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Visualizing Stress and Relief: How stressors and coping mechanisms interact in engineering graduate student experiences

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Abstract

Graduate students are poised in a unique place in life, facing the challenges of being full-time students while also maintaining independent, adult lives with the responsibilities that accompany both roles. As such, it is no surprise that graduate students report experiencing a significant amount of stress. For some students, this stress can serve as motivation. For other students, though, this stress can overwhelm and debilitate, causing students to struggle academically, develop mental health problems, or be at higher risk of disease. Though each individual's response to stress is different, numerous stressors have been identified that are common to the graduate education experience (*e.g.*, classes and grades, research appointments, etc.), as have the various coping mechanisms (*e.g.*, peers, mindfulness-based stress relief, exercise, etc.) that students use. While these individual stressors and coping mechanisms are important, it remains unclear how these different stressors and coping mechanisms might interact to compound or diminish student stress. The combination of stressors experienced by graduate students, as well as the combination of coping mechanisms used by graduate students can be characterized using resource networks, similar to social networks created for understanding interactions among people. The major aim of this project is to increase the understanding of the stress and coping mechanism networks of graduate students, as well as how these two different networks interact. The results will facilitate the development of better support programs for graduate students.

In this paper, we seek to answer the following research questions: (1) What are the primary stressors and coping mechanisms of current graduate students, and (2) What are the major differences between coping networks of students who are able to successfully manage stress versus those who are not able to? To answer these questions, we surveyed graduate engineering students at a mid-sized Mid-Atlantic institution. The survey consists of three major sections: (1) the Perceived Stress Questionnaire (S. Levenstein, et al. *J. Psychosom. Res.*, vol 37, no. 1, pp. 19-32, 1993.), which is a validated instrument that assesses an individual's perceived stress level, (2) a section for respondents to identify and rank major sources of stress, and (3) a section for respondents to identify and rank major coping strategies. The survey identified research, grades, and issues relating to mental health as major stressors for all groups, and people, including friends, family, and significant others, as the primary coping mechanisms used by students. Resource network analysis confirmed that these primary stressors and coping mechanisms often appeared together in responses. When results were sorted by ability to manage stress, it was found that students who were poorer at managing stress often had more sources of stress, and that these sources were not always related to their responsibilities as graduate students. Poorer stress managers also tend towards more passive coping mechanisms, such as watching TV/movies or eating food. These results indicate that struggling students may have trouble finding healthy coping mechanisms in their home lives, and so might require extra recognition and support from their faculty advisors and peers.

Introduction and Background

The number of graduate students who suffer from mental health challenges (*e.g.*, anxiety, depression, emotional distress) is rising at an alarming rate [1]–[3]. This poor mental health

epidemic has become so severe that one study found 56% of graduate students considered dropping out of their studies [4]. In response, a worldwide effort to better understand and improve the state of graduate students' mental well-being has begun [2], [5]. One factor contributing to poor mental health is chronic perceived stress [6]–[8], something common to the graduate student experience. Graduate students, regardless of discipline, are in a unique position in life being forced to balance the responsibilities of being a full-time student (*e.g.*, taking classes, performing research, meeting paper deadlines, teaching, etc.) along with those required to maintain, or for many to begin, an independent, adult life (*e.g.*, managing limited financial resources, sustaining relationships, etc.) [4], [9]–[11]. As such, it is no surprise that graduate students experience a significant amount of stress [2], [12]–[17].

While it seems clear that the stressors impacting graduate students are different than those facing undergraduate students, the majority of studies on student mental health either primarily focus on undergraduates or group the two populations together [1], [9], [10], [13], [14], [18], [19]. The handful of studies that do focus specifically on graduate students typically examine students in medical, nursing, or clinical psychology and counseling programs [10], [12], [15], [20]–[23], or examine graduate students across a number of majors [11], [13], [17], [24]. Very few studies focus solely on students within science, technology, engineering, and mathematics (STEM), even though students in STEM display high stress levels [1], [9], [25], as these students face a number of unique stressors, such as heavy research responsibilities, publishing requirements, and dual roles as student-teacher. Additionally, students enrolled in STEM fields are less likely to pursue help than their colleagues in other majors, despite having access to the same coping strategies [9], [25].

In the past, most studies examining graduate student stress have examined the individual effects of different stressors and coping mechanisms [3], [11], [12], [23]. For example, El-Ghoroury et al. [12] reported that most graduate students claim coursework is the biggest cause of stress. While cataloging and understanding the factors contributing to graduate student stress is vital, it is important to recognize that these stressors do not act independently of each other [26], [27]. Similarly, students may not always rely on a single coping strategy but may build a network of supports [28]. As such, developing a more complete understanding of how graduate students experience various stressors can help institutions assist their students in creating successful support networks. In this study, we seek to understand which stressors most highly impact graduate engineering students, as well as how these stressors interact. Additionally, we seek to know what coping strategies these students use and understand the characteristics of effective coping strategy networks. We do this by answering the following questions, (1) What are the primary stressors and coping mechanisms of current engineering graduate students, and (2) What are the major differences in coping networks between students who are able to successfully manage stress versus those who are not able to?

Methodology

This study aims to model not only which sources of stress and coping mechanisms are common in graduate students, but how they interact with one another (*e.g.*, how different stressors and coping mechanisms may be paired, the strength of the links between these pairs, how these links change based upon perceived stress and ability to handle stress, etc.). To this end, a survey was constructed through the survey-building platform Qualtrics that would collect information regarding stress levels, sources of stress, and coping mechanisms used by individual students. The survey was

distributed to all engineering graduate students at a mid-Atlantic university via email after appropriate human subjects' approvals were obtained. No incentives were offered for completion of the survey.

The survey collected data on a few metrics: demographics (including engineering discipline, age, race, ethnicity, gender identity, disability status, parental status, and program-specific details), stress level, sources of stress (selected from a checklist of 16 items), coping mechanisms (selected from a checklist of 21 items), and a self-reported ability to manage stress. Stress level was measured using a validated instrument known as the Perceived Stress Questionnaire (PSQ), which normalizes the results yielding a value between 0 and 1 [29]. Checklist items for sources of stress and coping mechanisms were generated using previous research in the area [3], [11], [12], [23], and each checklist had an "other" option with an optional text box to elaborate. Items the participant selected in the sources of stress checklist were carried forward to populate the next question, which allowed participants to rate each source of stress' contribution to their overall stress on a Likert scale. Similarly, students were able to rate each coping mechanism's effectiveness on a Likert scale. At this stage, the survey has accrued 43 complete responses. Partial responses were used where possible.

Data analysis began with the generation of several resource networks. Resource networks are a method for visualizing how different resources (in this case, sources of stress or coping mechanisms) are used in combination. A resource network is composed of nodes representing resources and connecting lines representing combinations of resources. Each node and link are sized in relation to their prevalence in the data; the most common sources of stress / coping mechanisms will appear the largest, and the most common combinations will have the thickest lines drawn between them. These resource networks acted as a starting point for supporting statistical analysis. At this early stage, only association rule mining (a data-mining technique which can identify relationships between items in lists) was used to analyze this data. While it largely serves to support the visual relationships in the resource network diagrams, it can analyze groups of more than two. Future directions for this research are largely focused on continuing statistical analysis.

Results and Discussion

Due to the nature of the research questions (both identifying primary stressors/mechanisms and understanding how different types of students experience stress), they will be answered simultaneously. Currently, 43 students have responded to the survey in its entirety. These students have been sorted into three categories based upon their self-reported ability to manage stress on a scale of 1–5 stars. Students rating themselves a 1 or 2 on this scale are considered poor stress managers (n = 10; 23.3%), those rating themselves a 3 are considered moderate stress managers (n = 14; 32.5%), and those rating themselves a 4 or 5 are consider good stress managers (n = 19; 44.2%), similar to previous studies [11]. Their responses to the questions "which items contribute to your stress?" and "which items help you cope with your stress?" are represented in Tables 1 and 2, respectively.

Table 1. Reported sources of stress of graduate students (n = 43), further separated by ability to manage stress out of five stars. 1–2 stars are considered poor stress management (n = 10), 3 stars is considered average stress management (n = 14) and 4–5 stars are considered good stress management (n = 19).

Source	Total (%)	4–5-star (%)	3-star (%)	1–2-star (%)
Research	72.1	63.2	85.7	70.0
Mental Health	67.4	57.9	78.6	70.0
Work-Life Balance	67.4	52.6	71.4	90.0
Grades	62.8	57.9	57.1	80.0
Finances	53.5	47.4	64.3	50.0
Physical Health	51.2	31.6	64.3	70.0
Interpersonal Issues	39.5	31.6	50.0	40.0
News	37.2	15.8	57.1	50.0
Advisor	23.3	15.8	35.7	20.0
Teaching	18.6	15.8	21.4	20.0
Social Media	16.3	10.5	14.3	30.0
Disability	14.0	15.8	7.1	20.0
Caregiving	14.0	5.3	21.4	20.0
Department	14.0	0.0	35.7	10.0
Discrimination	7.0	15.8	0.0	0.0

Table 2. Reported coping mechanisms of graduate students (n = 43), further separated by ability to manage stress out of five stars. 1–2 stars are considered poor stress management (n = 10), 3 stars is considered average stress management (n = 14) and 4–5 stars are considered good stress management (n = 19).

Mechanism	Total (%)	4–5-star (%)	3-star (%)	1–2-star (%)
Friends	69.77	73.68	71.43	60.00
Significant Other (S/O)	65.12	52.63	78.57	70.00
Family	62.79	63.16	78.57	40.00
TV/Movies	53.49	36.84	64.29	70.00
Exercise/Time Outdoors	51.16	52.63	50.00	50.00
Food	48.84	47.37	50.00	50.00
Video Games	37.21	36.84	35.71	40.00
Social Media	27.91	36.84	35.71	0.00
Advisor	27.91	31.58	21.43	30.00
Mindfulness	27.91	21.05	35.71	30.00
Peers	25.58	26.32	28.57	20.00
Counseling/Therapy	23.26	21.05	21.43	30.00
Arts/Crafts/Other Hobbies	20.93	26.32	14.29	20.00
Religion/Spirituality	16.28	21.05	14.29	10.00
Alcohol	16.28	15.79	14.29	20.00
Reading	16.28	10.53	14.29	30.00
Prescription Meds	11.63	15.79	7.14	10.00
Other Faculty	9.30	10.53	14.29	0.00
Marijuana	4.65	5.26	0.00	10.00
Other Drugs	0.00	0.00	0.00	0.00

Grades, research, mental health, and work-life balance appeared in 50% or more responses for the entire population, as well as each individual student group, indicating that these stressors are common regardless of ability to manage stress. While family, exercise/time outdoors, and TV/movies appeared in 50% of the overall sample, there were some groups for which substantially fewer than half of participants identified these coping mechanisms (e.g., only 40% of 1–2-star students identified family as a coping mechanism). Both of these results align with previous studies which identify these major stressors and coping mechanisms [11], [12]. Notably 67.4% of respondents identify mental health as a major stressor, an important finding given that chronic stress compounds with pre-existing mental health vulnerabilities, or can even spark new challenges [3]. Also, of interest is the relatively small portion of the population which leans on their at-work peers, their advisor, or other faculty for help in managing stress. This could be because they are more often perceived as sources of stress [2], [12], [30], or because students prefer to utilize coping mechanisms not related to school and/or work.

Though we were also able to compare students based upon degree program (MS vs PhD) and gender (male vs female), these groups yielded largely similar results. Grades, research, and mental health were common (*i.e.*, >50% of respondents noted them) across all student groups as sources of stress; similarly, friends and family were common coping mechanisms across all groups. A few differences of potential interest include physical health as a more common stressor for PhD students (65% of PhD students versus 32% of MS students), significant other (S/O) as a more common coping mechanism for female students (88% of female students versus 45% of male students), and TV/movies as a more common coping mechanism for female students (76% of female students compared to 38% of male students). More extensive discussion and investigation of these differences is considered outside the scope of this particular exploratory work, though frequency tables for each group can be found in Appendix A.

In this phase of data analysis, poor managers of stress will be compared directly to good managers of stress, as the moderate group is currently a fairly consistent middle ground between these other cohorts. The 1–2-star group displayed an average PSQ index of 0.58, considered high stress (>0.46), while the 4–5-star group had an average PSQ index of 0.38, considered moderate stress (0.34–0.46) [31]. Figure 1 shows the network of sources of stress for poor stress managers, and Figure 2 shows the same network for good stress managers. Please note that any "disconnected" nodes (discrimination in Figure 1, and department [culture] in Figure 2) were not selected for the specified group of students.

Of immediate interest in these diagrams is the overall "spread" of resources across the network: while the 4–5-star students experience stress from a few expected sources (notably grades, research, work-life balance, mental health, and finances), the 1–2-star students experience stress from more varied sources such as physical health, interpersonal issues, and news/politics. This is reflected on a more individual basis, as well: 4–5-star students noted an average of 4.5 sources, while 1–2-star students noted an average of 6.5. These results indicate that students who feel they are worse at managing their stress often experience stress from more sources, as well as from sources outside of their direct responsibilities as a graduate student. Other studies have found that students with multiple "roles" (student, instructor, parent, etc.) experience greater stress [11], and so it follows that students with stress outside of school would struggle more with stress management. The visual connections in the diagram imply a practical connection between these sources of stress as students experience them. Sources that tend to co-occur may be dependent upon one another; for example, it is possible that sources with heavier connections to work-life balance (in the 4–5-star group, grades, research, finances, and mental health) contribute more substantially to issues in work-life balance. Similarly, sources connected to mental health may contribute to work related stress or exacerbate already existing struggle with mental health. Further research involving more qualitative elements will likely help illuminate the cause-and-effect relationships at play in these connections, though this exploratory work only seeks to identify them.

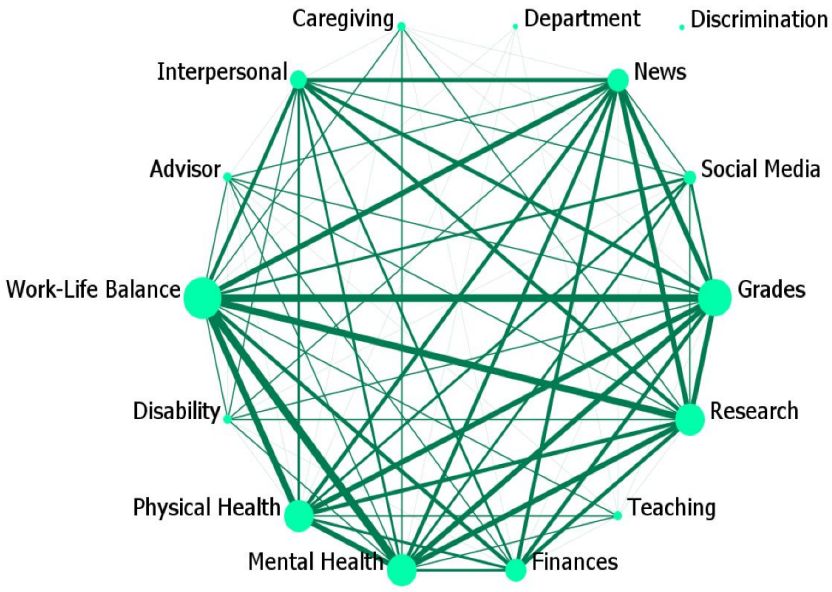

Figure 1. Source of stress for students who self-rated 1–2 out of 5 stars. Node size corresponds to the frequency of each source, and link width corresponds to the number of times each pair of sources appeared together (note: discrimination did not appear in any responses).

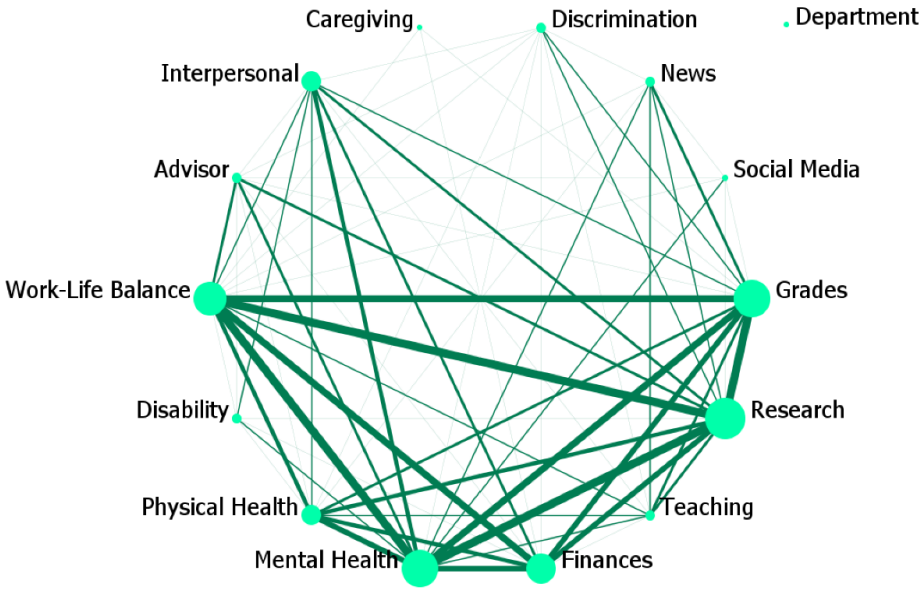

Figure 2. Source of stress for students who self-rated 4–5 out of 5 stars. Node size corresponds to the frequency of each source, and link width corresponds to the number of times each pair of sources appeared together (note: department [culture] did not appear in any responses).

At this stage of data collection, association rule mining is only useful for analyzing the entire dataset (n = 43) due to the small sample size and thus can only pick up on overarching data patterns (meaning the associations it identifies may or may not be unique to a particular student group). This process reinforced the relationships seen in the diagrams (e.g., grades and research appeared together often), but also placed an emphasis on the frequency with which grades, research, and work-life balance appeared together (45% of responses). This may indicate that stress related to grades and research often leads to an upset in work-life balance, though more data would be needed to support this claim. This does, however, align with previous studies, which have shown that graduate students consider maintaining a good work-life balance key to managing their work-related stressors [32], [33].

Like with the sources of stress, participants also selected coping mechanisms from a checklist. These responses have similarly been divided based on self-reported ability to manage stress; Figure 3 shows the network of coping mechanisms used by 1–2-star students, and Figure 4 shows the network of coping mechanisms used by 4–5-star students. Please note that disconnected nodes did not appear in any responses.

While these diagrams may at first imply that 4–5-star students use more resources than 1–2-star students, this is actually not true on an individual basis; 1–2-star students marked an average of 6 resources, while 4–5-star students marked an average of 6.1 resources. The primary difference here, then, is in which resources these groups use. 4–5-star students have a much more varied resource network, with emphasis on people (friends, family, and S/O). Promoting such varied social support networks can be especially important for students from historically marginalized groups, as social support is a strong predictor of persistence in higher education [12]. By comparison, 1–2-star students make use of passive activities (such as watching TV/movies and eating food) much more often (compare 37% of 4–5-star students using TV/movies to 70% of 1–2-star students using TV/movies). This would indicate that more passive coping mechanisms might be less effective in helping students actively manage their stress [11], [14]. This is reinforced by the heavier connections between friends, family, and exercise/time outdoors in the 4–5-star network; not only are these resources all “active” in some way, but they also are often used together, indicating that successful stress management requires the use of more than one coping mechanism. By comparison, the weightier connections in the 1–2-star network suggest that these students are engaging in largely passive activities, even if they do so in a group of friends / with their partner. The comparison between effective combinations of coping mechanisms (friends-family-exercise) and ineffective combinations (friends-S/O-TV/movies) demonstrates the need to understand which coping mechanisms are being used *and* in what combination. Statistical analysis of the connections through association rule mining did not reveal any associations not seen in the Figure 3 and Figure **4**.

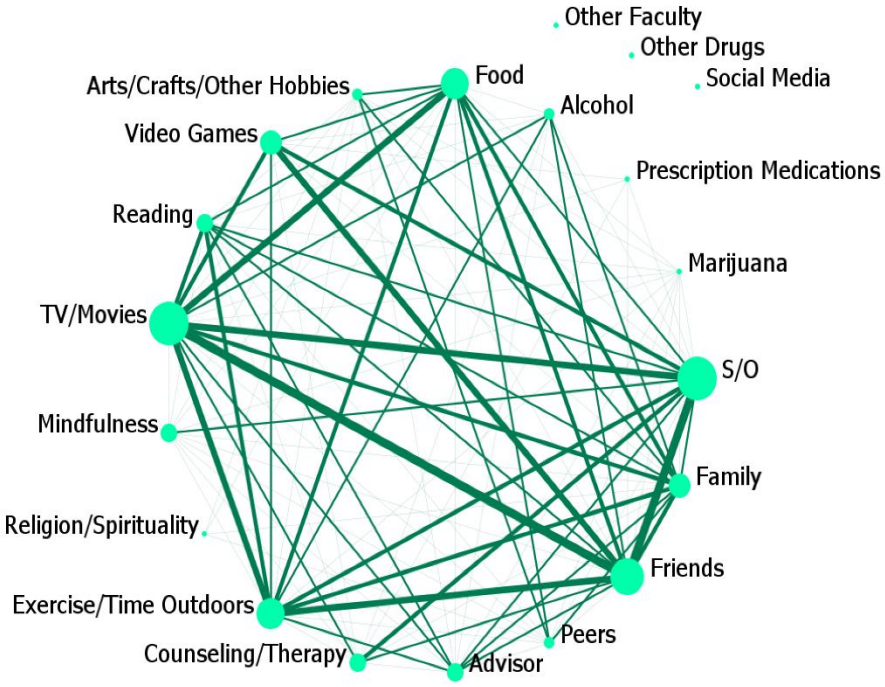

Figure 4. Coping mechanisms for students who self-rated 1–2 out of 5 stars. Node size corresponds to the frequency of each source, and link width corresponds to the number of times each pair of sources appeared together (note: other faculty, other drugs, and social media did not appear in any responses).

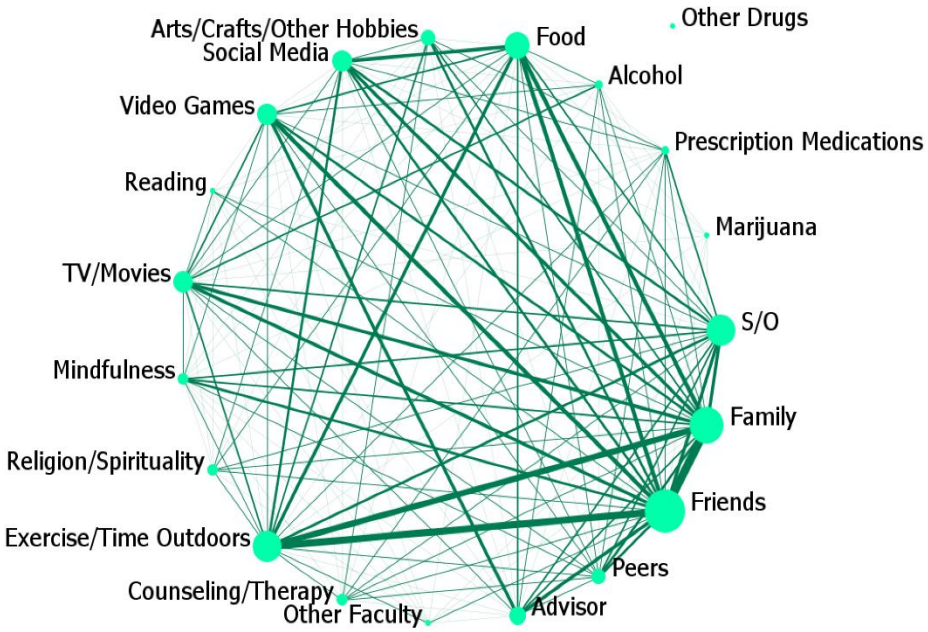

Figure 3. Coping mechanisms for students who self-rated 4–5 out of 5 stars. Node size corresponds to the frequency of each source, and link width corresponds to the number of times each pair of sources appeared together (note: other drugs did not appear in any responses).

Limitations and Future Work

The current data is limited in a few ways. First, it uses a relatively small sample size originating from a single institution, and so few definitive conclusions about stress for engineering graduate students overall can be made. Second, smaller cohorts with the population (*e.g.*, low stress students, poor stress managers, etc.) could not be analyzed using certain statistical analyses and data-mining processes (such as logistic regressions and association rule mining) because of the small sample size. The lack of responses from certain groups (particularly racial and ethnic minorities, students older than 30, parents, and students with disabilities) has unfortunately limited this work's ability to examine stress as experienced by minoritized students, or any intersection of student groups. These limitations of the data can hopefully be overcome with a larger sample. A future direction for the work includes redistributing the survey at other university campuses in the United States.

While the preceding analysis methods reveal interesting patterns in the data, the exact cause and effect at play is not clear. Plans to analyze qualitative data collected in the survey will help researchers develop a more concrete understanding of how graduate students experience and manage their stress.

Conclusions

Graduate student mental health remains an understudied phenomenon in many ways. While there is an agreement that graduate students experience more stress than the general population, the details of their experiences with stress remain unexamined and uncharacterized. This work aims to fill this gap, by examining the primary stressors and coping mechanisms of current engineering graduate students, as well as the major differences in coping networks between students who are able to successfully manage stress versus those who are not able to. These preliminary results found that students who felt they were better at handling stress were most often stressed by research, grades, and mental health, and tended to have a support network of friends, family, and significant others to help them cope with their stress. By contrast, those students who felt they were poorer at handling stress experienced stress from more angles, for example from finances, interpersonal relationships, news, etc., and often fell back on passive coping mechanisms such as watching TV/movies, playing video games, or eating food. Resource networks and association rule mining found that grades, research, and work-life balance appeared together frequently (45% of responses), indicating that students stressed by schoolwork often additionally find themselves struggling to maintain a healthy work-life balance. The preliminary results from this exploratory study can help guide further research into how graduate students experience and manage stress, as well as help faculty and institutions develop possible support measures for graduate students struggling to manage their stress.

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Appendix A

Table A1. Reported sources of stress of graduate students (n = 43), separated by degree program: MS students (n = 19) versus PhD students (n = 26).

Source	Total (%)	MS Students (%)	PhD Students (%)
Research	72.1	63.2	76.9
Mental Health	67.4	63.2	69.2
Work-Life Balance	67.4	73.7	65.4
Grades	62.8	63.2	61.5
Finances	53.5	52.6	50.0
Physical Health	51.2	31.6	65.4
Interpersonal Issues	39.5	42.1	38.5
News	37.2	31.2	38.5
Advisor	23.3	15.8	26.9
Teaching	18.6	10.5	23.1
Social Media	16.3	10.5	19.2
Disability	14.0	10.5	15.4
Caregiving	14.0	15.8	11.5
Department	14.0	5.3	19.2
Discrimination	7.0	0.0	11.5

Table A2. Reported sources of stress of graduate students (n = 43), separated by gender: male respondents (n = 25) versus female respondents (n = 17).

Source	Total (%)	Male (%)	Female (%)
Research	72.1	72.0	70.6
Mental Health	67.4	64.0	76.5
Work-Life Balance	67.4	80.0	52.9
Grades	62.8	64.0	64.7
Finances	53.5	48.0	52.9
Physical Health	51.2	44.0	58.8
Interpersonal Issues	39.5	32.0	52.9
News	37.2	32.0	41.2
Advisor	23.3	24.0	23.5
Teaching	18.6	16.0	17.6
Social Media	16.3	16.0	17.6
Disability	14.0	8.0	23.5
Caregiving	14.0	4.0	23.5
Department	14.0	8.0	17.6
Discrimination	7.0	12.0	0.0

Table A3. Reported coping mechanisms of graduate students (n = 43), separated by degree program: MS students (n = 18) versus PhD students (n = 26).

Source	Total (%)	MS Students (%)	PhD Students (%)
Friends	69.77	83.3	57.8
Significant Other (S/O)	65.12	50.0	73.1
Family	62.79	66.7	57.8
TV/Movies	53.49	44.4	57.8
Exercise/Time Outdoors	51.16	38.9	57.8
Food	48.84	44.4	50.0
Video Games	37.21	33.3	38.5
Social Media	27.91	22.2	30.8
Advisor	27.91	27.8	26.9
Mindfulness	27.91	22.2	30.8
Peers	25.58	22.2	26.9
Counseling/Therapy	23.26	27.8	19.2
Arts/Crafts/Other Hobbies	20.93	16.7	23.1
Religion/Spirituality	16.28	16.7	15.4
Alcohol	16.28	11.1	19.2
Reading	16.28	16.7	15.4
Prescription Meds	11.63	11.1	11.5
Other Faculty	9.30	5.5	11.5
Marijuana	4.65	0.0	7.7
Other Drugs	0.00	0.0	0.0

Table A4. Reported coping mechanisms of graduate students (n = 43), separated by gender: male respondents (n = 24) versus female respondents (n = 17).

Source	Total (%)	Male (%)	Female (%)
Friends	69.77	75.0	70.6
Significant Other (S/O)	65.12	45.8	88.2
Family	62.79	70.8	52.9
TV/Movies	53.49	37.5	76.5
Exercise/Time Outdoors	51.16	54.2	47.1
Food	48.84	50.0	47.1
Video Games	37.21	41.7	29.4
Social Media	27.91	29.2	29.4
Advisor	27.91	25.0	29.4
Mindfulness	27.91	16.7	41.2
Peers	25.58	29.2	23.5
Counseling/Therapy	23.26	12.5	41.2
Arts/Crafts/Other Hobbies	20.93	16.7	29.4
Religion/Spirituality	16.28	12.5	23.5
Alcohol	16.28	12.5	23.5