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Modelling the Effects of Environmental and Social Factors on Academic Performance Through Student's Physical Condition Using Structural Equation Modelling

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ABSTRACT

Academic performance is influenced by various environmental and social factors, yet the complex relationships among these factors remain difficult to explain using conventional statistical methods. This study aims to model the effects of environmental and social factors on academic performance through students' physical condition using Structural Equation Modeling (SEM). Secondary data from the Student Stress Monitoring Dataset obtained from Kaggle were analyzed. The analytical procedure included data preprocessing, measurement model evaluation using Confirmatory Factor Analysis (CFA), and structural model assessment based on goodness-of-fit indices. Environmental and social factors were specified as exogenous variables, students' physical condition as the mediating variable, and academic performance as the endogenous variable. The results indicate that both environmental and social factors significantly affect students' physical condition, with social factors demonstrating a stronger influence. Furthermore, students' physical condition has a significant positive effect on academic performance, confirming its mediating role in the proposed model. Following model modification, the structural model achieved acceptable goodness-of-fit, indicating that the proposed SEM adequately represents the relationships among the studied variables. These findings emphasize the importance of supportive environmental and social conditions in improving students' academic performance through better physical well-being.

Keywords: *Academic performance, Confirmatory factor analysis, Environmental factors, Mediation analysis, Physical condition, Social factors, Student well-being.*

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1. Introduction

In the modern educational landscape, academic performance has become one of the primary indicators for evaluating both student achievement and overall quality of educational system. Academic performance reflects not only students' cognitive abilities but also their capacity to adapt to academic demands, social pressures, and the surrounding learning environment. As educational expectations continue to increase alongside growing academic competition and the widespread adoption of both face-to-face and online learning, students are becoming increasingly vulnerable to stress, which may adversely affect their physical condition and academic performance [7]

In developing educational systems such as Indonesia, maintaining students' academic performance remains a significant challenge. Previous studies have shown that environmental factors, including noise levels, living conditions, safety, and the fulfillment of basic needs, substantially influence students' learning experience [2]. Likewise, social factors, such as social support, peer pressure, participation in extracurricular activities, and bullying, play an essential role in shaping students' academic development [6]. Rather than operating independently, these environmental and social factors interact with one another and may indirectly influence academic performance by affecting students' physical condition, including sleep quality, general health, and fatigue levels.

Despite the importance of these factors, academic performance is commonly evaluated solely through examination scores or academic grades. Such an approach fails to capture the complex interactions among external and internal factors that influence students' learning outcomes. In particular, students' physical condition may serve as a key mediating mechanism linking environmental and social influences to academic performance. However, empirical studies that simultaneously examine these multidimensional relationships within a single analytical framework remain limited.

Structural Equation Modeling (SEM) provides an effective statistical framework for addressing this limitation because it enables the simultaneous analysis of latent variables and complex direct and indirect relationships within a unified model [3]. Using the Student Stress Monitoring Dataset, this study develops a structural model to examine the effects of environmental and social factors on students' academic performance through their physical condition as a mediating variable. The findings are expected to provide a more comprehensive understanding of the mechanisms underlying academic performance and offer empirical evidence to support educators and policymakers in designing learning environments and social support systems that promote students' academic success.

2. Method Details

2.1. Data Collection

This study employed secondary data obtained from the Student Stress Monitoring Dataset, a publicly available dataset hosted on Kaggle. The dataset contains survey-based information collected from students regarding various factors associated with academic performance, including environmental conditions, social factors, psychological well-being, physical health, and academic outcomes. In this study, only the variables relevant to the proposed Structural Equation Modeling (SEM) framework were selected. Environmental and social factors were specified as exogenous variables, students' physical condition was treated as the mediating variable, and academic performance was considered the endogenous variable.

2.2. Research Variables

The variables employed in this study are presented in Table 1. The proposed Structural Equation Modeling (SEM) framework consists of two exogenous latent variables (environmental and social factors), one mediating latent variable (students' physical condition), and one endogenous latent variable (academic performance).

Table 1. Research Variable

Latent Variable	Indicator	Operational Definition
Environmental Factors (X1)	Noise Level	The level of environmental noise that may affect students'concentration, comfort, and psychological well-being.
	Living condition	The quality od student's living environment, including cleanliness, comfort, and the availability of basic facilities.
	Safety	Students' perceived level of safety from physical threats, violence, or environmental hazards in their living or learning environment.
	Basic Needs	The fulfillment of essential needs, including food, water, shelter, and access to healthcare, which contributes to overall well-being.
Social Factors (X2)	Social Support	Emotional, moral, or practical support received from family members, friends, or other significant individuals.
	Peer Presure	Social pressure experienced by students to conform to the norms, behaviors, or expectations of their peers.
	Extraculi-Cullar activities	Students' participation in activities outside formal academic learning, such as sports, arts, or student organizations, that contribute to social and emotional development
	Bullying	Repeated physical, verbal, or social aggressive behavior that negatively affects students' psychological well-being.
Student's Psycal Condition (X3)	Headache	The frequency of headaches experienced by students.
	Blood Presure	Students' blood pressure condition.
	Sleep Quality	The overall quality of students' sleep.
	Breathing Problems	Respiratory problems experienced by students
Academic Performance (Y)	Academic performance	Students' level of academic achievement, typically measured by academic performance or learning outcomes.

Latent Variable	Indicator	Operational Definition
	Teacher-Student Relationship	he quality of interpersonal relationships between teachers and students that influences learning motivation, comfort, and academic support.
	Future Career Concern	Students' concerns or uncertainty regarding future career plans and prospects that may influence learning motivation and academic stress

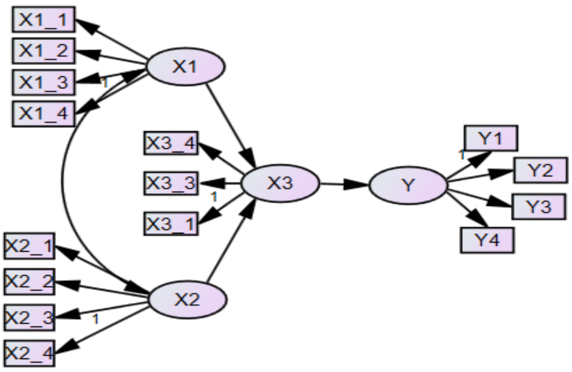

Figure 1. Proposed Structural Equation Model

2.3. Proposed Structural Equation Model

The proposed Structural Equation Model is presented in Figure 1. The model consists of two exogenous latent constructs, namely environmental factors and social factors, one mediating latent construct (students' physical condition), and one endogenous latent construct (academic performance). Environmental and social factors are hypothesized to influence academic performance indirectly through students' physical condition.

2.4. Structural Equation Model (SEM)

Structural Equation Modeling (SEM) is a multivariate statistical technique used to develop and estimate complex relationships among observed and latent variables. SEM integrates several statistical approaches, including factor analysis, regression analysis, and path analysis, into a single analytical framework, allowing researchers to simultaneously evaluate measurement models and structural relationships among latent constructs [4]. In general, SEM consists of two major components: the measurement model, which describes the relationships between latent variables and their observed indicators, and the structural model, which specifies the causal relationships among latent variables.

SEM based on the Linear Structural Relationship (LISREL) model consists of measurement equations for both exogenous and endogenous latent variables, followed by a structural equation describing the relationships among the latent constructs [8].

2.4.1. Measurement Model

The measurement model is estimated using Confirmatory Factor Analysis (CFA) to examine the relationships between latent variables and their observed indicators. The measurement equations for the exogenous and endogenous latent variables are presented as follows. Measurement model for exogenous latent variable presented bellow

$$\boldsymbol{X} = \boldsymbol{\Lambda_x}\xi + \boldsymbol{\delta}$$

$$\begin{bmatrix} x_1 \\ \vdots \\ x_q \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{21} & \lambda_{31} \\ \vdots & \ddots & \vdots \\ \lambda_{q1} & \cdots & \lambda_{qn} \end{bmatrix} \begin{bmatrix} \xi_1 \\ \vdots \\ \xi_n \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \vdots \\ \delta_n \end{bmatrix}$$

Where:

X : vector of observed exogenous variable
Λ_x : matrix of factor loading for exogenous variable
δ : vector of measurement errors
ξ : vector of exogenous latent variables
q : number of observed indicators

And the measurement model for endogenous latent variabel us presented bellow.

$$\boldsymbol{Y} = \boldsymbol{\Lambda_x}\boldsymbol{\eta} + \boldsymbol{\varepsilon}$$

$$\begin{bmatrix} y_1 \\ \vdots \\ y_q \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{21} & \lambda_{31} \\ \vdots & \ddots & \vdots \\ \lambda_{p1} & \cdots & \lambda_{pm} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \vdots \\ \eta_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_p \end{bmatrix}$$

Where:

Y : vector of observed endogenous variables
Λ_y : matrix of factor loadings for endogenous variables
ε : vector of measurement errors
η : vector of endogenous latent variables
p : number of observed indicators

2.4.2. Structural Model

The structural model specifies the causal relationships among the endogenous and exogenous latent variables. It describes how the endogenous latent constructs are influenced by other endogenous variables as well as by exogenous variables. The general form of the structural equation model is expressed as follows.

$$\boldsymbol{\eta} = \boldsymbol{B\eta} + \boldsymbol{\Gamma\xi} + \boldsymbol{\zeta}$$

$$\begin{bmatrix} \eta_1 \\ \vdots \\ \eta_m \end{bmatrix} = \left[\begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \vdots & \ddots & \vdots \\ \beta_{m1} & \cdots & \beta_{mm} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \vdots \\ \eta_m \end{bmatrix} \right] + \begin{bmatrix} \gamma_{11} & \gamma_{21} & \gamma_{31} \\ \vdots & \ddots & \vdots \\ \gamma_{m1} & \cdots & \gamma_{mn} \end{bmatrix} \begin{bmatrix} \xi_1 \\ \vdots \\ \xi_n \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \vdots \\ \zeta_m \end{bmatrix}$$

Where:

B : matrix of regression coefficients among endogenous latent variables (m × m)

Γ : matrix of regression coefficients representing the effects of exogenous latent variables on endogenous latent variables (m × n)

ζ : vector of structural disturbances (residual errors) (m × 1)

Following the specification of the measurement and structural models, the overall model adequacy was evaluated using several goodness-of-fit (GOF) indices. Model fit assessment determines the extent to which the proposed model adequately represents the observed data and serves as the basis for accepting or rejecting the hypothesized model.

2.4.3. Model Evaluation

The adequacy of the proposed Structural Equation Model was evaluated using several goodness-of-fit (GOF) indices. Model fit assessment determines the extent to which the hypothesized model adequately represents the observed data and serves as the basis for accepting or rejecting the proposed model. Following the recommendations of Hair et al. [3] and Arbuckle [1], both absolute and incremental fit measures were employed. The absolute fit measures included the chi-square divided by degrees of freedom (CMIN/DF), Goodness-of-Fit Index (GFI), Root Mean Square Error of Approximation (RMSEA), and Root Mean Square Residual (RMR). The incremental fit measures consisted of the Adjusted Goodness-of-Fit Index (AGFI), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), and Normed Fit Index (NFI). A structural model was considered acceptable when the majority of these indices satisfied the recommended threshold values presented in Table 2.

Table 2. Evaluation Metric

Goodness of Fit Index	Recomme Value	Reference
CMIN/DF	<3.0 (or <5,0)	Augusty (2002)
GFI	≥0,90	Augusty (2002)
RMSEA	≤0.08	Hair et al. (2006)
RMR	<0,05	Augusty (2002)
AGFI	≥0,90	Arbucke (2017)
CFI	≥0,90	Arbuckle (2017)
TLI	≥0,90	Hair et al. (2006)
NFI	≥0,90	Augusty (2002)

3. Result And Discussion

3.1. Measurement Model Evalution

3.1.1. Validity Assessment

Table 3 presents the standardized factor loadings obtained from the Confirmatory Factor Analysis (CFA) for the environmental factors (X_1), social factors (X_2), students' physical condition (X_3), and academic performance (Y).

Table 3. Standardized Model Evalution

Construct	Indicator	Std Factor loading	Vali-dity
Environmen-tal Factors (X_1)	X1_1 (Noise Level)	0.694	Valid
	X1_2 (Living Conditions)	-0.669	Valid
	X1_3 (Safety)	-0.801	Valid
	X1_4 (Basic Needs)	-0.768	Valid
Social Factors (X_2)	X2_1 (Social Support)	0.662	Valid
	X2_2 (Peer Pressure)	-0.778	Valid
	X2_3 (Extracurricular Activities)	-0.784	Valid
	X2_4 (Bullying)	-0.843	Valid
Students' Physical Condition (X_3)	X3_1 (Headache)	0.767	Valid
	X3_2 (Blood Pressure)	0.380	Invalid
	X3_3 (Sleep Quality)	-0.841	Valid
	X3_4 (Breathing Problems)	0.620	Valid
Academic Performance (Y)	Y1 (Academic Performance)	0.798	Valid
	Y2 (Teacher–Student Relationship)	-0.661	Valid
	Y3 (Future Career Concern)	0.817	Valid

The results indicate that most indicators have standardized factor loadings with absolute values greater than 0.50, satisfying the recommended criterion for construct validity. However, indicator X3_2 (Blood Pressure) has a standardized loading of 0.380, which is below the acceptable threshold of 0.50. Therefore, this indicator was considered invalid and excluded from the subsequent analysis. The remaining indicators demonstrated satisfactory validity and were retained for further model estimation.

3.1.2. Reliability Assessment

Construct reliability was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE). A construct was considered reliable when the CR value exceeded 0.70 and the AVE value exceeded 0.50.

Table 4. Construct Reliability Assessment

Construct	CR	AVE	Reliability
Environmental Factors (X_1)	0.8278	0.5470	Reliable
Social Factors (X_2)	0.8531	0.5927	Reliable
Students' Physical Condition (X_3)	0.8590	0.6052	Reliable
Academic Performance (Y)	0.7907	0.5600	Reliable

As shown in Table 4, all latent constructs satisfy the recommended reliability criteria, with Composite Reliability values greater than 0.70 and Average Variance Extracted values exceeding 0.50. These findings indicate that all constructs possess adequate internal consistency and convergent validity for subsequent structural model analysis.

3.2. Structural Model Evaluation

After confirming the validity and reliability of the measurement model, the proposed structural model was estimated using AMOS to examine the relationships among the latent variables. The initial model was evaluated based on several goodness-of-fit indices to determine whether the hypothesized model adequately represented the observed data. The final Structual Model is presented in Figure 2

The adequancy of the final structural model was assessed using several absolute and incremental fit indices. The result are presented in Tabel 5

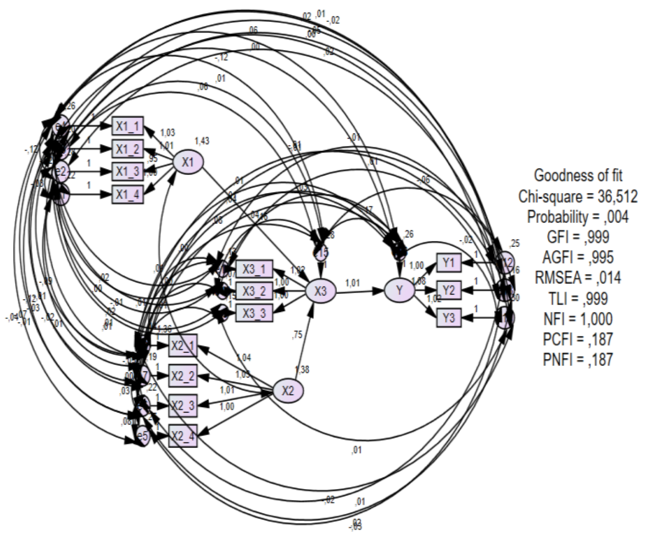

Figure 2. Final Stuctural Equation Model

Table 5. Goodness of Fit Indices of The Final Structural Model

Fit Index	Recommended Value	Result
CMIN/DF	<0,05	0,004
GFI	≥0,90	0,999
RMSEA	≤0.08	0,014
AGFI	≥0,90	0,995
TLI	≥0,90	0,999

As shown in Table 5, most goodness-of-fit indices satisfy the recommended threshold values, indicating that the proposed Structural Equation Model adequately represents the observed data. The GFI (0.999), AGFI (0.995), TLI (0.999), and NFI (1.000) values all exceed the recommended cut-off value of 0.90, demonstrating an excellent model fit. In addition, the RMSEA value of 0.014 is well below the recommended threshold of 0.08, indicating a close fit between the proposed model and the observed data.

Although the chi-square probability is 0.004, which is lower than the recommended value of 0.05, the chi-square statistic is known to be sensitive to sample size. Therefore, model adequacy should be evaluated using multiple goodness-of-fit indices rather than relying solely on the chi-square test. Overall, considering that the majority of the fit indices satisfy the recommended criteria, the final structural model can be considered acceptable and suitable for subsequent structural relationship analysis.

3.3. Structural Relationship Analysis

The structural relationships among the latent variables were evaluated using the regression weights obtained from the final Structural Equation Model. The results of the hypothesis testing are presented in Table 6

Table 6. Structural Path Coeficients

Structural Path	Estimate	p-value	Decision
Environmental Factors → Students' Physical Condition	0.158	0.010	Supported
Social Factors → Students' Physical Condition	0.752	< 0.001	Supported
Students' Physical Condition → Academic Performance	1.012	< 0.001	Supported

As shown in Table 6, environmental factors have a positive and statistically significant effect on students' physical condition (Estimate = 0.158, C.R. = 2.565, p = 0.010). This finding indicates that improvements in environmental conditions, including noise level, living conditions, safety, and the fulfillment of basic needs, contribute positively to students' physical well-being. Therefore, Hypothesis 1 is supported.

The results also reveal that social factors have a positive and significant effect on students' physical condition (Estimate = 0.752, C.R. = 12.047, $p < 0.001$). Compared with environmental factors, social factors exhibit a substantially stronger influence on students' physical condition. This suggests that social support, peer relationships, extracurricular involvement, and bullying experiences play a crucial role in shaping students' physical well-being. Therefore, Hypothesis 2 is supported.

Furthermore, students' physical condition has a positive and statistically significant effect on academic performance (Estimate = 1.012, C.R. = 99.404, $p < 0.001$). This finding indicates that students with better physical health tend to demonstrate higher academic performance. Consequently, Hypothesis 3 is supported, confirming the mediating role of students' physical condition in the relationship between environmental and social factors and academic performance.

Overall, the findings suggest that social factors exert the strongest influence on students' physical condition, while students' physical condition serves as a significant predictor of academic performance. These results emphasize the importance of creating supportive environmental and social conditions to enhance students' well-being and ultimately improve their academic outcomes.

4. Discussion

The findings of this study demonstrate that both environmental and social factors significantly influence students' physical condition, which subsequently affects their academic performance. These results indicate that students' academic achievement is shaped not only by cognitive abilities but also by the interaction between their surrounding environment, social experiences, and physical well-being.

The significant influence of environmental factors on students' physical condition suggests that a conducive environment plays an important role in maintaining students' health and readiness to learn. Environmental characteristics such as lower noise levels, safe surroundings, adequate living conditions, and the fulfillment of basic needs create conditions that support students' physical well-being. These findings are consistent with Fraser (2015), who emphasized that a supportive learning environment contributes to students' overall development and enhances the learning process [2].

The results also reveal that social factors exert a stronger influence on students' physical condition than environmental factors. This finding highlights the importance of positive social interactions in students' daily lives. Emotional support from family and friends, healthy peer relationships, and participation in extracurricular activities may reduce stress and improve students' physical well-being, whereas negative experiences such as bullying may adversely affect students' health. This finding supports the work of Malecki and Demaray (2003), who reported that social support plays a critical role in promoting students' psychological adjustment and educational outcomes [6].

Furthermore, students' physical condition was found to have a positive and significant effect on academic performance. This finding suggests that students who maintain good physical health are more likely to demonstrate better concentration, higher learning motivation, and improved academic achievement. Physical well-being, including adequate sleep quality and the absence of health-related problems, enables students to participate more effectively in academic activities. This result is in line with Santrock (2018), who argued that students' physical and psychological conditions are essential determinants of learning effectiveness and academic success [7].

Overall, the findings support the proposed Structural Equation Model by demonstrating that students' physical condition functions as an important mediating mechanism linking environmental and social factors to academic performance. These results imply that efforts to improve academic performance should extend beyond instructional strategies and include initiatives to enhance students' physical well-being, strengthen social support systems, and create supportive learning environments. Such interventions may contribute to more sustainable improvements in students' academic outcomes.

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