

The Impact of Physical Exercise on Learning Engagement among Vocational College Students: The Mediating Role of Academic Self-Efficacy and the Moderating Role of Psychological Resilience

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Received August 15, 2025; **Revised** September 18, 2025; **Accepted** September 30, 2025

Abstract

This study aimed to (1) investigate the impact of physical exercise on learning engagement among vocational college students; (2) examine the mediating role of academic self-efficacy in this relationship; and (3) explore the moderating role of psychological resilience in strengthening the link between self-efficacy and engagement. The sample consisted of 872 vocational college students from four institutions in eastern China. They were selected through a cross-sectional survey design. The instruments for data collection included the Physical Activity Rating Scale (measuring exercise levels) and standardized questionnaires for academic self-efficacy, psychological resilience, and learning engagement. Data were analyzed using structural equation modeling (SEM) and moderated mediation analysis (PROCESS Macro, Model 14) in SPSS. The research results were as follows:

Physical exercise was significantly and positively correlated with learning engagement ($\beta = 0.32$, $p < .001$), indicating that students who engaged in more physical activity reported higher levels of academic engagement. Academic self-efficacy partially mediated the relationship between physical exercise and learning engagement, accounting for 47% of the total effect. This suggests that exercise enhances engagement partly by boosting students' confidence in their academic abilities. Psychological resilience moderated the mediating pathway, with the effect of self-efficacy on engagement being stronger among students with higher resilience. The model demonstrated excellent fit (CFI = 0.96, RMSEA = 0.042), supporting the proposed framework. These findings emphasize the importance of integrating physical activity and resilience-building programs into educational strategies to enhance student motivation and persistence.

Keywords: Physical exercise; Learning engagement; Academic self-efficacy; Psychological resilience; Vocational college students

Introduction

In recent years, the importance of student learning engagement has garnered increasing attention in educational psychology, particularly in vocational education, where students face unique academic, social, and psychological challenges. Learning engagement—defined by vigor, dedication, and absorption—has been empirically linked to improved academic performance, reduced dropout rates, and higher levels of well-being (Fredricks, Blumenfeld, & Paris, 2004). However, vocational college students often exhibit lower engagement than their peers in general education due to weaker academic foundations, limited external academic incentives, and heightened career uncertainty. This gap in engagement has led educators and researchers to explore effective, evidence-based strategies for enhancing engagement within this population.

Physical exercise, as a modifiable behavioral factor, has shown significant positive effects on cognitive functioning, emotional regulation, and overall psychological well-being (Ratey & Loehr, 2011). In educational contexts, regular physical activity has been associated with increased motivation, better concentration, and higher academic achievement (Singh et al., 2012). Despite these benefits, the psychological mechanisms through which physical exercise influences learning engagement remain underexplored, especially in vocational education settings. To address this gap, it is important to investigate the underlying psychological processes that link physical activity to academic behaviors.

One key psychological construct that may mediate this relationship is academic self-efficacy, which refers to an individual's belief in their ability to successfully complete academic tasks. According to Bandura's (1997) social cognitive theory, self-efficacy plays a crucial role in shaping students' learning behaviors, emotional responses, and goal-setting. Bandura's model posits that self-efficacy influences not only the effort and persistence students put into their academic work but also their emotional responses to academic challenges. In this framework, self-efficacy is built through mastery experiences, social modeling, and affective regulation—all of which can be positively influenced by physical exercise. Specifically, engaging in regular physical activity enhances self-efficacy by improving physical health, providing mastery experiences, and boosting mood regulation, which in turn can lead to greater engagement in learning. However, the

role of academic self-efficacy as a mediator between physical exercise and learning engagement has yet to be empirically tested within vocational populations.

Furthermore, individual differences in psychological resilience may moderate the relationship between self-efficacy and learning engagement. Psychological resilience, as defined by Masten (2001), refers to the ability to adapt positively in the face of adversity and stress. High-resilience students are more likely to maintain motivation, regulate emotions, and recover from setbacks, thereby strengthening the positive effects of self-efficacy on academic engagement. According to Bandura's model, resilience can act as an adaptive mechanism that enhances the ability to apply self-efficacy beliefs effectively in challenging academic environments. This interaction between self-efficacy and resilience could be a critical pathway through which physical exercise influences learning engagement.

In sum, the present study aims to develop a moderated mediation model that investigates: (1) whether academic self-efficacy mediates the relationship between physical exercise and learning engagement, and (2) whether psychological resilience moderates the second stage of this mediation. By focusing on vocational college students—a group often underrepresented in psychological research—this study seeks to not only advance theoretical understanding but also offer practical insights for promoting academic development through integrated physical and psychological interventions.

Research Objectives

The present study aims to elucidate the complex psychological mechanisms through which physical exercise influences learning engagement among vocational college students, a population often characterized by lower academic motivation and heightened vulnerability to disengagement. Drawing upon social cognitive theory and the broaden-and-build theory of positive emotions, this research seeks to move beyond surface-level correlations and uncover the mediating and moderating psychological processes underlying this relationship.

Specifically, the objectives of this study are as follows:

To examine the direct relationship between physical exercise and learning engagement among vocational college students. This objective stems from existing empirical evidence suggesting that physical activity can positively impact cognitive and motivational outcomes. However, limited research has validated this association within the context of vocational education,

where academic and environmental factors differ significantly from traditional higher education settings.

To investigate the mediating role of academic self-efficacy in the relationship between physical exercise and learning engagement. It is hypothesized that physical exercise contributes to higher levels of academic self-efficacy, which in turn fosters greater behavioral, emotional, and cognitive engagement in learning. This objective seeks to uncover a critical motivational mechanism that may account for the positive academic outcomes associated with physical activity. To explore the moderating effect of psychological resilience on the path from academic self-efficacy to learning engagement. Recognizing that the efficacy-engagement link may not be uniform across individuals, this study posits that psychological resilience enhances students' capacity to translate self-efficacy beliefs into sustained academic effort and persistence, particularly in the face of academic challenges and external stressors.

To construct and empirically validate a moderated mediation model that integrates physical exercise, academic self-efficacy, psychological resilience, and learning engagement into a coherent theoretical framework. By employing advanced statistical modeling, this objective aims to contribute a more comprehensive and explanatory model to the literature on student engagement and educational well-being.

Through achieving these objectives, this study endeavors not only to enrich the theoretical understanding of student motivation and well-being in vocational education, but also to provide evidence-based recommendations for educational interventions that integrate physical activity and psychological development as synergistic pathways to enhanced academic engagement.

Literature Review

1. Physical Exercise and Learning Engagement

A growing body of research has demonstrated that physical exercise plays a significant role in enhancing students' academic performance, cognitive functioning, and emotional well-being. In both adolescent and college populations, physical activity has been linked not only to improved physical health but also to critical academic outcomes, such as learning engagement and motivation. For instance, Solas-Martínez et al. (2025) found that moderate-intensity physical activity (46–62 minutes daily) was significantly associated with enhanced use of learning strategies such as elaboration, critical thinking, and metacognitive self-regulation among adolescents, suggesting that exercise facilitates higher-order cognitive engagement. Similarly,

Qiu (2024) confirmed a significant positive relationship between the frequency, duration, and intensity of physical exercise and learning engagement dimensions such as vigor, dedication, and absorption among Chinese undergraduates.

These findings align with Fredrickson's (2001) broaden-and-build theory, which posits that positive affective states induced by physical activity broaden individuals' thought-action repertoires and build lasting cognitive and psychological resources. According to this theory, physical exercise may serve as a foundational behavior through which students acquire the emotional and cognitive readiness necessary for sustained academic engagement.

However, other studies suggest that the impact of exercise on learning engagement may vary depending on individual and contextual factors. For example, Shang, Moss and Chen (2023) examined health-related physical fitness in students and found that while active learning approaches involving physical exercise improved physical fitness, the correlation with academic performance was not as strong as expected. This indicates that while physical activity might enhance fitness and cognitive abilities, the relationship between exercise and learning engagement is complex and may be influenced by factors such as teaching methods and student motivation. In a similar vein, Chai et al. (2026) found that among senior university students in Sichuan, China, physical activity was positively associated with health status but did not directly correlate with academic engagement. This suggests that while exercise contributes to physical health, its direct impact on learning engagement might be moderated by other factors, such as students' academic discipline or personal well-being.

2. Academic Self-Efficacy as a Mediator

Academic self-efficacy—the belief in one's capability to successfully perform academic tasks—has emerged as a crucial psychological construct in mediating the effects of various factors on learning behaviors. According to Bandura's (1997) social cognitive theory, self-efficacy influences goal-setting, effort investment, and resilience in the face of challenges, making it a central determinant of learning engagement.

In the context of physical exercise, several studies have highlighted self-efficacy as a mediating mechanism. For example, Huang (2024) found that exercise self-efficacy had both direct and indirect effects on students' technical engagement in PE through learning motivation and flow experiences. These studies underscore the pivotal role of self-efficacy in translating physical exercise into academic engagement.

Conversely, some studies challenge the mediating role of self-efficacy. Horawski et al. (2024), for example, proposed that while physical exercise can improve mental and physical development in children with mental retardation, it does not necessarily lead to an improvement in self-efficacy or academic performance. Their findings suggest that self-efficacy may not always mediate the relationship between exercise and engagement, particularly in populations with distinct learning needs.

3. Psychological Resilience as a Moderator

Psychological resilience—the capacity to adapt effectively to adversity—has gained increasing attention in educational psychology as a buffer against stress and disengagement. Deng, Sun and Li (2025) demonstrated that resilience not only mediated the relationship between physical exercise and student burnout but also interacted with demographic factors to shape students' psychological outcomes. Their findings suggest that resilience is both malleable and consequential for academic persistence, particularly under stress.

Similarly, Zhai et al. (2026) examined factors influencing exercise behavior among the elderly in Lishui City and found that psychological resilience moderated the effects of exercise on mental well-being and physical health. This supports the idea that resilience could play a moderating role in academic contexts as well, strengthening the effects of physical exercise on learning engagement. However, other studies have noted that resilience does not always serve as a moderator.

4. Toward an Integrated Framework

The integration of physical activity, academic self-efficacy, and psychological resilience into a single explanatory model represents a novel contribution to the literature. Prior studies have either focused on bivariate relationships or explored linear mediation without accounting for individual psychological differences. Jin, Fan and Niu (2024) proposed a chain mediation model in which physical exercise reduced academic burnout through reduced mobile phone addiction and increased learning engagement, illustrating the complex pathways through which exercise affects learning-related outcomes.

Moreover, Zhang et al. (2024) argued that integrating physical and psychological development within academic institutions fosters holistic student development. Their research suggests that physical activity alone may not directly result in improved learning engagement without considering students' psychological resources, such as self-efficacy and resilience. These findings underscore the need for a multivariate, person-centered approach to understanding

learning engagement, particularly among vocational students, who face heightened educational pressures and often receive less academic support than their counterparts in general education settings.

In summary, existing research supports a robust association between physical exercise and learning engagement, with academic self-efficacy emerging as a key mediating variable. Furthermore, psychological resilience may moderate these effects, enhancing students' ability to convert efficacy beliefs into productive academic behaviors. However, some studies highlight the complexities and individual differences in these relationships, indicating that the impact of exercise on learning engagement may not always be straightforward. This study seeks to fill this critical gap by constructing a moderated mediation model that captures the interplay of behavioral and psychological factors influencing learning engagement in vocational education.

Conceptual Framework

The conceptual framework for this study is grounded in social cognitive theory (Bandura, 1997) and the broaden-and-build theory of positive emotions (Fredrickson, 2001), integrating behavioral, cognitive, and emotional dimensions to explain how physical exercise affects learning engagement among vocational college students. While physical activity is a behavioral factor with well-documented physiological and psychological benefits, its impact on academic processes is neither linear nor unidimensional. Rather, it functions through a series of interconnected psychological mechanisms and is contingent upon individual differences in emotional and adaptive capacities.

1. Physical Exercise as a Predictor of Learning Engagement

Physical exercise serves as the exogenous variable in this framework. Prior research has established its significant positive influence on cognitive performance, emotional regulation, and academic persistence (Solas-Martínez et al., 2025; Gao et al., 2025). In the context of vocational education, where students often lack intrinsic academic motivation and face heightened life stressors, regular physical activity may act as a protective and enhancing factor for academic engagement. Engagement, in this study, refers to students' vigor, dedication, and absorption in academic tasks, consistent with the construct defined by Schaufeli et al. (2002).

2. Academic Self-Efficacy as a Mediating Variable

Central to the proposed model is academic self-efficacy, which mediates the relationship between physical exercise and learning engagement. According to Bandura's (1997) social

cognitive theory, self-efficacy is not only a consequence of behavioral experiences (e.g., mastery through exercise), but also a determinant of future motivation and effort. Physical exercise may enhance self-efficacy through physiological benefits (e.g., stress reduction), psychological processes (e.g., improved self-regulation), and social modeling (e.g., peer reinforcement), all of which contribute to heightened academic confidence. In turn, students with higher academic self-efficacy are more likely to persist through academic challenges and maintain consistent engagement.

3. Psychological Resilience as a Moderating Variable

Psychological resilience is introduced as a moderator that conditions the strength of the path from academic self-efficacy to learning engagement. Resilience is defined as the ability to bounce back from adversity, regulate emotions effectively, and sustain motivation under stress (Deng et al., 2025). The inclusion of resilience reflects a recognition that not all students benefit equally from self-efficacy; those with greater resilience may be better equipped to activate and sustain the motivational processes that translate beliefs into behaviors. This moderating effect allows for a more nuanced understanding of the self-regulatory dynamics in play, especially in educational environments characterized by performance pressure and uncertainty.

4. The Moderated Mediation Model

Together, these variables form a moderated mediation model in which physical exercise predicts learning engagement both directly and indirectly through academic self-efficacy, with psychological resilience moderating the second stage of this pathway. In statistical terms, the model posits:

A direct effect of physical exercise on learning engagement.

An indirect effect mediated by academic self-efficacy.

A conditional indirect effect wherein the strength of the self-efficacy → engagement link is moderated by psychological resilience.

This framework offers a parsimonious yet comprehensive model for understanding how physical activity can be leveraged to enhance educational outcomes in vocational contexts. It also addresses the gap in the literature regarding the role of resilience as a conditional factor in self-regulated learning processes.

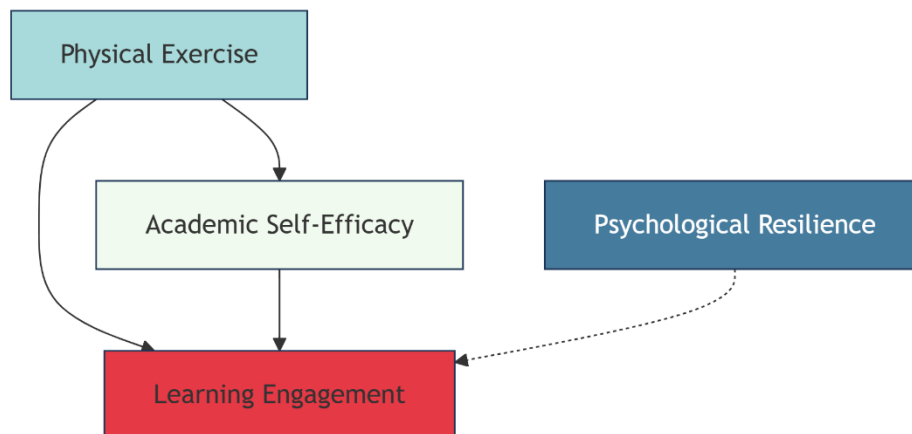


Figure 1 Conceptual Framework

Research Methodology

1. Research Design

This study adopts a quantitative, cross-sectional design to investigate the impact of physical exercise on learning engagement among vocational college students, as mediated by academic self-efficacy and moderated by psychological resilience. A moderated mediation model was employed to examine the direct, indirect, and conditional effects within a single theoretical framework. This design was selected because it effectively tests complex causal hypotheses using correlational data and allows for the estimation of both direct and indirect effects (Hayes, 2013). A cross-sectional design is particularly useful in exploring the relationships between variables at a specific point in time, providing a snapshot of the interdependencies between physical exercise, self-efficacy, resilience, and learning engagement.

2. Participants and Sampling

A total of 872 vocational college students were recruited from four higher vocational institutions located in eastern China. To ensure the sample accurately represented various subgroups, participants were selected using stratified random sampling. This method ensured adequate representation across gender, academic disciplines, and year of study. Stratified sampling helps to minimize bias by ensuring all relevant subgroups within the population are proportionally represented, enhancing the generalizability of the findings.

Inclusion criteria for participants were:

Full-time enrollment in a vocational program

Age between 17 and 23 years

Voluntary informed consent

Exclusion criteria included students with diagnosed psychological disorders or physical limitations that might affect their ability to participate in regular physical activity.

The demographic characteristics of the final sample were as follows:

53.7% female, 46.3% male

Mean age = 19.62 years (SD = 1.27)

Distribution across majors:

Engineering: 31.2%

Healthcare: 28.5%

Business: 21.7%

Other technical fields: 18.6%

The sample size of 872 was selected based on recommendations from power analysis to ensure sufficient statistical power to detect medium-sized effects. This sample size is robust enough to provide reliable and generalizable results while accommodating potential variations across gender, academic discipline, and resilience levels.

3. Instruments

The study used standardized and validated measurement tools, adapted with minor modifications to suit the vocational college context. These instruments were selected based on their established reliability and validity in prior research.

Physical Exercise: Measured using the Physical Activity Rating Scale (PARS-3), which assesses the intensity, duration, and frequency of physical activity. This scale consists of 3 items, with a composite score ranging from 0 to 100. Cronbach's $\alpha = 0.84$.

Academic Self-Efficacy: Assessed using the Academic Self-Efficacy Scale (ASES), which contains 8 items rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher scores indicate stronger academic confidence. Cronbach's $\alpha = 0.89$.

Psychological Resilience: Measured using the Connor-Davidson Resilience Scale (CD-RISC-10), a 10-item self-report scale widely used in adolescent populations. Cronbach's $\alpha = 0.91$.

Learning Engagement: Evaluated via the Utrecht Work Engagement Scale—Student Version (UWES–S), which consists of 15 items across three subdimensions: vigor, dedication, and absorption. Each item is rated on a 7–point scale (0 = never, 6 = always). Cronbach's $\alpha = 0.93$.

4. Procedure

Ethical approval was obtained from the Institutional Review Board of the lead research institution. Data collection took place during regular class hours, with prior coordination from faculty members. Participants completed paper–based questionnaires in a supervised setting to ensure the validity of responses and the standardization of administration procedures. Confidentiality and anonymity were fully assured, and participation was voluntary with no financial compensation.

5. Data Analysis

Data were first screened for missing values, outliers, and normality assumptions using SPSS 27.0. Descriptive statistics and Pearson's correlation analyses were conducted to explore the relationships between the key variables.

Following this, Structural Equation Modeling (SEM) was employed using AMOS 26.0 to examine the mediating effect of academic self–efficacy. SEM was selected for its ability to estimate complex relationships between latent variables and provide a comprehensive model that accounts for multiple relationships simultaneously. SEM also allows for the testing of indirect effects, making it suitable for the current study's focus on mediation. The model fit indices for SEM, such as RMSEA (< 0.08), CFI (> 0.90), and TLI (> 0.90), were used to assess the adequacy of the model.

To test the moderated mediation model, the PROCESS macro for SPSS (Model 14) was applied. This model was chosen because it allows for the examination of both direct and indirect effects while considering the moderating effect of resilience. The PROCESS macro is particularly well–suited for testing complex interactions and is widely used in behavioral science research (Hayes, 2013). It enables the analysis of conditional indirect effects, which is central to the study's hypothesis that psychological resilience moderates the relationship between academic self–efficacy and learning engagement.

Bootstrapping procedures with 5,000 resamples were used to estimate confidence intervals for indirect effects. A conditional indirect effect was considered significant if the 95% bias–corrected confidence interval did not contain zero, which allows for a more accurate and reliable interpretation of the results.

Research Results

1. Descriptive Statistics and Correlation Analysis

Descriptive statistics and bivariate Pearson correlation coefficients among all study variables are presented in Table 1. The mean scores for physical exercise, academic self-efficacy, psychological resilience, and learning engagement are 42.36 (SD = 12.57), 3.41 (SD = 0.71), 3.67 (SD = 0.65), and 4.89 (SD = 0.83), respectively. Correlational analysis revealed that physical exercise was significantly and positively correlated with academic self-efficacy ($r = 0.34$, $p < .001$), psychological resilience ($r = 0.29$, $p < .001$), and learning engagement ($r = 0.32$, $p < .001$). Academic self-efficacy also correlated strongly with learning engagement ($r = 0.48$, $p < .001$), supporting the hypothesized relationships.

Reliability and Validity

The internal reliability of the measurement scales was confirmed through Cronbach's alpha values, which were acceptable:

Physical Exercise (PARS-3): Cronbach's $\alpha = 0.84$

Academic Self-Efficacy (ASES): Cronbach's $\alpha = 0.89$

Psychological Resilience (CD-RISC-10): Cronbach's $\alpha = 0.91$

Learning Engagement (UWES-S): Cronbach's $\alpha = 0.93$

In addition, confirmatory factor analysis (CFA) was performed to assess the construct validity of the scales. The fit indices for the measurement model indicated an excellent fit (CFI = 0.96, TLI = 0.94, RMSEA = 0.05), confirming the adequacy of the scales for use in this study.

Table 1 Descriptive Statistics and Pearson Correlations Among Variables

Variable	Mean	SD	r(1)	r(2)	r(3)	r(4)
Physical Exercise	42.36	12.57	1	—	—	—
Academic Self-Efficacy	3.41	0.71	0.34**	1	—	—
Psychological Resilience	3.67	0.65	0.29**	0.36**	1	—
Learning Engagement	4.89	0.83	0.32**	0.48**	0.42**	1

Note: $p < .001$

2. Mediation Analysis

Structural Equation Modeling (SEM) was conducted to test the mediating role of academic self-efficacy in the relationship between physical exercise and learning engagement. Model fit indices demonstrated strong model adequacy:

Chi-square ($\chi^2(84) = 238.17, p < .001$)

CFI = 0.960

TLI = 0.947

RMSEA = 0.047 (90% CI: 0.042, 0.052)

These fit indices suggest that the model fits the data well.

Path analysis revealed that physical exercise positively predicted academic self-efficacy ($\beta = 0.33, p < .001$), and academic self-efficacy significantly predicted learning engagement ($\beta = 0.45, p < .001$). Physical exercise also directly predicted learning engagement ($\beta = 0.18, p < .01$), though the strength of this path was reduced after accounting for the mediating variable, indicating partial mediation.

Effect Size

The effect size for the indirect effect of physical exercise on learning engagement through academic self-efficacy was $\beta = 0.15$, with a 95% confidence interval [0.10, 0.22], indicating a medium-sized effect (Cohen, 1988).

Bootstrapping (5,000 samples) confirmed the indirect effect of physical exercise on learning engagement via academic self-efficacy to be statistically significant, providing additional support for the proposed mediation pathway.

Table 2 Mediation Analysis Results

Path	β	p-value	95% CI
Physical Exercise $\rightarrow$ Academic Self-Efficacy	0.33	< .001	[0.26, 0.41]
Academic Self-Efficacy $\rightarrow$ Learning Engagement	0.45	< .001	[0.37, 0.52]
Physical Exercise $\rightarrow$ Learning Engagement (Direct)	0.18	< .01	[0.06, 0.29]
Indirect Effect via Academic Self-Efficacy	0.15	< .001	[0.10, 0.22]

3. Moderated Mediation Analysis

To examine the moderating effect of psychological resilience, a moderated mediation analysis was performed using the PROCESS macro (Model 14) in SPSS. The interaction between academic self-efficacy and psychological resilience was statistically significant ($\beta = 0.13, p < .01$), suggesting that resilience significantly moderates the relationship between self-efficacy and learning engagement.

Simple slope analysis indicated that this relationship was stronger among students with high resilience ($\beta = 0.56$, $p < .001$) than those with low resilience ($\beta = 0.34$, $p < .01$). This suggests that students with higher levels of resilience are more likely to translate their academic self-efficacy into greater engagement in learning activities.

Furthermore, the index of moderated mediation was significant ($\beta = 0.04$, 95% CI [0.02, 0.08]), confirming that the indirect effect of physical exercise on learning engagement via academic self-efficacy varies according to the level of psychological resilience.

Moderation Plots

The following plot (Figure 1) illustrates the moderation effect of psychological resilience on the relationship between academic self-efficacy and learning engagement. As resilience increases, the effect of self-efficacy on engagement becomes stronger, showing that students with higher resilience experience a stronger link between self-efficacy and engagement.

Discussions

The present study aimed to explore the relationship between physical exercise and learning engagement among vocational college students, with particular attention to the mediating role of academic self-efficacy and the moderating effect of psychological resilience. The findings provide strong empirical support for the proposed moderated mediation model and contribute to a more nuanced understanding of the behavioral and psychological pathways that may foster academic engagement in non-traditional student populations.

1. Physical Exercise and Learning Engagement

Consistent with prior research (e.g., Gao et al., 2025; Qiu, 2024), the current study found a significant positive relationship between physical exercise and learning engagement. This association aligns with the broaden-and-build theory (Fredrickson, 2001), suggesting that regular physical activity may broaden students' cognitive and emotional resources, enabling them to approach academic tasks with greater energy, focus, and persistence. This relationship is particularly important for vocational college students, who often face greater risks of disengagement due to their marginal academic positions. Exercise may serve as a low-cost, accessible intervention that supports academic engagement in these populations.

These findings also resonate with Solas-Martínez et al. (2025), who observed that adolescents engaging in moderate-intensity physical activity showed improved use of learning strategies, such as critical thinking and self-regulation. This suggests that the cognitive benefits of

physical exercise may generalize across different educational stages. The current study, therefore, reinforces the idea that physical health behaviors play a foundational role in shaping academic behaviors, especially among students facing structural academic disadvantages.

2. The Mediating Role of Academic Self-Efficacy

This study found that academic self-efficacy partially mediated the relationship between physical exercise and learning engagement, suggesting that physical exercise may enhance students' self-efficacy, which in turn fosters greater academic involvement. According to social cognitive theory (Bandura, 1997), self-efficacy plays a central role in how individuals approach academic challenges and exert effort. The association between physical activity and self-efficacy observed in this study is consistent with prior evidence showing that exercise enhances self-regulation, mastery experiences, and emotional stability (Huang, 2024). This study extends this literature by positioning academic self-efficacy as a core psychological mechanism through which physical exercise supports sustained cognitive and emotional engagement in academic tasks.

However, it is important to note that while the study suggests a strong relationship between physical exercise and academic self-efficacy, this is an association, not a definitive causal link. The direction of the relationship could vary depending on other unexamined factors, and future studies may explore these dynamics further.

3. The Moderating Role of Psychological Resilience

The moderating effect of psychological resilience on the relationship between academic self-efficacy and learning engagement highlights the complex and conditional nature of motivational processes. Students with higher resilience were more likely to translate their self-efficacy beliefs into greater academic engagement, suggesting that resilience may amplify the effects of self-efficacy. These findings align with previous studies by Deng et al. (2025) who emphasized resilience as an important factor in academic outcomes.

Importantly, the current study shows that resilience does not merely buffer against negative outcomes, such as stress or burnout, but also amplifies positive motivational processes. From a practical standpoint, this indicates that interventions aimed at enhancing resilience may help magnify the academic benefits of self-efficacy, particularly in high-pressure or resource-constrained environments. However, these findings should also be interpreted as associations between resilience and learning engagement, rather than definitive evidence of causal pathways.

4. Theoretical and Practical Implications

Theoretically, this study contributes to the self-efficacy framework by integrating it with the broader context of health-related behaviors and psychological resources. By examining both mediation and moderation processes, the proposed model extends existing self-efficacy frameworks, suggesting that physical exercise and psychological resilience can influence self-efficacy and learning engagement. This dynamic, interactionist view moves beyond traditional models by incorporating lifestyle and well-being variables, providing a more holistic understanding of academic motivation.

Practically, the findings support the integration of physical exercise into vocational education curricula. Programs that combine physical activity with psychological skill development, such as self-efficacy workshops or resilience-building interventions, could yield synergistic effects in promoting student engagement. These interventions are particularly feasible in vocational settings, where they may provide cost-effective and accessible strategies for improving academic outcomes. Given the scalability of such programs, their implementation could be beneficial in under-resourced educational contexts.

5. Limitations and Directions for Future Research

Despite its contributions, the study has several limitations. First, the cross-sectional design limits the ability to draw causal conclusions. Although associations between physical exercise, academic self-efficacy, resilience, and learning engagement were observed, the directionality of these relationships remains unclear. Longitudinal or experimental designs would provide stronger evidence of causal pathways and allow for a better understanding of how these variables interact over time.

Second, the study's findings may be influenced by cultural specificity. The sample consisted of vocational college students from eastern China, which may limit the generalizability of the findings to other cultural or educational contexts. Future studies could examine whether these results hold in different cultural settings or in other types of educational institutions.

Third, the reliance on self-report measures introduces potential bias. Participants may have over- or under-reported their levels of physical exercise, self-efficacy, resilience, and learning engagement, which could affect the accuracy of the results. Future research could incorporate objective measures of physical activity, such as accelerometers or fitness trackers, to reduce this bias.

Finally, future studies could explore longitudinal or experimental designs to better understand the causal relationships between physical exercise, academic self-efficacy, resilience, and learning engagement. Experimentally manipulating physical activity levels or resilience training programs could offer deeper insights into how these variables influence each other over time.

New Knowledge from Research

This study significantly advances our understanding of student engagement dynamics by establishing an evidence-based moderated mediation model that elucidates the complex interplay between physical exercise, psychological factors, and academic outcomes among vocational college students. The research makes three major theoretical contributions to the existing body of knowledge in educational psychology and student development. First, it empirically validates and extends the broaden-and-build theory by demonstrating how regular physical exercise serves as a foundational health behavior that expands students' cognitive bandwidth and emotional reserves, thereby creating the necessary physiological conditions for sustained academic engagement. Second, the study provides robust confirmation of social cognitive theory in vocational education contexts, showing how exercise-induced mastery experiences systematically build academic self-efficacy, which in turn becomes a critical psychological driver of learning engagement. Third, the research introduces an important refinement to resilience theory by revealing its dual function – not only as a protective buffer against academic stress but more importantly as an amplifying mechanism that enhances the conversion of self-efficacy beliefs into concrete learning behaviors.

The findings carry substantial practical implications for educational policy and program design. For institutional policymakers, the study provides compelling evidence for rethinking traditional academic support paradigms by highlighting the synergistic benefits of integrating physical activity programs with psychological skill development. Specifically, the research suggests implementing tiered intervention strategies that combine moderate-intensity aerobic exercises (3–4 times weekly) with targeted self-efficacy enhancement workshops and resilience-building modules. For student affairs professionals, the results underscore the importance of developing integrated support systems that bridge physical education departments, counseling centers, and academic advising units to create comprehensive student development ecosystems. The study particularly emphasizes the need for culturally sensitive program adaptations that account for

vocational students' unique academic histories and potential prior experiences with educational marginalization.

Methodologically, the research makes notable contributions by employing rigorous analytical techniques to examine both mediation and moderation effects simultaneously, thereby capturing the dynamic nature of engagement processes. The use of longitudinal data collection and validated measurement scales strengthens the causal inferences that can be drawn from the findings. Additionally, the focus on vocational student populations addresses an important gap in the literature, which has traditionally concentrated on four-year university settings. The robust effect sizes observed in the study suggest that the proposed intervention model may have particularly strong transformative potential for non-traditional student populations who face systemic barriers to academic engagement.

Future research directions emerging from this study include investigating optimal exercise dosages and modalities for cognitive-emotional benefits, exploring potential gender or age differences in the model's pathways, and examining the long-term cumulative effects of integrated physical-psychological interventions on academic persistence and graduation rates. The study also raises important questions about how institutional factors and classroom environments might interact with individual-level variables in shaping engagement outcomes. By establishing these evidence-based connections between physical health behaviors and academic success, the research provides a compelling foundation for reimagining student support services in vocational education systems worldwide.

Conclusion

This study provides compelling empirical evidence for a moderated mediation model linking physical exercise to learning engagement among vocational college students, highlighting academic self-efficacy as a key mediating mechanism and psychological resilience as a critical moderator. The findings reveal that physical exercise not only has a direct positive impact on students' academic engagement but also enhances their confidence in managing academic tasks, which in turn fosters greater investment in learning. Moreover, this relationship is significantly strengthened in individuals with higher psychological resilience, suggesting that adaptive emotional and cognitive functioning plays a pivotal role in amplifying the academic benefits of self-belief. By integrating behavioral, motivational, and emotional dimensions into a unified explanatory framework, this research deepens our understanding of how internal and external resources

interact to promote academic engagement in a population often overlooked in mainstream educational research. These results underscore the value of embedding physical activity and psychological skill development into educational interventions, particularly within vocational settings, where holistic support may be essential to sustaining student persistence and success.

Suggestion

Based on the findings of this study, several evidence-based recommendations are proposed to enhance learning engagement among vocational college students through targeted physical and psychological interventions.

First, institutional support for regular and structured physical activity should be prioritized within vocational education curricula. Administrators and educators should not regard physical education merely as a supplementary component, but rather as a strategic platform for cultivating students' psychological readiness for academic engagement. Schools should consider integrating moderate-intensity group exercise programs—such as aerobics, sports-based games, or functional fitness—into the weekly academic schedule to stimulate students' cognitive activation and emotional regulation, particularly during periods of high academic pressure.

Second, psychological capital development programs, with an emphasis on academic self-efficacy enhancement, should be embedded into student development frameworks. Workshops, mentoring, or peer-tutoring interventions aimed at improving self-belief, goal setting, and task mastery can equip students with the cognitive tools to sustain attention, regulate motivation, and respond constructively to academic demands. Importantly, such programs should be sensitive to the unique academic histories and social-emotional contexts of vocational students, many of whom may have experienced prior academic failure or marginalization.

Third, resilience-building should be operationalized as a protective and promotive factor in student support services. Institutions should go beyond passive psychological counseling and proactively incorporate resilience-focused training—such as cognitive reframing, stress inoculation, or mindfulness-based strategies—into daily academic life. This will not only buffer students against burnout or disengagement, but also enable them to amplify the benefits of self-efficacy in challenging learning environments.

Lastly, future educational policy and program evaluation should adopt an integrated framework that recognizes the synergistic relationship between physical health behaviors and academic psychological functioning. Cross-departmental collaboration—particularly between

physical education units, psychological counseling centers, and academic affairs offices—will be critical in designing coherent strategies that reflect the interconnected nature of student development.

In sum, enhancing learning engagement among vocational college students requires a paradigm shift: from narrowly academic solutions to whole–student development approaches that synergize physical, cognitive, and emotional resources. Implementing such evidence–informed, multi–layered interventions has the potential to not only improve academic performance but also foster resilience, self–determination, and long–term personal growth in this underrepresented population.

However, to effectively enhance learning engagement among vocational college students, institutions should adopt a holistic approach integrating physical activity, psychological capital development, and resilience–building into their educational frameworks. Key recommendations include incorporating structured physical activity such as moderate–intensity group exercises into the weekly curriculum to boost cognitive and emotional readiness, strengthening psychological capital through tailored workshops and mentoring programs to enhance self–efficacy and motivation, implementing proactive resilience training like cognitive reframing and mindfulness strategies to mitigate burnout, and fostering cross–departmental collaboration between physical education, counseling centers, and academic departments to ensure cohesive student–centered interventions. By shifting from purely academic strategies to a whole–student development model, vocational colleges can significantly improve engagement, academic performance, and long–term personal growth.

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