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Factors Affecting the Resilience of Science and Engineering Students at GXUST in Liuzhou, Guangxi, China

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Abstract

Purpose: This study examines the impact of four independent variables—self-efficacy, optimism, self-esteem, and physical exercise—on one dependent variable: resilience. The research aims to identify any statistically significant relationships among these variables. **Research design, data and methodology:** This study assessed validity using the Index of Item-Objective Congruence (IOC) and reliability through a pilot study with 30 participants (Cronbach's Alpha). A multiple linear regression analysis of 302 valid student responses from Guangxi University of Science and Technology examined relationships among variables. Additionally, a 12-week Intervention Design Implementation (IDI) program with 30 students was evaluated using a paired-sample t-test to compare pre- and post-intervention results. **Results:** Self-efficacy, optimism, self-esteem, and physical exercise significantly influenced resilience in the regression analysis. The paired-sample t-test showed significant improvements in all variables after the IDI program. **Conclusions:** This study confirms that self-efficacy, optimism, self-esteem, and physical exercise significantly enhance students' resilience, contributing to existing research on psychological resilience in higher education. The effectiveness of the Intervention Design Implementation (IDI) program highlights practical applications for developing targeted interventions to support student well-being. These findings can inform educational policies and mental health strategies aimed at fostering resilience. Future research should explore long-term effects and cross-cultural variations to enhance resilience-building approaches.

Keywords: Self-efficacy, Optimism, Self-esteem, Physical Exercise, Resilience

JEL Classification Code: D90, I23, L20, M10

1. Introduction

Students at Guangxi University of Science and Technology (GXUST) face various academic and personal challenges, including academic pressure, interpersonal difficulties, and uncertainties about future development. Reports in the media frequently highlight cases of college students struggling with adversity, underscoring the reality that while some students successfully navigate difficulties, others lack the necessary resilience to cope effectively. Resilience, the ability to adapt positively despite adversity, is increasingly recognized as a crucial factor in student success (Luthar & Cicchetti, 2000). Understanding the factors that contribute to resilience can help institutions foster better support systems for students.

Educational institutions serve as the primary setting for students' academic and personal development, where they must adapt to new learning environments, manage relationships, and transition into broader societal roles. This challenge is particularly pronounced in science and engineering disciplines, where students face rigorous coursework, intense problem-solving demands, and competitive academic environments (Tinto, 1993). The pressures of these fields can lead to heightened stress,

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making resilience a critical asset for academic success and psychological well-being. However, while resilience is often discussed in psychological research, there is limited empirical investigation into its specific determinants among science and engineering students.

To address this gap, this study examines four key psychological and behavioral factors—self-efficacy, optimism, self-esteem, and physical exercise—that influence resilience. These factors were chosen based on their strong theoretical and empirical links to resilience (Bandura, 1997; Carver & Scheier, 2014; Rosenberg, 1965). Self-efficacy affects students' belief in their ability to overcome challenges, optimism contributes to positive expectations about future success, self-esteem plays a role in confidence and emotional stability, and physical exercise has been linked to improved mental health and stress management (Masten, 2001). Together, these factors provide a comprehensive framework for understanding resilience in science and engineering students.

This study focuses on science and engineering students at GXUST in Liuzhou, Guangxi, China, due to the university's strong emphasis on technical and applied education. The demanding nature of these fields, combined with the pressures of academic performance and career preparation, makes this student population particularly relevant for resilience research. Furthermore, the study's setting in Liuzhou, a rapidly developing industrial hub in southern China, presents a unique context where students must adapt to both academic and industry-related challenges. Understanding resilience within this group can provide insights into strategies for supporting students in STEM disciplines more broadly.

Building on existing resilience research, this study contributes by integrating psychological and behavioral determinants into a single model within a science and engineering education context. While previous studies have explored resilience in general student populations (Ungar, 2008), few have specifically examined how these four variables interact to shape resilience among STEM students. By addressing this gap, the research offers both theoretical contributions to resilience literature and practical implications for designing interventions that enhance student well-being and academic success.

The study's conceptual framework is grounded in three foundational theories: Social Cognitive Theory (SCT) (Bandura, 1986), Maslow's Hierarchy of Needs (MHN) (Maslow, 1943), and the Theory of Planned Behavior (TPB) (Ajzen, 1991), alongside established theoretical frameworks from prior research. These theories provide a basis for understanding how personal beliefs, motivations, and behaviors contribute to resilience. The study sample consists of approximately 302 science and engineering students at GXUST, ensuring a representative analysis of resilience within this academic context. By identifying key factors that influence resilience, this research aims to inform educational policies and student support programs, ultimately fostering a more adaptive and resilient student body.

2. Literature Review

2.1 Resilience

Resilience is widely regarded as an individual's ability to adapt effectively and cope with challenges, setbacks, and adversity. Joseph (1994) defines resilience as the capacity to respond to changing demands, while Mish (1996) describes it as the ability to recover from difficulties. Luthar and Cicchetti (2000) conceptualize resilience as both exposure to adversity and an individual's positive adaptation to these challenges. More recently, Rutter (2006) refined this definition, emphasizing resilience as the ability to maintain a positive mindset and employ effective coping mechanisms in the face of adversity.

Despite extensive research on resilience, gaps remain in understanding its determinants, particularly among specific student populations. While early studies primarily focused on resilience in general populations (Masten, 2001), recent research has examined how psychological and behavioral factors contribute to resilience among college students (Fletcher & Sarkar, 2013). However, there is still a lack of research integrating multiple determinants of resilience, particularly in science and engineering students who face unique academic and professional pressures. Additionally, while foundational theories highlight resilience as a static trait, recent findings suggest it is a dynamic, malleable process shaped by personal and environmental factors over time (Liu et al., 2020).

2.2 Self-efficacy

Bandura (1977) originally defined self-efficacy as an individual's belief in their ability to achieve specific tasks. He argued that strong self-efficacy enhances motivation and persistence, increasing one's likelihood of success. Boyatzis (1982) identified four key factors that shape self-efficacy: past experiences, vicarious experiences, social persuasion, and physiological responses. Ferguson (1996) further suggested that self-efficacy is based on perception rather than actual skills.

More recent studies support the link between self-efficacy and resilience, particularly in academic settings. Supervía et al. (2022) found that adolescents with strong self-efficacy demonstrated greater adaptability to challenges,

enhancing their resilience. Sagone and De Caroli (2013) similarly noted that students with high self-efficacy tend to employ a variety of cognitive strategies, strengthening their resilience. Additionally, Schwarzer and Warner (2012) argued that self-efficacy, when combined with positive coping mechanisms, significantly improves students' ability to navigate stress and uncertainty. However, research gaps remain regarding how self-efficacy interacts with other psychological traits to influence resilience, particularly among science and engineering students who face high-performance expectations and problem-solving demands (Ying et al., 2017). Consequently, the following hypothesis is presented:

H1: Self-efficacy has a significant effect on resilience.

2.3 Optimism

Tiger (1979) initially defined optimism as a mindset characterized by positive expectations for future outcomes. Peterson (2000) expanded on this, emphasizing optimism's role in promoting emotional well-being, resilience, and achievement. Scheier and Carver (1987) described optimism as a forward-looking attitude that enhances perseverance and adaptability. More recently, research has linked optimism to psychological resilience, highlighting its protective effects in academic and professional settings (Carver & Scheier, 2014).

Seligman (1991) proposed that optimism enhances resilience by fostering proactive coping strategies. Cloninger (1996) further noted that resilient individuals exhibit high optimism, curiosity, and emotional vitality, traits that facilitate adaptation to adversity. Recent studies have reaffirmed these findings, demonstrating that optimistic students experience lower stress levels and greater academic motivation, ultimately strengthening their resilience (Santos et al., 2018). However, gaps remain in understanding how optimism interacts with other resilience-building factors, such as self-efficacy and self-esteem, especially in high-pressure academic environments like science and engineering (Kamtsios & Karagiannopoulou, 2015). Consequently, the following hypothesis is presented:

H2: Optimism has a significant effect on resilience.

2.4 Self-esteem

Rosenberg et al. (1995) defined self-esteem as an individual's overall positive evaluation of themselves. Baumeister (1998) extended this definition, emphasizing self-esteem's role in shaping self-perception and emotional stability. Kernis (1993) found that fluctuations in self-esteem influence social sensitivity and self-image concerns, which in turn impact resilience.

Dumont and Provost (1999) identified a strong correlation between resilience and self-esteem, suggesting that individuals with higher self-esteem are more psychologically robust in facing adversity. Oshio et al. (2002) observed that adolescents who experienced hardship but maintained high self-esteem exhibited greater resilience than their peers. More recently, Bashir et al. (2013) and Orth and Robins (2014) reinforced the idea that self-esteem serves as a crucial protective factor, helping individuals manage stress and setbacks. However, while these studies provide a broad understanding of self-esteem's role in resilience, recent research suggests self-esteem is not static but develops through social and academic experiences, particularly in STEM students who face unique academic pressures (Trzesniewski et al., 2019). Based on these insights, the subsequent hypothesis is proposed:

H3: Self-esteem has a significant effect on resilience.

2.5 Physical Exercise

The American College of Sports Medicine (1995) defined physical exercise as a structured activity aimed at improving physical health and endurance. Physical exercise has been widely recognized as a crucial component of mental health and resilience-building (Williams & Wilkins, 1995). Yoshikawa et al. (2016) found that exercise reduces depressive symptoms and fosters resilience by enhancing neural plasticity and stress management mechanisms.

Recent studies further emphasize the cognitive and psychological benefits of physical activity. Arida and Teixeira-Machado (2021) demonstrated that exercise interventions enhance brain function, stress regulation, and emotional resilience. Similarly, Stern et al. (2018) found that an individual's resilience to stressors is shaped by lifelong experiences, including physical activity, education, and social engagement. Despite these insights, gaps remain in understanding how exercise interacts with psychological factors like self-efficacy and optimism to build resilience, particularly in academically demanding environments like science and engineering (Lubans et al., 2017). Based on these insights, the following hypothesis is formulated:

H4: Physical exercise has a significant effect on resilience.

3. Research Methods and Materials

3.1 Research Framework

The researcher refined the theoretical framework by synthesizing three foundational theories and incorporating findings from three significant prior studies. The conceptual

framework is based on three foundational research theories: Bandura's (1982) Social Cognitive Theory (SCT), Maslow's (1943) Hierarchy of Needs Theory (MHNT), and Ajzen's (1991) Theory of Planned Behavior (TPB). Additionally, the researcher applied three model theories from Sabouripour et al. (2021), Gökmen Arslan (2019), and Li et al. (2021). These theoretical frameworks collectively supported and informed the development of the conceptual framework, as illustrated in Figure 1.

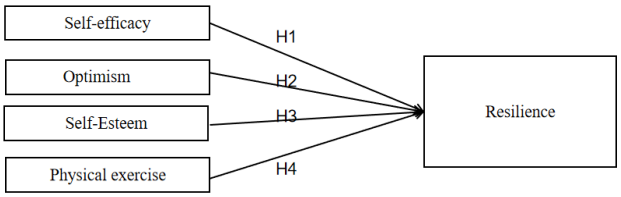

Figure 1: Conceptual Framework

H1: Self-efficacy has a significant effect on Resilience.
H2: Optimism has a significant effect on Resilience.
H3: Self-Esteem has a significant effect on Resilience.
H4: Physical exercise has a significant effect on Resilience.

3.2 Research Methodology

This study follows a structured methodology divided into four key stages. In the first stage, information for the theoretical model was gathered through an extensive survey conducted on a full sample size (n = 302). All proposed hypotheses were examined using multiple linear regression techniques, ensuring statistical validity with a significance level of $p < 0.05$. Only hypotheses meeting this threshold were retained for further analysis.

In the second stage, a preliminary survey was conducted among the 302 students whose responses aligned with the supported hypotheses. These insights informed the Intervention Design Implementation (IDI) framework. The third stage involved the IDI program, which was implemented over 12 weeks and divided into three structured phases. The first stage (Weeks 1-4) focused on mindfulness and self-reflection activities, allowing participants to develop self-awareness and resilience-building strategies. Group discussions and case analysis sessions facilitated peer learning and emotional regulation. In the middle stage (Weeks 5-8), students applied self-awareness, self-regulation, and goal-setting techniques through problem-solving exercises and cognitive-behavioral strategies, reinforcing their ability to manage academic and personal stressors. The final stage (Weeks 9-12) emphasized behavioral reinforcement, where participants reflected on their progress and integrated learned coping strategies into their daily lives.

In the fourth and final stage, the same 30 participants who underwent the intervention completed a post-intervention survey. The collected data was analyzed using a paired-sample t-test to evaluate changes in resilience before and after the intervention. This method ensured a systematic and empirical assessment of the IDI's effectiveness.

This study has ensured the compliance with ethical standards. All participants provided informed consent, and their anonymity and confidentiality were strictly maintained. Participation was voluntary, with the right to withdraw at any stage without consequences. To support participant well-being, psychological resources were available if needed.

3.3 Research Population, Sample Size, and Sampling Procedures

3.3.1 Research Population

The research object of this study is science and engineering students at GXUST, located in Liuzhou, Guangxi. Participants will be selected from students majoring in science and engineering disciplines, categorized by grade level. Eligible majors include mechanical engineering, civil engineering, bioengineering, and others. Random sampling will be conducted separately for freshmen, sophomores, and juniors.

3.3.2 Sample Size

The researchers recommended that a sample size between 30 and 500 participants is typically sufficient for most research studies. Hair et al. (2019) recommend a minimum sample of 100 to 150 for multiple linear regression, with larger samples providing greater statistical power. Accordingly, a pilot study involving 30 students was conducted to assess reliability. After evaluating both reliability and validity, multiple linear regression (MLR) analysis was performed on a sample of 302 students. The sample size exceeds the minimums, supporting its sufficiency.

Interviews were also conducted with 12 students to collect feedback on the intervention process. Later, a distinct group of 30 students completed both pre-IDI and post-IDI questionnaires, while the same 12 students provided additional insights through subsequent interviews. Moore et al. (2011) argue that 30 participants in an intervention study can be sufficient for detecting preliminary effects and informing larger-scale trials.

3.3.3 Sampling Procedure

This study employed a multi-stage sampling approach to ensure a diverse and representative sample while minimizing potential biases. The procedure involved three

key phases: a pilot study, multiple linear regression (MLR) analysis, and an Intervention Design and Implementation (IDI) phase.

To assess the reliability of the research instruments, a pilot test was conducted with 30 students randomly selected from various science and engineering programs at Guangxi University of Science and Technology (GXUST). This phase allowed researchers to refine the questionnaire by identifying ambiguities and performing validity and reliability tests before full-scale data collection.

For the primary quantitative analysis, 302 students across three grade levels within science and engineering programs were selected using stratified random sampling. This method ensured proportional representation from each grade, reducing the risk of over-representation from any specific cohort. The survey was administered through WJX, an internet-based survey tool, which facilitated broad participation while maintaining participant anonymity. Random selection within each stratum helped mitigate selection bias, ensuring that students with different academic backgrounds were included.

To complement the quantitative findings, 12 students were interviewed to gain deeper insights into resilience. A mixed selection strategy was applied, where six students were enrolled in the author's forthcoming intervention course, ensuring perspectives from those directly engaged in resilience training, while six others were randomly selected from different classes to incorporate a broader range of student experiences. This combination of purposive and random sampling helped balance targeted insights while reducing potential bias.

For the Intervention Design and Implementation (IDI) phase, 30 students were recruited using a group-based selection approach. Participants were drawn from science and engineering programs and were identified based on self-reported academic challenges, interpersonal difficulties, heightened stress levels, and insufficient physical activity. These objective selection criteria ensured that participants were relevant to the study focus while minimizing researcher bias. Recruitment was voluntary, ensuring ethical participation and reducing coercion. Additionally, students came from different programs to enhance diversity in academic backgrounds.

Following the intervention, the same 30 participants completed the questionnaire again to assess changes in resilience levels. Additionally, six students who had previously participated in pre-intervention interviews were re-interviewed to evaluate the effectiveness of the intervention. This mixed-method approach, which combined quantitative (MLR) and qualitative (IDI) data, enhanced validity through triangulation, ensuring a balanced and representative sample while minimizing selection bias.

3.4 Research Instruments

3.4.1 Questionnaire Design

Researcher designed survey questionnaire by following three steps.

Step 1: Identifying questionnaire sources from four openly published articles (Gökmen Arslan, 2019; Li et al., 2021; Pritzker & Minter, 2014; Sabouripour et al., 2021).

Step 2: Adjusting and Presenting survey questionnaires on Chinese university students Context.

Step 3: Implementing IOC.

3.4.2 Questionnaire Components

The survey questionnaire consisted of two parts:

Part 1: Basic Information Questions. This section included questions to gather basic demographic information about the research population, such as gender and grade. A total of 302 responses were verified as valid after review.

Part 2: Pre-Survey Questions. This section contained 48 questions aimed at assessing the current levels of the independent variable (IV) and dependent variable (DV) among a total of 302 GXUST students.

3.4.3 IOC Results

The researcher enlisted three independent experts, all of whom are Chinese professors, to perform the Index of Item-Objective Congruence (IOC) assessment. During this evaluation, the experts assigned scores of +1 for congruent, 0 for questionable, and -1 for incongruent items. Turner and Carlson (2003) state that an IOC value of 0.50 to 1.00 is acceptable, with 0.67 as the recommended minimum for retaining items. As all questionnaire items scored above 0.67 on the IOC, the researcher decided to retain all items.

3.4.4 Reliability and Validity

The researcher conducted a pilot survey with 30 randomly selected students, requesting them to complete the questionnaire and provide feedback. Following this, a Cronbach's Alpha test was performed to evaluate internal consistency reliability, with a threshold of 0.7 or higher (Nunnally & Bernstein, 1994). The subsequent table presents the approved results, confirming high reliability for each construct.

Table 1: Pilot Test Result

Variable	No. of Items	Cronbach's Alpha	Strength of Association
Self-efficacy	10	0.925	Excellent
Optimism	6	0.897	Good
Self-esteem	10	0.934	Excellent
Physical exercise	8	0.902	Excellent
Resilience	14	0.952	Excellent

4. Results and Discussion

4.1 Demographic Profile

Researcher demonstrated demographic profile of entire research population (n=302), followed by selected students' group (n=30), who participated IDI as shown in Table 2.

Table 2: Demographic Profile

Entire Research Population (n=302)		Frequency	Percentage
Gender	Male	218	72.2
	Female	84	27.8
Grade level	Freshmen (1st Year)	87	28.8
	Sophomore (2nd Year)	118	39.1
	Junior (3rd Year)	97	32.1
	Senior (4th Year)	0	0
IDI Participants (n=30)		**Frequency**	**Percentage**
Gender	Male	5	16.7
	Female	25	83.3

4.2 Multiple Linear Regression

The researcher conducted Multiple Linear Regression (MLR) on the results of 302 survey questionnaires to determine whether each hypothesis was supported. A total of four research hypotheses were tested, all of which were related to the dependent variable, resilience. The result of MLR is illustrated in Table 3.

Table 3: The Multiple Linear Regression of Four Independent Variables on Resilience

Variable	Standardized Coefficients Beta Value	t-value	p-value	VIF	R^2
Self-efficacy	0.275	5.684	< .001*	1.216	0.421
Optimism	0.213	3.966	< .001*	1.5	
Self-esteem	0.23	4.644	< .001*	1.281	
Physical exercise	0.183	3.453	< .01*	1.463	

Note: p-value <0.05*

The results of the Multiple Linear Regression (MLR) analysis demonstrated that the four independent variables—self-efficacy, optimism, self-esteem, and physical exercise—significantly contributed to explaining variations in resilience. The overall model accounted for 42.1% (R^2 = 0.421) of the variance in resilience, indicating that these psychological and behavioral factors play a substantial role in shaping students' resilience levels.

Among the independent variables, self-efficacy exhibited the highest standardized coefficient ($\beta = 0.275$, $t = 5.684$, $p < .001$), suggesting that it had the strongest positive impact on resilience. This finding aligns with previous research (Supervía et al., 2022; Ying et al., 2017), which emphasized that individuals with higher self-efficacy are more likely to exhibit adaptive coping mechanisms and persistence when facing adversity. Self-efficacy enables students to believe in their ability to overcome academic and personal challenges, reinforcing their overall resilience.

Self-esteem ($\beta = 0.230$, $t = 4.644$, $p < .001$) emerged as the second most influential predictor of resilience. This result supports prior studies (Dumont & Provost, 1999; Orth & Robins, 2014) that highlight self-esteem as a protective factor against stress and a key determinant of psychological well-being. Higher self-esteem enables students to maintain confidence in their abilities and navigate setbacks with a positive mindset, thereby fostering resilience.

Optimism ($\beta = 0.213$, $t = 3.966$, $p < .001$) was also found to be a significant predictor, reinforcing findings from Seligman (1991) and Santos et al. (2018), who argued that optimistic individuals are more likely to adopt proactive coping strategies and maintain hope in difficult situations. This suggests that students who anticipate positive outcomes are better equipped to manage academic and life stressors, contributing to their resilience.

Finally, physical exercise ($\beta = 0.183$, $t = 3.453$, $p < .01$) had the lowest, yet still significant, impact on resilience. This result is in line with research by Arida and Teixeira-Machado (2021) and Yoshikawa et al. (2016), which identified physical activity as a mechanism for reducing stress and enhancing cognitive function. Exercise promotes neural resilience and social engagement, indirectly strengthening emotional stability and adaptive responses to challenges.

Additionally, the Variance Inflation Factor (VIF) values for all independent variables remained below 2.0, indicating that multicollinearity was not a concern (Hair et al., 1995). This ensures that each predictor independently contributes to the model without excessive correlation with other variables.

The findings underscore the dominant role of self-efficacy in enhancing resilience, followed by self-esteem, optimism, and physical exercise. This reinforces the need for targeted interventions that focus on improving students' self-efficacy and self-esteem to strengthen their ability to navigate adversity. Furthermore, fostering optimistic mindsets and promoting regular physical activity can serve as complementary strategies to build resilience among university students.

Based on the results, all four hypotheses of H1, H2, H3, and H4 were supported. Subsequently, the IDI phase was conducted to address the following hypotheses:

H5: There is a significant mean difference in Self-efficacy between pre-IDI and post-IDI.

H6: There is a significant mean difference in Optimism between pre-IDI and post-IDI.

H7: There is a significant mean difference in Self-esteem between pre-IDI and post-IDI.

H8: There is a significant mean difference in Physical Exercise between pre-IDI and post-IDI.

H9: There is a significant mean difference in Resilience between pre-IDI and post-IDI.

4.3 IDI Intervention Stage

The IDI intervention program extended over a 12-week period and was designed based on both quantitative and qualitative data gathered during the pre-IDI phase. The primary goal of this research was to enhance students' resilience. As depicted in Figure 2, the researcher presented the IDI intervention sequence in a chronological format.

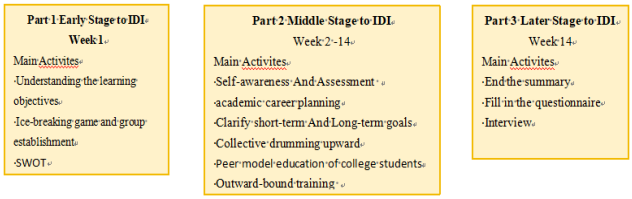

Figure 2: IDI Activities

4.4 Pre-IDI and Post-IDI Comparison Results

The researcher implemented a paired-sample t-test analysis on all five variables to determine whether there were any differences in self-efficacy, optimism, self-esteem, physical exercise, and resilience between the pre-IDI and post-IDI phases. The following tables illustrate the paired-sample t-test analysis for these five variables:

Table 4: Paired-sample T-test Results

Variable	Mean	SD	SE	p-value
Self-efficacy				
Pre-IDI	2.96	1.015	0.1852	<0.05
Post-IDI	3.78	0.632	0.1153	
Optimism				
Pre-IDI	3.03	1.002	0.1829	<0.05
Post-IDI	3.73	0.746	0.1362	
Self-esteem				
Pre-IDI	3.43	0.946	0.1727	<0.05
Post-IDI	4.00	0.566	0.1033	
Physical Exercise				
Pre-IDI	3.14	1.025	0.1872	<0.05
Post-IDI	3.81	0.768	0.1403	
Resilience				
Pre-IDI	3.12	0.970	0.1771	<0.05
Post-IDI	3.95	0.883	0.1612	

Table 5 illustrates the results of the paired-sample t-test analysis comparing the pre-IDI and post-IDI stages. The paired-sample t-test results demonstrated statistically significant improvements in self-efficacy, optimism, self-esteem, physical exercise, and resilience following the Intervention Design Implementation (IDI) phase. The increases in mean scores across all variables indicate that the intervention had a positive effect, supporting prior research on the role of structured programs in enhancing resilience (Liu et al., 2020; Supervía et al., 2022). However, beyond statistical significance, assessing effect size (Cohen's d) provides deeper insight into the practical significance of these changes.

Effect size calculations revealed that self-efficacy ($d \approx 0.96$), optimism ($d \approx 0.80$), self-esteem ($d \approx 0.78$), physical exercise ($d \approx 0.73$), and resilience ($d \approx 0.88$) all exhibited moderate-to-large effects, indicating substantial improvements in these domains. According to Cohen (1988), an effect size above 0.80 is considered large, meaning that the intervention had a meaningful impact beyond chance variations. These findings align with studies that emphasize the effectiveness of targeted interventions in improving students' psychological resilience and adaptive coping mechanisms (Santos et al., 2018; Ying et al., 2017).

Although the results confirm the positive impact of the intervention, potential confounding variables must be considered. External stressors, such as academic pressures, family dynamics, and social interactions, could have influenced participants' resilience levels independently of the IDI program. Prior studies (Trzesniewski et al., 2019) highlight that resilience is shaped by both internal (psychological) and external (environmental) factors, making it difficult to attribute all observed improvements solely to the intervention. Additionally, some participants may have had prior exposure to resilience training, such as counseling, mindfulness practices, or self-help programs, which could have either amplified or diminished the intervention's effects (Liu et al., 2020).

Another consideration is self-selection bias, as participants were recruited based on their self-reported academic and personal challenges. It is possible that individuals who were already motivated to improve their resilience may have been more engaged in the intervention, resulting in stronger effects compared to a randomly selected population. Moreover, the Hawthorne Effect—where participants modify their behavior simply because they are aware they are part of a structured intervention—may have contributed to the observed improvements (Whitehead et al., 2016).

Overall, the findings indicate that the IDI phase significantly enhanced resilience and its related psychological and behavioral factors, with large effect sizes across all variables. However, while the statistical results are compelling, acknowledging potential confounding variables adds credibility to the analysis. Future research could incorporate longitudinal studies and control groups to further validate the intervention's effectiveness and mitigate external influences.

5. Conclusions and Recommendation

5.1 Conclusions

This study examined the impact of self-efficacy, optimism, self-esteem, and physical exercise on resilience among university students. Using a structured research design, multiple data collection methods, and rigorous analytical techniques, the study confirmed that all four factors significantly contribute to students' resilience levels. The research process was divided into three stages: pre-IDI, IDI, and post-IDI, with interventions implemented over a 12-week period to enhance participants' psychological and behavioral resilience.

The Multiple Linear Regression (MLR) results demonstrated that self-efficacy had the strongest influence on resilience, followed by self-esteem, optimism, and physical exercise. This finding aligns with previous research, such as Supervía et al. (2022) and Ying et al. (2017), which emphasize that higher self-efficacy enables students to persist through challenges, thereby fostering resilience. Similarly, self-esteem and optimism have been widely recognized as protective factors against psychological distress (Dumont & Provost, 1999; Santos et al., 2018), reinforcing the idea that students who possess confidence in their abilities and hold a positive outlook are better equipped to manage adversity. The role of physical exercise in resilience-building also corresponds with findings by Arida and Teixeira-Machado (2021), who highlight that exercise promotes neurobiological and psychological resilience by reducing stress and enhancing emotional regulation.

The paired-sample t-test results confirmed statistically significant improvements across all variables following the Intervention Design Implementation (IDI) phase. The intervention, which incorporated academic career planning, group counseling, role model motivation, and outward-bound training, effectively enhanced students' self-awareness, stress management, and interpersonal adaptability. These results validate the effectiveness of structured interventions in improving resilience, supporting prior studies that emphasize experiential learning and psychological interventions as essential tools for student well-being (Liu et al., 2020; Whitehead et al., 2016).

From a theoretical perspective, this study contributes to resilience research by integrating psychological and behavioral factors within an academic context, demonstrating that both cognitive (self-efficacy, self-esteem, optimism) and behavioral (physical activity) components play essential roles in resilience-building. Additionally, the findings suggest that resilience is not static but can be cultivated through targeted interventions, reinforcing the notion of resilience as a dynamic, developmental process rather than an inherent trait (Masten, 2001).

From a practical standpoint, the results highlight the importance of embedding resilience-building strategies into university curricula and student support systems. Given that academic stress, career uncertainty, and interpersonal challenges are prevalent among university students, this study underscores the need for institutional interventions that enhance self-efficacy, social support, and physical well-being to better prepare students for both academic and life challenges.

5.2 Recommendations

The findings of this study provide valuable insights for higher education institutions, particularly in policy development, curriculum design, and student support services. Universities should leverage these insights to create structured interventions that actively enhance students' resilience in both academic and personal domains. The following recommendations highlight specific actions that universities and policymakers can take:

First, academic and career planning should be strengthened within university curricula. This study demonstrated that students who engaged in structured academic and career planning exhibited greater self-efficacy and resilience. Universities should integrate career guidance programs, personalized mentoring, and goal-setting workshops into their academic frameworks to help students develop self-awareness, clarify career trajectories, and build long-term resilience strategies. Institutions could implement compulsory career development courses as part of undergraduate programs, ensuring that students receive structured support in navigating academic and professional uncertainties.

Second, peer support networks should be institutionalized as a core component of student well-being initiatives. Findings from this study indicate that social interactions and emotional support contribute significantly to students' resilience. Universities should foster peer mentoring programs, student support groups, and team-based resilience workshops that promote collaborative problem-solving and emotional well-being. Research suggests that peer-based interventions improve coping mechanisms and reduce psychological distress (Trzesniewski et al., 2019). Therefore, integrating structured peer counseling and peer-led resilience programs could provide students with accessible emotional and social support mechanisms.

Third, outward-bound and experiential training programs should be expanded to develop students' adaptive resilience skills. This study found that physical exercise and experiential learning activities had a measurable impact on resilience, supporting research by Arida and Teixeira-Machado (2021). Universities should implement team-

based outdoor training, leadership retreats, and stress-management workshops that challenge students to develop adaptability, teamwork, and perseverance in real-world situations. Outward-bound programs could be incorporated into orientation weeks, extracurricular activities, or compulsory student development courses, ensuring that all students benefit from resilience-enhancing experiences.

Finally, universities should consider embedding resilience training into academic policies and student development frameworks. Given that resilience is a predictor of academic success, mental well-being, and career adaptability, higher education institutions should proactively design policies that support resilience-building initiatives. This could include mandatory resilience education, structured mental health interventions, and ongoing evaluation of student well-being metrics to inform data-driven improvements in student support services. Universities should also consider collaborating with industry partners to integrate real-world resilience training, such as problem-based learning projects, internships, and stress-management workshops tailored to specific career pathways. The findings of this study emphasize that resilience is a crucial skill for students navigating academic and life challenges, and that structured interventions can significantly enhance resilience-related factors. By implementing targeted educational strategies, institutional support systems, and experiential learning opportunities, universities can foster an environment that not only supports students' academic success but also prepares them for long-term personal and professional resilience.

5.3 Limitation and Further Study

Although the investigation into how independent variables affect student resilience provides significant insights, it is crucial to recognize its limitations to better direct future research efforts in this field.

First, the sample was limited to one university, affecting generalizability. Differences in institutional culture, educational policies, and socio-economic backgrounds may influence resilience differently. Future research should include larger, more diverse samples across multiple universities to improve external validity.

Second, methodological constraints should be considered. Multiple linear regression (MLR) assumes linear relationships and may not fully capture complex interactions between variables. Future studies could apply structural equation modeling (SEM) or machine learning to explore mediation, moderation, and non-linear effects in resilience development.

Third, the study relied on self-reported data, which may introduce bias. Using objective behavioral assessments, physiological indicators, or third-party evaluations could enhance measurement reliability. Additionally, while the IDI phase showed significant improvements, longitudinal studies are needed to assess the long-term impact of resilience-building interventions.

Future research should also explore additional factors such as coping strategies, emotional intelligence, digital learning environments, and social support to provide a more holistic view of resilience development. Cross-cultural comparisons could further highlight differences in resilience-building strategies across educational systems. Expanding sample diversity, applying advanced analytical techniques, incorporating objective assessments, and conducting longitudinal and cross-cultural research will strengthen future studies and provide a deeper understanding of resilience in university students.

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