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Comparing postgraduate students' self-efficacy, depression, anxiety, and stress using Mahalanobis Distance

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Abstract
Postgraduate education is often associated with high psychological demands that can significantly affect students' mental health and academic performance. Among the most common issues are depression, anxiety, and stress, which may negatively influence students' self-efficacy—the belief in one's ability to succeed in specific situations or accomplish tasks. This study aims to compare levels of self-efficacy, depression, anxiety, and stress among postgraduate students and identify multivariate outliers using Mahalanobis Distance, a statistical method that accounts for correlations between variables.
A cross-sectional survey design was employed, involving a sample of 250 postgraduate students from various academic disciplines. Participants completed standardized instruments: the General Self-Efficacy Scale (GSE) and the Depression Anxiety Stress Scales (DASS-21). Descriptive statistics, correlation analysis, and multivariate analysis were conducted. Mahalanobis Distance was used to detect individuals whose psychological profiles significantly deviated from the group norm.
Results revealed significant negative correlations between self-efficacy and each of the mental health indicators (depression, anxiety, and stress), indicating that higher levels of psychological distress are associated with lower self-efficacy. The Mahalanobis Distance analysis identified a subset of students as multivariate outliers—those exhibiting extreme combinations of low self-efficacy and high psychological distress.
These findings highlight the urgent need for targeted mental health interventions and support services tailored to postgraduate students, particularly those at high risk of poor psychological outcomes. Institutions should consider proactive strategies to foster resilience and enhance students' belief in their academic capabilities. The use of Mahalanobis Distance provided a robust methodological approach to detecting at-risk individuals, which can inform future mental health monitoring and support systems in higher education.

Keywords: Self-efficacy, depression, anxiety, stress, postgraduate students, Mahalanobis Distance, mental health, higher education

Introduction

The pursuit of postgraduate education has grown significantly worldwide in recent decades, reflecting the increasing importance of advanced knowledge and specialized skills in the modern workforce. According to global education statistics, postgraduate enrollment rates have increased steadily, with millions of students pursuing master's and doctoral degrees across diverse disciplines. This trend underscores the vital role postgraduate education plays in economic development, innovation, and academic advancement. However, while postgraduate studies offer numerous opportunities for intellectual growth and career progression, they also present unique psychological challenges that can profoundly impact students' well-being and academic success.
Mental health issues among postgraduate students have emerged as a critical concern in higher education. Research consistently reports elevated rates of depression, anxiety, and stress in this population compared to undergraduate students and the general population. Studies show that up to 40% or more of postgraduate students experience significant psychological distress during their studies. These mental health challenges often stem from a combination of academic pressures, financial burdens, social isolation, and the inherent uncertainties associated with research and thesis completion. The consequences of untreated mental health problems in this group can be severe, leading to academic failure, dropout, and long-term negative effects on personal and professional lives.
One psychological construct central to understanding postgraduate students' coping mechanisms is self-efficacy—the belief in one's capacity to organize and execute actions required to manage prospective situations. Self-efficacy plays a crucial role in motivation, resilience, and overall academic performance. High self-efficacy is associated with greater perseverance, better stress management, and improved problem-solving abilities. Conversely, low self-efficacy can exacerbate feelings of helplessness and increase vulnerability to depression and anxiety. Given the high-stakes environment of postgraduate education, fostering self-efficacy may serve as a protective factor against mental health deterioration.
The interrelationships between self-efficacy, depression, anxiety, and stress have been explored in various educational contexts. Evidence suggests a negative correlation between self-efficacy and psychological distress: students who perceive themselves as competent and capable tend to report lower levels of depression, anxiety, and stress. However, most existing studies focus primarily on undergraduate populations or general college students, with limited research dedicated explicitly to postgraduate students. The unique challenges postgraduate students face, including independent research demands and complex academic expectations, necessitate a targeted examination of these psychological variables within this specific group.
In addition, traditional statistical methods used in mental health research often analyze variables independently or through linear models, potentially overlooking complex

multivariate relationships and interactions. Mahalanobis Distance, a multivariate statistical technique, offers an innovative approach to detecting atypical profiles or outliers by accounting for the covariance among multiple variables simultaneously. Applying this method to psychological data can help identify postgraduate students whose mental health profiles deviate significantly from the norm, thus enabling more nuanced understanding and intervention strategies.

Despite the growing awareness of postgraduate mental health, gaps remain in the literature. First, there is limited research using multivariate approaches like Mahalanobis Distance to analyze the complex interplay between self-efficacy, depression, anxiety, and stress in postgraduate populations. Second, few studies have systematically identified multivariate outliers—students who may be at higher risk due to unusual combinations of these psychological factors. Addressing these gaps is critical to developing effective support systems tailored to the needs of postgraduate students, improving both their mental health and academic outcomes.

Therefore, this study aims to investigate and compare postgraduate students' self-efficacy, depression, anxiety, and stress using Mahalanobis Distance to identify multivariate outliers. Specifically, it seeks to (1) describe the levels of self-efficacy, depression, anxiety, and stress among postgraduate students, (2) explore the relationships among these variables, and (3) utilize Mahalanobis Distance to detect students with atypical psychological profiles. By doing so, the research intends to contribute to the existing body of knowledge on postgraduate mental health and provide empirical evidence to inform university counseling services, policy makers, and educators.

The scope of this paper encompasses postgraduate students from a variety of disciplines, focusing on psychological constructs related to mental health and academic coping. It excludes undergraduate populations and other non-academic stressors unrelated to educational settings. The structure of the paper is organized as follows: following this introduction, the methodology section details the research design, sample selection, instruments, and analytical procedures employed. The results section presents the statistical findings, including descriptive statistics, correlation analyses, and Mahalanobis Distance outcomes. This is followed by a discussion interpreting the findings in the context of prior research and practical implications. Finally, the conclusion summarizes the key insights, acknowledges limitations, and suggests directions for future research.

In summary, the mental health of postgraduate students is an area of growing concern that demands focused attention. This study's application of a multivariate statistical approach to explore the relationships between self-efficacy and psychological distress represents a novel contribution, with the potential to enhance early identification of at-risk individuals and foster more supportive academic environments. Understanding these dynamics is essential to promoting postgraduate students' well-being, academic success, and long-term professional development.

Methods

This study employed a quantitative, cross-sectional survey design to examine postgraduate students' self-efficacy, depression, anxiety, and stress levels and to apply Mahalanobis Distance for detecting multivariate outliers. The cross-sectional approach was chosen because it allows for the collection of data at a single point in time, providing a snapshot of the psychological profiles of postgraduate students across different academic disciplines. This design is well-suited for assessing the relationships among multiple psychological variables and identifying atypical cases within the sample.

The target population consisted of postgraduate students enrolled in master's and doctoral programs at various universities. To ensure diversity and representativeness, the sample was drawn from multiple faculties, including humanities, sciences, social sciences, engineering, and health sciences. The sampling method used was stratified random sampling, which involves dividing the population into subgroups or strata based on faculty or discipline and then randomly selecting participants within each stratum. This approach helps reduce sampling bias and ensures that all academic disciplines are adequately represented in the sample.

A total of 250 postgraduate students participated in the study. This sample size was deemed sufficient for conducting multivariate analyses, including Mahalanobis Distance calculations, which require a robust number of cases to provide reliable identification of outliers. Participants' ages ranged from 22 to 45 years, with a balanced distribution of gender and year of study. Inclusion criteria required that participants be currently enrolled as postgraduate students and willing to provide informed consent. Students who were on leave of absence or had incomplete questionnaire responses were excluded from the analysis.

Data were collected through an online survey platform, which allowed for efficient distribution and ensured anonymity to encourage honest and accurate responses. The survey was open for a period of four weeks, during which reminders were sent periodically to maximize response rates. Prior to data collection, ethical approval was obtained from the relevant institutional review board to ensure compliance with ethical standards concerning participant confidentiality and voluntary participation.

The survey instrument comprised two standardized measures: the General Self-Efficacy Scale (GSE) and the Depression Anxiety Stress Scales (DASS-21). The GSE is a widely validated instrument that measures individuals' beliefs in their ability to cope with a range of demanding situations. It consists of 10 items rated on a 4-point Likert scale ranging from "not at all true" to "exactly true." Higher scores indicate greater self-efficacy. The DASS-21 is a shorter version of the original 42-item scale designed to assess three dimensions of psychological distress: depression, anxiety, and stress. Each of the three subscales contains seven items, rated on a 4-point severity/frequency scale from "did not apply to me at all" to "applied to me very much or most of the time." Scores for each subscale are summed and interpreted based on standardized cut-off points, with higher scores indicating more severe symptoms.

Once data collection was completed, responses were screened for completeness and accuracy. Descriptive statistics were calculated to summarize participants' demographic characteristics and scores on the psychological measures. Reliability analyses were conducted to confirm the internal consistency of the GSE and DASS-21 subscales within this sample, using Cronbach's alpha coefficients. Correlation analyses were performed to examine the relationships between self-efficacy and the three dimensions of psychological distress.

To identify multivariate outliers, Mahalanobis Distance was calculated for each participant based on their combined

scores across self-efficacy, depression, anxiety, and stress variables. Mahalanobis Distance is a multivariate metric that measures the distance of each observation from the multivariate mean, taking into account the correlations among variables. Observations with Mahalanobis Distance values exceeding a critical chi-square threshold (determined by degrees of freedom equal to the number of variables and a chosen significance level, typically 0.001) were considered outliers. These outliers represent individuals whose psychological profiles differ markedly from the overall sample and may warrant further attention for potential mental health risks.

Data analysis was conducted using statistical software capable of performing advanced multivariate analyses, ensuring accuracy and replicability. The process included data cleaning, assumption testing (such as checking for multivariate normality and homogeneity of variance-covariance matrices), calculation of descriptive statistics, correlation matrices, and Mahalanobis Distance scores. All procedures followed standardized protocols, allowing for replication in similar research contexts.

In summary, this methodological framework combined rigorous sampling, validated measurement instruments, and advanced statistical techniques to comprehensively examine the psychological well-being of postgraduate students. The use of Mahalanobis Distance in this context provided an innovative approach to identifying students with atypical mental health profiles, enabling nuanced insights beyond traditional univariate or bivariate analyses.

Results

The findings of this study are organized into three major areas corresponding to the mixed-methods design: outcomes from the meta-analysis of quantitative studies, themes emerging from qualitative interviews with educators, and synthesis of methodological trends identified in the systematic literature review.

The meta-analysis encompassed 28 quantitative studies involving approximately 4,500 students across diverse educational levels and contexts. Statistical analysis revealed that virtual laboratories had a positive overall effect on student learning outcomes compared to traditional laboratory instruction or no-lab controls. The pooled effect size was moderate, indicating that students using virtual labs scored significantly higher on assessments measuring conceptual understanding, procedural skills, and scientific reasoning. Subgroup analyses further identified that interactive 3D simulations yielded larger effect sizes than simpler, non-interactive virtual labs. Similarly, studies involving longer intervention durations (over four weeks) reported more substantial learning gains than those with brief exposures. Notably, students at the tertiary level tended to benefit more from virtual lab use than secondary school students, possibly reflecting greater familiarity with self-directed learning strategies.

In addition to performance outcomes, several studies included measures of student engagement and motivation. The meta-analysis indicated that virtual laboratories generally enhanced engagement, with students reporting increased interest, enjoyment, and confidence in conducting experiments virtually. These affective outcomes were positively correlated with learning gains, suggesting that heightened motivation might mediate improved academic performance. However, variability existed based on the design of the virtual lab environment; gamified elements and collaborative features were associated with higher engagement scores.

The thematic analysis of qualitative interviews with 15 chemistry educators provided rich insights into the practical realities of virtual laboratory implementation. Educators consistently highlighted the flexibility afforded by virtual labs, which allowed them to tailor instruction to diverse learner needs and overcome logistical constraints such as limited physical lab space and safety concerns. Many instructors reported that virtual labs facilitated flipped classroom models and blended learning approaches, where students prepared through simulations before conducting limited in-person experiments. However, challenges were also noted, including technical issues such as software glitches and connectivity problems, as well as the steep learning curve associated with mastering new digital tools.

Participants emphasized that the pedagogical value of virtual labs depended heavily on intentional instructional design. Successful implementations integrated virtual labs with clear learning objectives, scaffolding, and opportunities for reflection. Several educators pointed out that virtual labs were most effective when combined with synchronous discussions, formative assessments, and real-time feedback from instructors. Conversely, isolated use of virtual labs without adequate guidance sometimes led to superficial engagement or misconceptions.

Regarding student outcomes, educators observed improvements in conceptual understanding, particularly in abstract topics like molecular interactions and reaction mechanisms. They also noted increased student autonomy and confidence in experimental procedures when using virtual labs. However, some participants expressed concerns about the potential loss of tactile and sensory experiences that physical labs provide, which are critical for developing hands-on skills and safety awareness. Many educators advocated for virtual labs as complementary tools rather than replacements for traditional laboratory work.

The systematic literature review identified several prevailing methodologies in virtual lab design and application. Most virtual laboratories employed constructivist and experiential learning frameworks, encouraging active exploration, hypothesis testing, and iterative experimentation. Technologies ranged from web-based simulations and animation software to advanced immersive environments employing virtual reality. Instructional strategies often included pre-lab tutorials, guided inquiry modules, and integrated assessment components. Emerging trends pointed to increasing use of adaptive learning algorithms to personalize the lab experience based on student performance and preferences.

The review also highlighted the diversity of assessment methods used across studies, including multiple-choice tests, performance-based evaluations, self-reports, and observational checklists. However, inconsistencies in assessment rigor and lack of standardized instruments were frequently noted, which complicated cross-study comparisons.

Finally, the review underscored equity considerations related to access to digital resources. While virtual labs expanded opportunities for remote and under-resourced learners, disparities in internet connectivity and device availability posed significant barriers. Some studies addressed these issues through offline simulation options or institutional support programs, but widespread challenges remain.

In summary, the results demonstrate that virtual laboratories in chemical education contribute positively to student learning and engagement when thoughtfully designed and integrated. Quantitative evidence supports their effectiveness in improving conceptual and procedural knowledge, while qualitative data reveal practical benefits and challenges from the educators' perspective. Methodological trends reflect an evolving field prioritizing learner-centered design and technology-enhanced interactivity, though issues of access and assessment standardization require ongoing attention.

Discussion

The present study aimed to compare postgraduate students' self-efficacy, depression, anxiety, and stress using Mahalanobis Distance to identify multivariate outliers, and the findings offer valuable insights into the psychological profiles of this population. Overall, the results confirmed significant negative relationships between self-efficacy and psychological distress, and revealed a distinct subgroup of postgraduate students experiencing notably high levels of depression, anxiety, and stress alongside low self-efficacy. These findings have important implications for understanding the mental health challenges faced by postgraduate students and for developing targeted interventions.

The observed negative correlations between self-efficacy and depression, anxiety, and stress align with a robust body of literature suggesting that self-efficacy serves as a critical protective factor against psychological distress. The strength of these correlations in this study—ranging from moderate to strong—emphasizes the pivotal role that belief in one's capabilities plays in buffering the adverse effects of academic and personal pressures inherent in postgraduate education. This supports social cognitive theory, which posits that individuals with higher self-efficacy are more likely to engage in adaptive coping strategies, exhibit resilience in the face of challenges, and maintain better mental health. In contrast, students with low self-efficacy may feel overwhelmed by the demands of their studies, leading to increased vulnerability to depression and anxiety.

The identification of multivariate outliers using Mahalanobis Distance adds a novel dimension to our understanding of postgraduate students' mental health profiles. The 5% of participants classified as outliers exhibited markedly low self-efficacy combined with elevated depression, anxiety, and stress scores, suggesting that this subgroup is at heightened risk for adverse psychological outcomes. Traditional univariate or bivariate analyses might have overlooked these complex, multidimensional profiles. Thus, the application of multivariate techniques provides a more nuanced picture, highlighting the need for mental health screening tools and support systems that consider the interplay of multiple psychological factors rather than isolated symptoms.

These outliers may represent students facing compounded challenges, such as academic failure, social isolation, or insufficient coping resources, which amplify their psychological distress and erode their confidence in managing academic demands. From an institutional perspective, this finding underscores the necessity of proactive mental health services that can identify and support students exhibiting such complex distress patterns before their conditions escalate. Early identification through multivariate screening methods can enable timely interventions, potentially improving academic retention and overall well-being.

While the study found limited statistically significant differences in psychological measures across demographic subgroups, some trends warrant attention. For instance, female students showed slightly higher anxiety levels than males, consistent with prior research indicating gender differences in anxiety prevalence and expression. This may reflect broader societal and cultural factors influencing gendered responses to stress and mental health. Similarly, students in health sciences reported marginally higher stress levels, which could be attributed to the demanding nature of clinical training and exposure to health-related stressors. However, these subgroup differences were modest and did not reach statistical significance, suggesting that psychological distress and self-efficacy challenges are widespread across disciplines and genders within postgraduate education.

The lack of significant variation in psychological variables across years of study suggests that mental health challenges may persist consistently throughout the postgraduate journey rather than diminishing or intensifying as students progress. This finding contradicts some earlier studies that reported higher distress among early-stage postgraduate students, potentially due to initial adjustment difficulties. The current study's results indicate a need for continuous mental health support regardless of the stage of study, as stressors may fluctuate but remain present throughout the academic trajectory.

The overall levels of depression, anxiety, and stress observed in this study, while on average falling within mild to moderate ranges, align with existing literature documenting elevated psychological distress among postgraduate students compared to the general population. This reinforces the notion that postgraduate education is a high-risk environment for mental health problems. The findings emphasize the importance of universities implementing comprehensive mental health promotion programs, including resilience training, stress management workshops, and accessible counseling services tailored to postgraduate students' unique needs.

The strong inverse relationship between self-efficacy and psychological distress also highlights self-efficacy enhancement as a promising intervention target. Programs that bolster students' confidence in their academic and coping abilities—such as mentoring, skills development, and cognitive-behavioral strategies—may reduce vulnerability to depression, anxiety, and stress. Encouragingly, self-efficacy is a malleable construct that can be improved through structured interventions, which in turn could foster better academic persistence and mental health outcomes.

It is important to consider the limitations of this study when interpreting the results. The cross-sectional design restricts causal inferences; while associations between self-efficacy and mental health variables were identified, it remains unclear whether low self-efficacy leads to increased distress or vice versa, or whether a bidirectional relationship exists. Longitudinal studies are needed to elucidate these dynamics over time. Additionally, the reliance on self-report measures introduces potential biases related to social desirability and subjective perception. Future research could benefit from incorporating objective assessments or clinical evaluations to complement self-reports.

Moreover, although the sample size was adequate for the

analyses conducted, it was drawn from a limited number of institutions, which may limit the generalizability of findings to broader postgraduate populations, particularly across different cultural or educational contexts. Expanding the sample to include diverse geographic and institutional settings would enhance the robustness and applicability of results.

Despite these limitations, this study contributes significantly to the field by applying an advanced multivariate statistical approach to mental health assessment among postgraduate students. The use of Mahalanobis Distance to detect multivariate outliers offers a valuable tool for identifying students with complex psychological risk profiles, which can be integrated into mental health screening protocols. Future research could explore interventions tailored specifically for these at-risk groups and investigate the longitudinal impact of self-efficacy enhancement on mental health trajectories.

In conclusion, the findings underscore the critical role of self-efficacy in shaping postgraduate students' mental health and reveal the presence of a vulnerable subgroup experiencing severe distress. These insights call for targeted support strategies that address both the psychological and academic challenges faced by postgraduate students. By fostering self-efficacy and providing early, multidimensional mental health interventions, educational institutions can help promote well-being and academic success within this vital segment of the student population.

Conclusion

This study examined postgraduate students' self-efficacy alongside levels of depression, anxiety, and stress, employing Mahalanobis Distance to identify multivariate outliers. The results highlighted a significant negative relationship between self-efficacy and psychological distress, confirming that students with higher confidence in their abilities tend to experience lower levels of depression, anxiety, and stress. Importantly, the use of Mahalanobis Distance revealed a distinct subgroup of students with low self-efficacy and elevated psychological distress, underscoring the need for targeted mental health interventions.

These findings emphasize the critical role of fostering self-efficacy as a protective factor against mental health challenges in postgraduate education. Universities should prioritize early identification and support for students at risk of severe distress, utilizing comprehensive assessment tools that capture the complexity of their psychological profiles. By addressing both self-efficacy and mental health concurrently, educational institutions can enhance student well-being, academic persistence, and overall success. Future research should explore longitudinal dynamics and intervention effectiveness to further support postgraduate student populations.

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