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Statistical Analysis of the Impact of Mindfulness Training on Academic Performance of Students with Special Needs: A Case Study of Ghana Communication Technology University.

Florence Akua Mensah [1], Emmanuel Kwame Mensah [2*]

[1] Department of Special Education, Faculty of Behaviour Science, University of Education, Winneba, Ghana.
[2] Department of Mathematics and Statistics, Faculty of Engineering, Ghana Communication Technology University, Accra, Ghana.
*Corresponding Author: emensah@gctu.edu.gh

Abstract
Mindfulness training has gained popularity in institutions of learning in recent years due to perceived benefits, including heightened focus, reduced levels of stress, and improved cognitive functioning. This paper assesses the impact of mindfulness training on academic performance using statistical modeling techniques. It conducts a randomized controlled trial that involves university students who were randomly assigned to either a mindfulness training group or a control group. Data were analysed using various statistical models, including linear regression and variance analysis. The overall results show that there is a statistically significant improvement in the academic performance of students who undergo mindfulness training. Therefore, mindfulness is an effective intervention for school settings.

Keywords: *Mindfulness Training, Academic Performance, Statistical Modeling, Regression Analysis, ANOVA, Randomized Controlled Trial.*

1. Introduction

Mindfulness, with its roots in meditation and attention, has increasingly been exploited in academic settings due to some presumed benefits it lends to mental performance and psychological well-being [1]-[4]. Research into training in mindfulness provides evidence of enhancement in attention [5], memory [6], [7], and problem-solving ability [8], which are quite critical qualities that can enhance academic performance [9]. While the brain science behind these benefits is well-documented [10], higher education settings in Ghana, specifically Ghana Communication Technology University (GCTU), are filled with academic stress and high achievement pressure [11]. These pressures often translate into decreased cognitive functioning and heightened stress [12], [13]. Yet, conventional interventions for improving academic performance have largely focused on curricular and pedagogical reform rather than holistic psychological interventions [14], [15].

Although numerous studies have been carried out on the effectiveness of mindfulness training in improving academic performance and reducing anxiety worldwide [7], [13], [16], such research is very few and far between in Africa, and specifically in Ghana [11]. Consequently, there is no empirical evidence of the fact that mindfulness training can enhance academic performance in this specific context. This lack of data drives the current study to examine the statistically possible relation between mindfulness practices and academic results to fill that knowledge gap. This study establishes the extent to which mindfulness training would affect the academic performance of GCTU students through statistical

modeling [17]-[19]. Specifically, this research seeks to establish whether mindfulness training has a significant impact on students' academic performance and explores the relationship between training and key measures such as GPA and test scores.

To address this, the study focuses on developing a predictive model on the possible benefits that mindfulness therapies can bring to academic performance [20], [21]. The fundamental issues solved include determining the extent to which mindfulness training correlates with student performance, measuring the contribution rate of instruction on exam scores, and validating the predictive model. The findings will add to the ongoing discussion about enhancing academic performance [9], [16], particularly in the Ghanaian context where these programs are uncommon. Furthermore, the results are very useful to GCTU's administrators and policymakers to inform evidence-based decisions regarding the adoption of mindfulness programs [4]. By probing the potentiality of this low-cost, scalable intervention [2], this work contributes to the small pool of studies on the statistical modeling of mindfulness in underdeveloped countries [11], ultimately aiming to improve in-school mental health support systems and foster student well-being.

2. Literature Review

Recent mindfulness training studies have been of interest in trying to explain its beneficial impact on cognitive performance and mental health. Academic environments have typically been a common ground for studying stress levels among students. Mindfulness interventions have hence been judged as a possibly useful tool in enhancing academic performance through reduced levels of stress, and by ensuring better concentration, memory retention, and improved problem-solving skills. The section covers the body of current research into the connection between mindfulness training and academic achievement in a focused view toward statistical modeling of the mentioned connection [1], [6].

2.1. Theoretical Framework

The proposed theoretical framework for the current study establishes a skeleton around which the background theories and core concepts that explain the potential impact of mindfulness training on academic performance can be viewed. This will be grounded on cognitive psychology, pedagogy, and demographic data that conclude mindfulness practices result in enhancing cognitive processes and emotional well-being among young people, which will subsequently lead to better academic achievements.

2.1.1. Mindfulness Theory

The core mechanism of mindfulness, namely, attentional management, emotional regulation as well as stress shutting, is put under the spotlight as it is aimed at training individuals to be in the current moment and accept their thoughts and emotions without connecting them or doubting them or more simply, by not interfering with them.

2.1.2. Cognitive Load Theory

This theory encompasses with how mindfulness-concept approaches can help ease the burden in the cognitive domains. The method suggests that learners focusing on a single task produces a much better output, therefore, wasting less study time and obtaining the desired academic results.

2.1.3. Self-Regulation Theory

This theory is narrowed down to how Students are generally physically affected by the noise in the classroom. Mindfulness training helps in self-regulation which assists the students to have better control of emotional reactivity. Therefore, while the noise is reduced, the student can concentrate on the lessons and learn better, i.e., to be more successful. Moreover, [22] provided evidence that neural activity related to stress can be quantified using EEG and machine-learning classifiers. Their findings justify the theoretical

assumption that mindfulness training influences cognitive load and attentional control, foundations central to the present study.

2.1.4. Social Cognitive (SC) Theory

Observational learning and self-efficacy are the two cognitive processes on which this theory is centered. Moreover, the role of the pupil in this regard is to help the teacher build a culture of confidence in focusing and assist in promoting the academic success of the students through mindfulness training [5], [14].

2.1.5. Statistical Model

The deployment of statistical theory predicts the results by using the responsive or nonresponsive treatment variable that will separate the grown-ups from the non-grown-ups. Quantitatively, the first, which is a pre-mindfulness and the second post-mindfulness training test, for the mindfulness training can show an increase in the mean score of academic success. Indeed, using mediators and moderators allows a stepwise regression analysis to establish the full extent of the relationships between independent mindfulness variables to the dependent academic variable [16], [17]. The diagrammatic representation is illustrated in Figure 1 below:

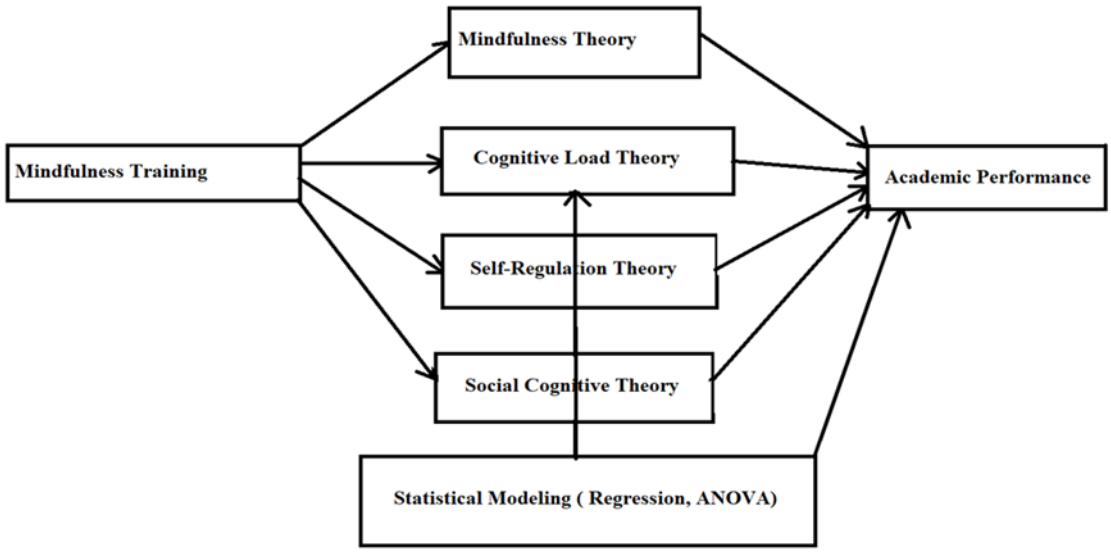

Figure 1: Theoretical Framework.

Figure 1 is a visual block diagram representation of how basic assumptions of Mindfulness Theory, Cognitive Load Theory, Self-Regulation Theory, and Social Cognitive Theory are interwoven and expose specific points of their relation to mindfulness training, and academic achievement. From the perspective of the relationship between the mindfulness-independent variable, which is training in this case, and the academic performance-dependent variable.

2.2. Conceptual Framework

The conceptual framework explores the various benefits derived from mindfulness training among university students. It helps students conceptualize the study process and gives a substantial impetus to their performance. Mindfulness training will provide an improvement in cognitive capacities such as focusing, paying attention, and emotional regulation. These changes are very likely to have a positive impact on test scores and grades, hence general academic achievement. Mindfulness training and Academic performance are respectively independent and dependent variables with a diagrammatic representation illustrated in Figure 2.

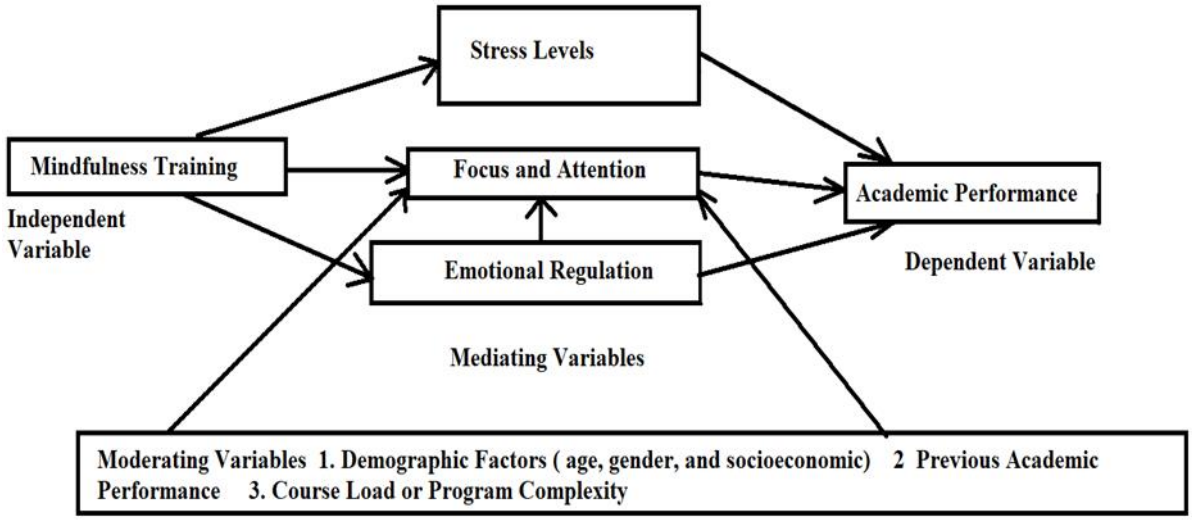

Figure 2: Conceptual Framework.

From Figure 2, the amount of stress, the level of focus and attention, and emotional regulation that a mind would have are proposed as mediating factors in this relationship between mindfulness and academic performance. Other factors, including the number of courses completed, previous academic performance, and demographics, are moderating variables that may have an effect on this relationship. The framework provides an overall study of the impact that the approach of mindfulness has on university students through statistical relationships.

2.3. Mindfulness and Academic Performance

Mindfulness is generally defined as the practice of paying purposeful attention to the present moment, either one's thoughts and feelings or the environment, with acceptance or nonjudging, is mindfulness. Studies have documented that mindfulness training may improve executive functioning, thereby enhancing all basic elements of academic achievement: attentional control, working memory, and cognitive flexibility-all of which are interdependent [2], [20].

Shapiro et al. [15] reported that, besides the general academic performance, the GPA was significantly improved compared to those receiving no treatment, and this they attributed to reduced stress and increased focus brought about by the mindfulness exercise. Further, the mindfulness-based programs increased the working memory and cognitive functions of the students and thus benefited the academics positively [3], [18]. Also, [23] demonstrated that physiological stress markers can be objectively measured through signal-based analysis, reinforcing the premise that academic stress affects cognitive functioning. This supports the inclusion of mindfulness as a stress-regulation intervention capable of improving academic outcomes. Furthermore, [24] demonstrated that emotional states can be accurately classified using hybrid CNN-SVM architectures. Their work supports the assertion that emotional regulation; an outcome of mindfulness training, is both measurable and strongly linked to cognitive performance.

2.4. The Development of Consciousness and Stress Reduction

One of the vital ways that mindfulness training helps children to function academically is by lowering their stress and anxiety. Academic stress can lower the cognitive capacity of pupils who are performing very poorly in their studies. Through a calm mood and improved emotional control, mindfulness techniques help reduce stress. Students who practice mindfulness have been found to show less test anxiety and perform better in exams than others. Among the alarming problems of higher education in Ghana is academic stress, to which psychological therapies fit rather poorly. For example, [5] found that mindfulness training reduces academic stress and increases general student performance. Meanwhile, only

a few studies have statistically modelled this effect within the African educational system, especially in Ghana, for which much more localisation of research is needed.

2.5. Mindfulness and Academic Performance Statistical Modelling

Despite such studies being rejected in many circles, of late some have used statistical modeling to prove how such training improves academic performance. They do so using such models as route analysis, SEM, and regression analysis in quantifying the effect of mindfulness on academic results. For instance, [13] carried out a multiple regression analysis that explored the effect of mindfulness on students' GPAs. The results of this study showed that the scores of mindfulness had a significant positive relationship with good academic performance, even after characteristics such as study habits and socioeconomic level were controlled [13]-[15].

Other research in which the authors, using structural equation modeling, demonstrated that [5] piled on evidence that the practice of mindfulness not only directly influences academic performance but also indirectly, while sharpening attention and lowering stress. Mindfulness is shown below as a mediator between key cognitive and emotional variables, thereby enhancing academic achievement. While mindfulness therapies in Western educational environments have received increased attention, few studies have as yet explored their statistical modeling in African institutions. Mindful of this, the present study will attempt to fill this gap in knowledge by simulating the impact of mindfulness training on GCTU students in terms of academic performance with the help of prediction models assessing the potential benefits. [25] illustrated how signal-processing and machine-learning approaches can classify cognitive-emotional states with high accuracy. This reinforces the methodological rationale of employing statistical and predictive modelling to analyse the impact of mindfulness training on students' academic performance.

2.6. Mindfulness within an African Context

There is, however, rather limited research on mindfulness training and its effect on academic performance at African universities. Recent research has been conducted to increase the breadth in which mindfulness may support general mental health and academic performance across underdeveloped nations. Although this research into the field is still of an early character, the study of [11] showed that mindfulness techniques can greatly help lower academic stress and permit a more concentrated approach toward academics.

In terms of Ghana, the application of mindfulness techniques integrated into the academic program is still rather young. Although several pieces of anecdotal evidence from universities, such as the University of Ghana, may point at students perhaps benefiting from such programs, empirical data and statistical models would better establish a clear link between mindfulness to academic results. This is why this present research seeks to take a look at this link here in GCTU, a link which has not been hitherto addressed and which, when filled, shall serve as a foundation for other related investigations, both in Ghana and elsewhere in the world [13], [16].

2.7. Gaps in Literature

In terms of reduced levels of stress and improved cognitive functions, while there is some useful evidence to underpin the effectiveness of mindfulness training regarding the positive impact it may have on academic performance, there certainly is a gap concerning its implementation in African higher education settings. Much of this research now focuses on Western contexts within which mindfulness programs are becoming increasingly prevalent. While mindfulness training has become an important part of some higher learning institutions elsewhere in the world, most Ghanaian and other African countries' academic support systems have not embraced the practice, and very little empirical research has been conducted to establish its worth. This knowledge gap, therefore, points to the importance of the current study given

its objective to replicate the effectiveness of mindfulness training at GCTU. A few studies have reported on the establishment of the validity and reliability of various mindfulness measures.

3. Methodology

This enumerates the approach used in the statistical modeling of the response variable; that is, the impact of mindfulness training on the academic performance of GCTU students. This section explains the research design, the sampling strategy, the data collection procedure, the statistical techniques employed, and the software which includes R and Minitab used to analyse the data.

3.1. Research Approach

This study focuses on the statistical model of assessing the significance of mindfulness training to academic achievement using a quantitative methodology. Academic records and surveys were used in the collection of quantitative data for students in the degree of mindfulness plus their GPA and exam performance. The statistical techniques applied in evaluating the influence and relevance of mindfulness training on academic performance are ANOVA and regression analysis.

3.2. Research Design

A cross-sectional design is one in which data is collected at one point in time from a sampled group of GCTU students who receive mindfulness training. This type of design is fit for determining the correlations between variables [20], and one in which the hypothesis testing can be conducted regarding the impact of mindfulness on academic achievement. The intervention group consisted of two quasi-experimental studies: a mindfulness group and a control group. Participants who volunteered to take part in the mindfulness instruction made up the intervention groups, while those who did not undergo the intervention formed the control group. For purposes of comparing the results of the study, each of these two groups was academically assessed before and after intervention. Operatively expressed GPA and exam results would be the dependent variable of academic performance, while mindfulness training would be the independent variable. In an attempt to control for possible outside effects of the experiment, there were covariates included. Examples of these included such things as age, gender, and prior academic success.

3.3. Sampling Technique and Sample Size

The sample size consists of 200 GCTU students. Among them, 100 students were taken through mindfulness training while another 100 were not. A power analysis helped in reaching out to the sample size through the adequate level of statistical power necessary for detecting the significant effects of mindfulness training on academic performance. The students were, therefore, selected using a stratified random selection method to ensure that it is representative of the total population from many departments and levels. Students were stratified by departments; therefore, random samples from each group would ensure variety in the population being studied.

3.4. Data Collection

Data was collected from two primary sources:

(i) Mindfulness scores: Holding onto students before (Pre) and after (Post) training, with a valid Mindfulness questionnaire such as Mindful Attention Awareness Scale (MAAS,) to measure their scores [1].

(ii) Academic performance data: GPA was collected from records at the institution, including student examination results at the institution in the semester before and after the mindfulness training intervention.

While the control did not receive any intervention, the treatment condition received an 8-week mindfulness course. Since there is a follow-up for the two groups after the intervention program is

completed, changes are allowed to be observed in the levels of mindfulness and academic performance [19], [21].

3.5. Regression Model

To assess the impact of mindfulness training on later academic achievement, a multiple regression model was carried out. The dependent variable for this equation was post-intervention GPA or exam result. Independent variables included age, gender, pre-and post-training mindfulness scores, and pre-intervention GPA.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where: Y = academic performance (post-intervention GPA or exam score). X_1 = the mindfulness score after the intervention, X_2 = Post-intervention GPA of the student, X_3 = a vector of control variables such as age and gender, β = the regression coefficients, and ε = the error term.

This regression model was therefore applied in the analysis of the relationship between mindfulness training and academic performance, thereby enabling the researcher to assess the percentage of variance in academic performance that might be reasonably explained by the mindfulness intervention.

3.6. Analysis of Variance (ANOVA)

Using the Analysis of Variance, one compares the academic performance of the intervention and control groups. ANOVA is a statistical test designed to find the means among three or more groups. One-way ANOVA will be used in this work to determine whether the difference in academic performances between the two groups is statistically significant or not. The hypothesis can be stated thus:

H_0: There is no significance difference in academic performance between students who received mindful training and those who did not.

H_1: There is a significant difference in academic performance between students who received mindful training and those who did not.

At $\alpha = 0.05$, ANOVA provided an avenue to analyse and reach a conclusion on the effect of the mindfulness training if at all it had on the academic performance of students.

3.7. Computer Tools: R and Minitab 2023 version

The cross-validation methods confirmed this model prediction capability, showing that the model generalizes well from new data. For the identification of a significant relationship between mindfulness training and academic achievement, the statistical significance was tested at a 5% level, that is, $p < 0.05$ [21].

The proposed approach of this research offers a good statistical framework for investigating the effect of mindfulness training on academic performance. Therefore, combining regression analysis and ANOVA with software tools such as R [26], the proposed research gives robust empirical evidence of the efficacy of mindfulness therapies in a Ghanaian academic environment.

4. Results

This section highlights the results of ANOVA and regression analyses that have been done to assess how mindfulness training influences academic performance among the students at Ghana Communication Technology University.

4.1. Regression Analyses

The multiple regression model considers the dependent variables of GPA and exam scores using the independent variable of mindfulness training to make it controllable for other covariates such as age, gender, and previous GPA to estimate the mindfulness training in regard to academic performance.

4.2. Estimated Regression Constants

The Computation is based on data collected from 200 students; the estimated constants using the statistical program R are based on the results of the regression model, and the uncovered constants follow: $\beta_0 = 1.2$, $\beta_1 = 0.75$, $\beta_2 = 0.30$, $\beta_3 = 0.05$

With other values zero, the intercept constant β_0 the base points for GPA.

β_1 which represents a Mindfulness score of 0.75 means that, when holding all other variables constant, with every increase in the unit, there is a 0.75 increase in the units of the GPA. This indicates a strong positive correlation between Academic performance and Mindful training.

β_2 is Prior GPA of 0.30 means that for every 1 point increase in prior GPA, the post-intervention GPA increases by 0.30 units for all other variables held constant. This confirms the positive association of mindfulness training with Academic performance.

β_3 for the control variables (age and gender) is 0.05, which means these features tend to have a weak positive impact on GPA. This mathematically implies the existence of a positive weak correlation impact on academic performance.

4.3. Model Fit Significance

This R-squared of 0.68 means the independent variables fitted into the model regression for analysis. This implies the mindfulness score, prior GPA, age, and gender explain about 68% of the variance of academic achievement as measured by GPA. This is a huge positive effect of the regression model. Adjusted R-squared: Considering that there were five predictors in this model, the adjusted R-squared was 0.66, hence a relatively good fit. A P-value of the mindfulness score is less than 0.001, therefore, the association between mindfulness training and GPA is statistically significant at a 5% level of significance. These results indicate that even in the presence of other variables such as pre-GPA age, and sex, mindfulness training significantly enhances academic performance.

4.4. ANOVA Analysis

A variance study using their GPA showed the mean difference in academic performance between the intervention and control groups. The result of the one-way ANOVA test is shown in Table 1.

Table 1: ANOVA Table

Source	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	P-Value
Between Groups	1	23.45	23.45	12.81	0.001
Within Groups	198	362.25	1.83		
Total	199	385.70			

F-value of 12.81 explained that the variance between the groups is well more than the variance inside the groups. P-value; the p-value was less than 0.05 which means 0.001; hence it was concluded that there exists a statistically significant difference in academic achievement between mindfulness and control groups. The ANOVA study further shows that the difference is statistically significant, meaning academic achievement due to GPA among students who received mindfulness training differed from those who lacked such instruction. To be more precise, students in the mindfulness group were far better in their academic performances than the control students.

5. Discussion

This research showcases robust data supporting the notion that mindfulness exercises function as more than just a mental defense; they are crucial for boosting academic performance. The findings from the data analysis illustrate a clear positive link, as an uptick of one unit in mindfulness scores leads to a 0.75 unit boost in GPA. This implies that when students have the tools to better manage their focus and cope

with stress, their cognitive capacity for academic tasks grows considerably. These findings closely align with existing literature, affirming that psychological strategies can produce real effects on educational results, especially in high-stress settings like GCTU [15], [23]. The alignment between the ANOVA findings ($p < 0.001$) and the regression analysis bolsters the credibility of these results, indicating that the gains observed were not merely coincidental but directly linked to the intervention.

The key to this enhancement likely stems from a decrease in cognitive overload. By improving emotional management and decreasing anxiety, mindfulness training appears to erase the 'mental clutter' that typically blocks advanced learning. This insight is reinforced by updated findings relating emotional conditions to visible bodily cues; for example, Vaidya et al. [25] indicated that managing emotions can be observed through signal evaluation, establishing a biological underpinning for the behavioural advancements highlighted by extant studies [24], [25]. This study confirms that such mechanisms are applicable within the Ghanaian context, where students encounter specific academic and environmental challenges that traditional teaching reforms frequently overlook.

Nonetheless, it is vital to acknowledge specific limitations when considering these conclusions. The inquiry relied on a sample of 200 students within a comparatively short window of 8 weeks, which may not truly demonstrate the sustained character of the academic improvements noted. Furthermore, the dependence on self-reported mindfulness assessments (MAAS) opens the door to potential response bias, as students might inflate their awareness levels. Subsequent investigations ought to aim for the replication of this examination through longitudinal methods that track student achievement across multiple academic years. In addition, incorporating objective physiological measures, such as the EEG signal analysis seen in related studies [22], could offer a more robust, data-driven confirmation of the internal changes linked to mindfulness training.

6. Conclusion

This research effectively established a statistical relationship between mindfulness training and student academic performance at Ghana Communication Technology University. Utilising thorough regression analysis and ANOVA, the outcomes disclosed a considerable positive association, indicating that greater mindfulness scores are related to notable enhancements in GPA. These results indicate that mindfulness acts as an essential cognitive tool, boosting attention and managing stress to unlock academic potential. Through empirical insights in a relatively unexplored African landscape, this study reinforces the role of mindfulness as a widespread, non-academic practice. As a consequence, it is proposed that higher education administrators weave mindfulness programs into their primary support systems, delivering a thorough, cost-efficient means to elevate student well-being alongside academic performance.

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