for Response Items (N = 1,201)

	N (%)	Mean	Std. Dev.	Min	Max
Outcomes					
Depression	1,201	5.814	4.858	0	27
None	*576 (48%)*	*-*	*-*	*0*	*4*
Mild Depression	*406 (33.8%)*	*-*	*-*	*5*	*9*
Moderate Depression	*141 (11.7%)*	*-*	*-*	*10*	*14*
Moderately Sever Dep.	*49 (4.1%)*	*-*	*-*	*15*	*19*
Severe Depression	*29 (2.4%)*	*-*	*-*	*20*	*27*
Suicidal Ideation	1,201	.051	.220	0	1
Covariates					
Self-Sufficiency	1,201	3.321	1.251	0	5
Sense of Belonging	1,201	3.205	1.443	0	5
Social Self-Efficacy	1,201	3.818	1.170	0	5

For each of the categorical covariate (independent, explanatory) variables, each of the categories was run as dummy dichotomous variables in the linear regression model. Equation 1 below shows the regression equation for the model.

$$\widehat{depression}_i = a + b_{SE1}(self\ sufficiency)_i + \cdots + b_{SE6}(self\ sufficiency)_i \qquad (1)$$
$$+ b_{SoB1}(sense\ of\ belonging)_i + \cdots + b_{SoB6}(sense\ of\ belonging)_i$$
$$+ b_{SSE1}(social\ self\ efficacy)_i + \cdots + b_{SSE6}(social\ self\ efficacy)_i$$
$$+ \epsilon rror$$

For this study, students who reported to "Never" experiencing *self-sufficiency*, *sense of belonging*, and *social self-efficacy* in the past month were left as the baseline group as they would be the most likely to experience higher levels of *depression*.

In Model 2, the outcome of interest was whether the individual had experienced *suicidal ideation* in the past year, measured as a dichotomous variable. This led to a binary logistic regression model (logit model) to be run to try and understand the relationship between the covariates and the outcome of interest [22-23].

Logit models are based in probabilities. The probability of an event occurring (p), such as the event that a SEM graduate student experienced any level of *suicidal ideation* in the past year, can be represented by an odds, as seen in Equation 2 below.

$$odds = \frac{p}{1-p} \qquad (2)$$

Therefore, the logit model, expressed in Equation 3, is the linear combination of the independent (explanatory) variables. A unit change in an independent variable is related to a change in the log-odds of the dependent variable.

$$\ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots \tag{3}$$

For interpretation of the results, this equation of log-odds is transformed to express odds ratios, as seen in Equation 4 below. Odds ratios are simpler to interpret, with odds less than one representing in a decrease in the likelihood of an outcome relative to the baseline outcome and an odds greater than one representing in an increase in the likelihood of an outcome relative to the baseline outcome. For this study, students who reported "Never" experiencing *self-sufficiency*, *sense of belonging*, and *social self-efficacy* in the past month were left as the baseline group as they would be the most likely to experience *suicidal ideation* in the past year.

$$\frac{p}{1-p} = e^{\alpha} + e^{\beta_1 x_1} + e^{\beta_2 x_2} + e^{\beta_3 x_3} + \cdots \tag{4}$$

Limitations
There are several limitations in this study. The variables chosen were elected to represent specific concepts being tested in the research questions and hypotheses. However, it is likely that one variable is not enough to fully measure these concepts; *depression* is only one of several mental health measures that can be used to gauge students' mental health. Although students may have lower reported *depression* scores, it does not mean that they do not have mental health problems (i.e., stress or anxiety). In addition, the explanatory measures used were taken from a pre-defined survey. The wording used in these questions may be eliciting responses that do not match the assumed definitions given in this paper. Finally, the measures of *self-sufficiency*, *sense of belonging*, and *social self-efficacy* most likely have some overlap in what they are measuring. These quantities may be measuring some underlying factor that was not identified and should be studied further to explore this (such as the interaction effects).

Findings
Descriptive statistics show that for SEM graduate students, 33.8% reported mild depression, 11.7% reported moderate depression, 4.1% reported moderately severe depression, and 2.4% reported severe depression. The average *depression* score was a 5.814, which coincides with mild depression. On the other hand, 48% of the population reported no depression. In terms of *suicidal ideation*, 5.1% of the population reported having some form of *suicidal ideation* in the past year.

Table 4 on the following page presents the results from the multiple regression model. The results are interpreted in terms of their standardized coefficients, beta. For all cases, one can see that *social self-efficacy* has the highest beta values throughout, indicating the strongest relationship with *depression* scores. One can also note that the values increase in negative magnitude as the responses shift from "once or twice" a month to "everyday." Also, once the frequency of reporting any of the three covariant reaches "2 or 3 times a week," it has a significant influence on the resulting *depression* score.

Table 4
Model 1 Predicting Relationship with Depression Score

	Raw Coefficient (Std. Err.)	t	p	beta
Once or Twice				
Self-Sufficiency	-.294 (.275)	-1.07	.286	-.0641
Sense of Belonging	-.173 (.136)	-1.27	.204	-.0572
Social Self-Efficacy	-.354 (.165)	-2.14	.032*	-.0956
About Once a Week				
Self-Sufficiency	-.332 (.268)	-1.24	.216	-.0940
Sense of Belonging	-.318 (.135)	-2.35	.019*	-.1119
Social Self-Efficacy	-.854 (.158)	-5.42	.000***	-.2845
2 or 3 times a week				
Self-Sufficiency	-.675 (.265)	-2.55	.011*	-.2660
Sense of Belonging	-.470 (.13)	-3.61	.000***	-.2035
Social Self-Efficacy	-1.074 (.150)	-7.16	.000***	-.4876
Almost everyday				
Self-Sufficiency	-.742 (.263)	-2.82	.005**	-.3670
Sense of Belonging	-.528 (.130)	-4.07	.000***	-.2407
Social Self-Efficacy	-1.282 (.150)	-8.57	.000***	-.6379
Everyday				
Self-Sufficiency	-.719 (.265)	-2.72	.007**	-.3506
Sense of Belonging	-.619 (.133)	-4.66	.000***	-.2645
Social Self-Efficacy	-1.360 (.159)	-8.56	.000***	-.5104
Total Observations	1,201			
F-Value (1,200 DOF)	29.55			
R-Squared	.2722			
Adjusted R-Squared	.8301			

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

Table 5 on the following page presents the results from Model 2, the logit model. As mentioned above, the odds ratios will be used to discuss the results as their interpretation is more straightforward compared to the raw coefficients. The table shows that for all but "about once a week," an increase in the reported level of *social self-efficacy* significantly decreases the odds of having *suicidal ideation* in the past year. These trends are also shown for the higher occurrences of *sense of belonging* and *self-sufficiency* when one observes the odds ratio, although these are not shown to be statistically significant.

Table 5
Model 2 Predicting Odds of Suicidal Ideation

	Raw Coefficient (Std. Err.)	Odds Ratio (Std. Err.)	z	p
Once or Twice				
Self-Sufficiency	.217 (.636)	1.242 (.790)	.34	.733
Sense of Belonging	-.200 (.562)	.818 (.460)	-.36	.722
Social Self-Efficacy	-1.790 (.802)	.167 (.134)	-2.23	.026*
About Once a Week				
Self-Sufficiency	-.675 (.676)	.509 (.344)	-1.00	.318
Sense of Belonging	.000 (.557)	1.000 (.558)	.00	.999
Social Self-Efficacy	-1.061 (.728)	.346 (.252)	-1.46	.145
2 or 3 times a week				
Self-Sufficiency	-.557 (.631)	.573 (.362)	-.88	.378
Sense of Belonging	-.100 (.554)	.905 (.501)	-.18	.857
Social Self-Efficacy	-1.864 (.758)	.155 (.117)	-2.46	.014*
Almost Everyday				
Self-Sufficiency	-.641 (.644)	.527 (.339)	-1.00	.319
Sense of Belonging	-.597 (.592)	.550 (.326)	-1.01	.313
Social Self-Efficacy	-2.196 (.751)	.111 (.084)	-2.92	.003**
Everyday				
Self-Sufficiency	-1.378 (.848)	.252 (.214)	-1.62	.104
Sense of Belonging	-1.001 (.680)	.368 (.250)	-1.47	.141
Social Self-Efficacy	-1.976 (.767)	.139 (.106)	-2.58	.010*
Total Observations	1,201			
Null Log Likelihood	-241.206			
Final Log Likelihood	-219.082			
Pseudo R	0.0917			

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

Discussion

Looking back at the research questions, the purpose of this study was to investigate the roles of *self-sufficiency*, *sense of belonging*, and *social self-efficacy* on the reported mental health measures of *depression* and *suicidal ideation*. The models presented in the results do this. For *depression*, it is seen that all explanatory variables have a significant relationship with a decreased *depression* score, and therefore less severe reporting of *depression*. It is apparent, however, that *social self-efficacy* has the strongest relationship with a decreased *depression* score, as seen through the reported beta values being roughly double of *self-sufficiency* or *sense of belonging* for each reported category.

When looking at *suicidal ideation*, one should note that outside of "about once a week," the frequency of feeling *social self-efficacy* did not impact its relationship with *suicidal ideation*. That is, as long as some measure of *social self-efficacy* was present, there was a positive correlation in reducing *suicidal ideation*. Although there were similar trends in the reported *sense of belonging* and *self-sufficiency*, these trends were not statistically significant.

Overall, one can observe that *social self-efficacy* has a strong relationship with mental health measures, in that it is shown to have a strong correlation with lower reported *suicidal ideation* and *depression*. Now this may be that *depression* itself is a predictor for *suicidal ideation*, and that someone suffering from higher levels of *depression* would also have higher occurrences of *suicidal ideation*. This may suggest that although *self-sufficiency* and *sense of belonging* help to mitigate less severe mental health symptoms, it is really the confidence to participate and be a part of those relationships that differentiates those with more severe mental health symptoms.

Conclusion

This study has shown that higher reported levels of *self-sufficiency*, *sense of belonging*, and *social self-efficacy* were associated with lower reported level of *depression*, and that for most measures of reported *social self-efficacy, suicidal ideation* was significantly lower within US science, engineering, and mathematics graduate students.

It is therefore crucial that further studies be conducted to determine why *social self-efficacy* plays such a critical role in conjunction with efforts focused on increasing social support for US domestic SEM graduate students. Future studies should increase the number of mental health measures being explored in addition to testing the correlation between these measures. In terms of explanatory variables, it would be beneficial to expand the survey items being used to measure each of the terms, or to find a consensus on what each item is specifically measuring (i.e., is it measuring self-efficacy or comfort with self-disclosure). There are other measures of social support that could and should be explored outside of *self-sufficiency*, *sense of belonging*, and *social self-efficacy*.

Given the specific academic disciplines being targeted, it would be beneficial to measure the level of social support one feels at one's school and department by determining how the presence of social support from one's peers, teachers, administrators, and advisors influence mental health measures. Future efforts to increase graduate students' social support should include programmatic efforts to foster a sense of community, peer mentoring programs to provide advice and facilitate building relationships, and staff and faculty professional development to provide awareness of the role of social support and how building it can benefit their students.

Finally, this paper did not explore the role of demographics (i.e., age, gender, race) on measures of social support or mental health. Given the past research that has shown that demographics play a role in both these aspects, future researchers should explore this in the specific SEM graduate student context.

Acknowledgments

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