Physical literacy based planning in Physical Education: a structural model approach

Planificación basada en la alfabetización física en la Educación Física: un enfoque de modelo estructural

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Abstract

Introduction: Physical literacy has emerged as a multidimensional framework redefining physical education toward lifelong engagement.
Objective: This study aimed to examine the structural relationships between physical literacy based planning design, implementation quality, student engagement, and physical literacy.
Methodology: A quantitative cross-sectional design was employed involving 350 secondary school students. Data were analyzed using partial least squares structural equation modeling (PLS-SEM).
Results: The findings revealed that planning design significantly influences physical literacy both directly (β= 0.358, p < 0.001) and indirectly through implementation quality (β= 0.115) and student engagement (β= 0.250). Student engagement emerged as the strongest predictor.
Discussion: The results confirm that instructional planning functions as a structural determinant influencing classroom processes and learning outcomes.
Conclusions: Physical literacy development is strongly shaped by pedagogical planning and student engagement, emphasizing the importance of literacy-oriented instructional design.

Keywords

Implementation quality; instructional planning; physical literacy; PLS-SEM; student engagement.

Resumen

Introducción: La alfabetización física ha surgido como un marco multidimensional que redefine la educación física hacia la participación a lo largo de la vida.
Objetivo: Este estudio tiene como objetivo examinar las relaciones estructurales entre el diseño de la planificación basada en la alfabetización física, la calidad de la implementación, la participación estudiantil y la alfabetización física.
Metodología: Se empleó un diseño transversal cuantitativo con 350 estudiantes de secundaria. Los datos se analizaron mediante el modelado de ecuaciones estructurales de mínimos cuadrados parciales (PLS-SEM).
Resultados: Los hallazgos revelaron que el diseño de la planificación influye significativamente en la alfabetización física, tanto de forma directa (β= 0.358, < 0,001) como indirecta a través de la calidad de la implementación (β= 0,115) y la participación estudiantil (β= 0,250). La participación estudiantil se identificó como el predictor más fuerte.
Discusión: Los resultados confirman que la planificación instruccional funciona como un determinante estructural que influye en los procesos del aula y los resultados del aprendizaje.
Conclusiones: El desarrollo de la alfabetización física está fuertemente condicionado por la planificación y la gestión pedagógicas, lo que subraya la importancia del diseño instruccional orientado a la alfabetización.

Palabras clave

Calidad de la implementación; planificación didáctica; alfabetización física; PLS-SEM; participación estudiantil.

Introduction

Over the past two decades, physical education (PE) has gradually shifted from a sport-centered instructional paradigm toward a broader developmental orientation that emphasizes lifelong engagement in physical activity. Within this evolution, the concept of Physical Literacy has emerged as a central theoretical framework for redefining the purposes of physical education. As articulated by (Chambers, 2021), Physical Literacy encompasses physical competence, motivation, confidence, knowledge, and sustained participation, positioning movement not merely as a skill to be mastered but as an integral dimension of human flourishing. Subsequent scholarship has strengthened this multidimensional perspective and highlighted its association with health, well-being, and long-term physical activity participation (Cairney et al., 2019; Edwards et al., 2017; Blain et al., 2021; Dudley et al., 2017) and Recent evidence indicates that comprehensive school physical activity programs significantly improve students' physical literacy, highlighting the strategic role of school-based planning and the integration of physical activities (Hadyansah et al., 2025).

Motor competence has been linked to sustained physical activity patterns (Hulteen et al., 2018; Stodden et al., 2014), while longitudinal evidence suggests that early proficiency in movement skills predicts adolescent participation levels (Field et al., 2017). Intervention-based studies in school settings also demonstrate that structured physical education programs can positively influence students' activity levels and fitness outcomes (Sacchetti et al., 2013; Marin et al., 2023). Collectively, these findings reinforce the view that physical education has the potential to serve as a critical platform for fostering lifelong engagement in physical activity, Recent evidence from Indonesia indicates that while many students demonstrate promising levels of physical literacy, their motor skills and the assessment system still require improvement and Students demonstrate promising levels of physical literacy, though their motor skills and the assessment system still require improvement (Chaeroni et al., 2025).

Despite these theoretical and empirical advances, a persistent tension remains between conceptual aspirations and classroom realities. In many educational contexts, physical education continues to emphasize technical skill acquisition and sport performance, often at the expense of affective and cognitive development (Robinson et al., 2016; Casey & Dyson, 2015).

Instructional planning represents a foundational component of pedagogical practice. It shapes learning objectives, content sequencing, task design, and assessment strategies, thereby influencing the quality of classroom implementation (Ennis, 2017; Kirk et al., 2006). Research consistently demonstrates that well-designed instruction enhances student engagement and learning outcomes (Morgan & Hansen, 2008; Young & McKenzie, 2018). Participatory and student-centered pedagogical approaches, in particular, have been associated with improved motivational climates and deeper engagement (Casey et al., 2018; Durden-Myers et al., 2018). Engagement itself is widely recognized as a proximal determinant of educational outcomes, mediating the relationship between instructional quality and learning achievement (Young & McKenzie, 2018). Yet, within the Physical Literacy discourse, the structural relationship between planning design, implementation quality, engagement, and literacy outcomes remains underexplored.

The state of the art in Physical Literacy research thus reveals a concentration on conceptual clarification, measurement validation, and intervention evaluation (Edwards et al., 2017; Shearer et al., 2018; Morgan & Barnett, 2016). While these contributions are essential, they primarily focus on outcomes rather than upstream pedagogical determinants. Few empirical studies have examined how Physical Literacy-oriented lesson planning influences literacy development through instructional and engagement mechanisms, particularly using advanced structural modeling techniques.

Student engagement has been shown to significantly influence learning effectiveness (Ullrich et al., 2013; Tilga et al., 2023), and the implementation of authentic assessment remains inconsistent (Barrientos et al., 2022). Although efforts have been made to develop Physical Literacy instruments adapted to local contexts (Spittle, 2012; Keegan et al., 2019), research integrating planning design, instructional quality, engagement, and Physical Literacy outcomes within a unified empirical model remains limited. Moreover, the role of teachers in fostering students' confidence and motivation toward physical activity continues to require systematic investigation (Huhtiniemi et al., 2019; Pérez et al., 2019).

Taken together, the literature indicates a clear research gap: while Physical Literacy is theoretically robust and increasingly measurable, the pedagogical architecture that supports its development particularly at the level of lesson planning has not been sufficiently examined through an integrated structural framework. Understanding how Physical Literacy Based Planning Design shapes implementation quality and student engagement, and how these processes collectively influence literacy outcomes, remains an unresolved empirical question.

Accordingly, this study aims to develop and empirically test a structural model examining the influence of Physical Literacy Based Planning Design on students' Physical Literacy, with Implementation Quality and Student Engagement positioned as mediating variables. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), this research seeks to provide empirical evidence clarifying the mechanisms through which pedagogical planning contributes to holistic literacy development in school-based physical education.

Method

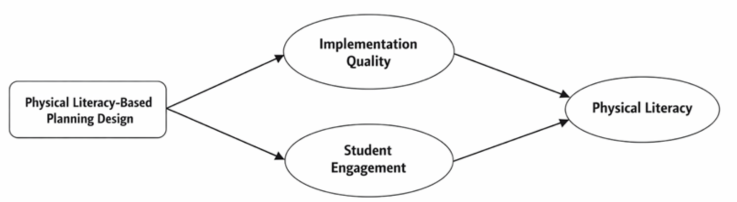
This study employed a cross-sectional explanatory research design using a quantitative approach. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine both direct and mediated relationships among constructs. PLS-SEM was selected because:

1. The model includes multiple mediation paths.
2. The study aims at prediction and theory development.
3. The model integrates newly operationalized constructs in Physical Literacy-based planning design.
4. The distribution of educational data is often non-normal.

The analysis was conducted using SmartPLS 4.

The conceptual model is grounded in the holistic Physical Literacy framework proposed by Margaret Whitehead, integrating instructional design theory and student engagement theory.

Figure 1. Conceptual Framework Figure



Hypothesized Relationships:

H1: PL-Based Planning Design → Physical Literacy

H2: PL-Based Planning Design → Implementation Quality

H3: PL-Based Planning Design → Student Engagement

H4: Implementation Quality → Physical Literacy

H5: Student Engagement → Physical Literacy

H6: PL-Based Planning Design → Physical Literacy through Implementation Quality

H7: PL-Based Planning Design → Physical Literacy through Student Engagement

Ethical Considerations

This study was conducted in accordance with ethical standards for research involving human participants. Informed consent was obtained from all participants prior to data collection. Participants were assured of the confidentiality and anonymity of their responses, the study protocol was reviewed and approved by the Institutional Review Board (IRB) / Ethics Committee Universitas Bhayangkara Jakarta Raya, Indonesia. Participation was voluntary, and respondents had the right to withdraw at any time without any consequences.

Participants

The population consisted of secondary school students enrolled in Physical Education (PE) classes, sample size was determined based on the recommendation of Joseph F. Hair Jr. for PLS-SEM, which suggests that the minimum sample should range between 5 to 10 times the total number of measurement indicators in reflective models, a total of 500 respondents were initially recruited for this study. However, following a data screening process that included checking data completeness, response consistency, and outlier detection, 350 respondents were deemed valid and included in the final analysis.

This sample size remains sufficient for PLS-SEM analysis, as it exceeds the minimum requirement based on the 10-times rule. The data screening process was conducted to ensure data quality, including the removal of incomplete responses and the detection of inconsistent response patterns (straight-lining). To enhance statistical power, improve parameter estimation accuracy, and strengthen bootstrapping stability, a total of 500 respondents were initially recruited. After data screening procedures, 350 valid responses were retained for the final analysis, which remains sufficient for PLS-SEM.

The sampling technique used in this study was purposive sampling. Participants were selected from high school students attending physical education classes organized in accordance with the applicable curriculum standards. Inclusion criteria for this study included: (1) students aged 15–18 years, (2) actively participating in physical education classes, and (3) willingness to complete the research questionnaire. This sampling approach was chosen due to ease of access to respondents and its suitability for the exploratory research objectives of developing a structural model.

Procedure

All constructs were measured using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). All constructs were modeled as reflective measurement models.

Table 1. Operationalization of Constructs

Construct	Dimensions	Number of Items	Source Adaptation
PL-Based Planning Design (X1)	Goal integration, activity design, student-centered strategies, authentic assessment	8	Developed from PL framework
Implementation Quality (X2)	Instructional clarity, feedback, method variation, classroom management	8	Adapted from instructional quality literature
Student Engagement (X3)	Behavioral, emotional, cognitive	9	Adapted from engagement theory
Physical Literacy (Y)	Physical competence, confidence, knowledge, participation	10	Based on PL multidimensional framework

Following pilot testing and measurement model evaluation, several items with outer loadings below 0.70 were removed to improve construct validity and reliability

Instrument

1. Item generation based on literature synthesis
2. Expert validation (3–5 experts in PE & curriculum design)
3. Content Validity Index (CVI) calculation
4. Pilot testing (n = 50)
5. Item refinement before main survey

Data analysis

PLS-SEM analysis followed the two-step approach:

Measurement Model Evaluation

Convergent Validity:

1. Outer loadings ≥ 0.70
2. AVE ≥ 0.50

Reliability:

1. Composite Reliability ≥ 0.70
2. Cronbach's Alpha ≥ 0.70

Discriminant Validity:

1. HTMT < 0.90
2. Fornell-Larcker Criterion

Structural Model Evaluation

1. Collinearity (VIF < 5)
2. Path Coefficients (Bootstrapping 5,000 resamples)
3. R^2
4. Effect size (f^2)
5. Predictive relevance (Q^2)
6. SRMR (< 0.08)

Mediation Analysis

Mediation was assessed using bootstrapping procedures. The Variance Accounted For (VAF) index was calculated:

1. VAF < 20% = No mediation
2. 20–80% = Partial mediation
3. 80% = Full mediation

Results

Statistical descriptive analysis was conducted to provide an initial overview of respondents' perceptions toward each measurement indicator. This analysis aims to describe the distribution of responses, central tendency, and variability of each item before proceeding to further inferential analysis. Descriptive statistics include the number of observations (N), range, minimum and maximum values, mean, standard deviation, and variance. All items were measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The total number of valid responses analyzed was 350, with no missing data (valid N listwise = 350). The 350 valid responses were used in the final analysis after data screening procedures standard deviation.

Table 2. Descriptive Statistics

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
X1.1	350	4	1	5	2.99	.974	.948
X1.2	350	4	1	5	2.97	.973	.947
X1.3	350	4	1	5	3.00	1.009	1.017
X1.4	350	4	1	5	2.99	.978	.957
X2.1	350	4	1	5	3.01	1.028	1.057
X2.2	350	4	1	5	2.98	1.011	1.023
X2.3	350	4	1	5	2.99	.983	.966
X2.4	350	4	1	5	2.99	1.010	1.020
X3.1	350	4	1	5	2.98	1.003	1.005
X3.2	350	4	1	5	2.99	.990	.980

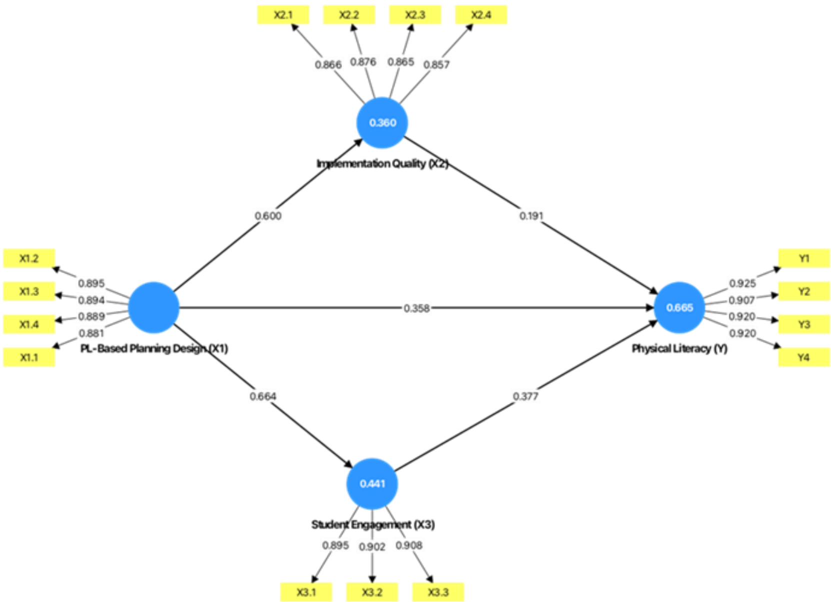
X3.3	350	4	1	5	2.99	.983	.965
Y1	350	4	1	5	3.01	.990	.980
Y2	350	4	1	5	3.01	.993	.986
Y3	350	4	1	5	2.98	1.010	1.020
Y4	350	4	1	5	2.97	1.004	1.008
Valid N (listwise)	350						

Descriptive statistical analysis was conducted to provide an initial overview of respondents' responses to each measurement indicator. All items were measured using a five-point Likert scale, and the analysis included 350 valid responses (valid N = 350), indicating complete data without missing values. The results show that all indicators have a full response range (minimum = 1; maximum = 5), suggesting that respondents utilized the entire scale. The mean values range from 2.97 to 3.01, indicating moderate perceptions across all variables. Standard deviation values vary between 0.973 and 1.028, reflecting relatively consistent and moderate dispersion of responses. Overall, the descriptive findings demonstrate stable data distribution and sufficient variability, supporting the suitability of the dataset for subsequent reliability and structural model analysis. The final measurement model retained 4 indicators for X1, 4 indicators for X2, 3 indicators for X3, and 4 indicators for Y after item purification

Convergent Validity

All indicator loadings exceeded the recommended threshold of 0.70, ranging from 0.721 to 0.884. This indicates adequate indicator reliability. Average Variance Extracted (AVE) values were as follows:

Figure 2. Measurement Model Evaluation



Outer loadings

Measurement Model Evaluation (Outer Model)

The measurement model was assessed through convergent validity, internal consistency reliability, and discriminant validity.

Table 3. Outer Loadings

	Implementation Quality (X2)	PL-Based Planning Design (X1)	Physical Literacy (Y)	Student Engagement (X3)	Description
X1.2		0.895			Valid
X1.3		0.894			Valid
X1.4		0.889			Valid
X2.1	0.866				Valid
X2.2	0.876				Valid

X2.3	0.865				Valid
X2.4	0.857				Valid
X3.1				0.895	Valid
X3.2				0.902	Valid
X3.3				0.908	Valid
Y1			0.925		Valid
Y2			0.907		Valid
Y3			0.920		Valid
Y4			0.920		Valid
X1.1		0.881			Valid

Outer loadings were examined to assess indicator reliability within each construct. As presented in Table 3, all indicators demonstrate loading values well above the recommended threshold of 0.70, ranging from 0.857 to 0.925. For PL-Based Planning Design (X1), loadings range between 0.881 and 0.895, indicating strong representation of the construct. Implementation Quality (X2) indicators load between 0.857 and 0.876, while Student Engagement (X3) shows loadings from 0.895 to 0.908. Physical Literacy (Y) exhibits the highest loadings overall, ranging from 0.907 to 0.925. These results confirm that all measurement items possess adequate indicator reliability and are statistically valid for inclusion in the structural model analysis.

Average Variance Extracted (AVE)

Table 4. Average Variance Extracted (AVE)

	AVE	Description
Implementation Quality (X2)	0.750	Valid
PL-Based Planning Design (X1)	0.791	Valid
Physical Literacy (Y)	0.843	Valid
Student Engagement (X3)	0.813	Valid

Convergent validity was further assessed using the Average Variance Extracted (AVE). The results indicate that all constructs exceed the recommended minimum threshold of 0.50. Implementation Quality (X2) obtained an AVE value of 0.750, PL-Based Planning Design (X1) reached 0.791, Physical Literacy (Y) demonstrated the highest AVE at 0.843, and Student Engagement (X3) achieved 0.813. These findings confirm that each construct explains more than 75% of the variance in its respective indicators, thereby establishing strong convergent validity across the measurement model.

Reliability

Table 5. Reliability

	Cronbach's alpha	rho_c	Description
Implementation Quality (X2)	0.889	0.923	Reliable
PL-Based Planning Design (X1)	0.912	0.938	Reliable
Physical Literacy (Y)	0.938	0.955	Reliable
Student Engagement (X3)	0.885	0.929	Reliable

Internal consistency reliability was evaluated using Cronbach's Alpha and Composite Reliability (rho_c). The results indicate that all constructs exceed the recommended threshold of 0.70, confirming strong internal consistency. Implementation Quality (X2) obtained a Cronbach's Alpha of 0.889 and a Composite Reliability of 0.923. PL-Based Planning Design (X1) demonstrated values of 0.912 and 0.938, respectively. Physical Literacy (Y) showed the highest reliability, with Cronbach's Alpha of 0.938 and Composite Reliability of 0.955. Meanwhile, Student Engagement (X3) achieved values of 0.885 and 0.929. These findings indicate that all constructs are reliably measured and suitable for subsequent structural model analysis.

Discriminant Validity

Heterotrait–Monotrait Ratio (HTMT)

Table 6. Heterotrait–Monotrait Ratio (HTMT)

	Implementation Quality (X2)	PL-Based Planning Design (X1)	Physical Literacy (Y)	Student Engagement (X3)
Implementation Quality (X2)				
PL-Based Planning Design (X1)	0.666			
Physical Literacy (Y)	0.721	0.781		
Student Engagement (X3)	0.757	0.738	0.815	

Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT). As shown in the results, all HTMT values are below the conservative threshold of 0.90, indicating satisfactory discriminant validity among constructs. The HTMT value between PL-Based Planning Design (X1) and Implementation Quality (X2) is 0.666, while the value between Physical Literacy (Y) and Implementation Quality (X2) is 0.721. The relationship between Physical Literacy (Y) and PL-Based Planning Design (X1) yields an HTMT value of 0.781. The highest HTMT value is observed between Student Engagement (X3) and Physical Literacy (Y) at 0.815, which remains within acceptable limits. These findings confirm that each construct is empirically distinct and measures different conceptual domains within the model.

Table 7. Fornell-Larcker Criterion

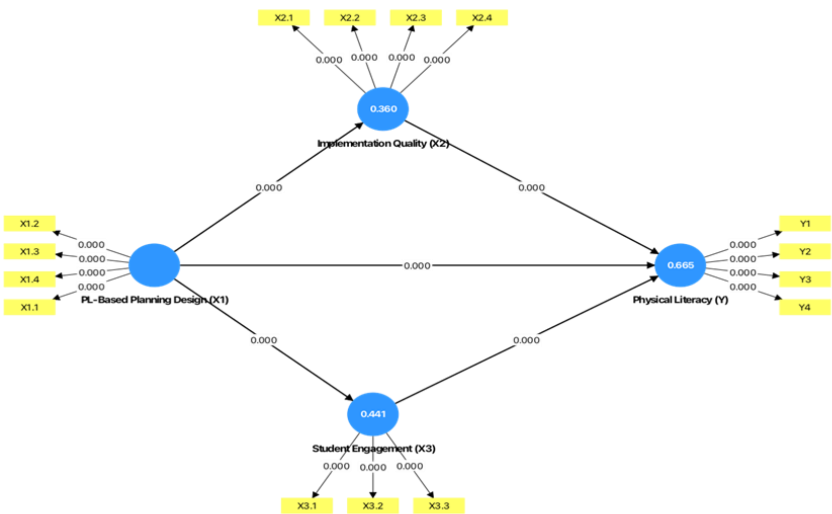
	Implementation Quality (X2)	PL-Based Planning Design (X1)	Physical Literacy (Y)	Student Engagement (X3)
Implementation Quality (X2)	0.866			
PL-Based Planning Design (X1)	0.600	0.890		
Physical Literacy (Y)	0.659	0.723	0.918	
Student Engagement (X3)	0.672	0.664	0.743	0.902

Discriminant validity was further assessed using the Fornell–Larcker criterion. The results indicate that the square root of the AVE for each construct exceeds its correlations with other constructs, thereby satisfying the recommended requirement. Specifically, the square root of AVE values are 0.866 for Implementation Quality (X2), 0.890 for PL-Based Planning Design (X1), 0.918 for Physical Literacy (Y), and 0.902 for Student Engagement (X3). Each of these values is higher than the corresponding inter-construct correlations presented in the matrix. These findings confirm that the constructs demonstrate adequate discriminant validity and are empirically distinct within the measurement model.

Structural Model Evaluation (Inner Model)

The structural model evaluation was conducted to examine the predictive relationships among the latent constructs and to test the proposed hypotheses. This stage assesses the explanatory power of the model as well as the strength and significance of the structural paths between variables. The evaluation includes the analysis of collinearity, coefficient of determination (R^2), path coefficients, effect sizes, and predictive relevance to ensure that the structural relationships are statistically robust and theoretically meaningful.

Figure 3. Inner Model



Collinearity (VIF)

Collinearity was assessed using the Variance Inflation Factor (VIF) to ensure that multicollinearity does not bias the structural model estimates.

Table 8. Variance Inflation Factor (VIF)

	VIF
X1.2	2.950
X1.3	2.833
X1.4	2.791
X2.1	2.297
X2.2	2.513
X2.3	2.342
X2.4	2.234
X3.1	2.415
X3.2	2.575
X3.3	2.570
Y1	3.932
Y2	3.355
Y3	3.721
Y4	3.735
X1.1	2.578

The results indicate that all VIF values range between 2.234 and 3.932. Specifically, the indicators of PL-Based Planning Design (X1) show VIF values between 2.578 and 2.950, Implementation Quality (X2) ranges from 2.234 to 2.513, and Student Engagement (X3) ranges from 2.415 to 2.575. For Physical Literacy (Y), VIF values range from 3.355 to 3.932. All values are below the conservative threshold of 5.00, indicating that multicollinearity is not a concern in the model. These findings confirm that the predictor constructs are sufficiently independent and suitable for subsequent structural analysis.

Table 9. Path Coefficients

No	Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistik (|O/STDEV|)	P-value (P values)	Description
1	PL-Based Planning Design (X1) -> Physical Literacy (Y)	0.358	0.357	0.043	8.395	0.000	Supported
2	Implementation Quality (X2) -> Physical Literacy (Y)	0.191	0.192	0.044	4.302	0.000	Supported
3	Student Engagement (X3) -> Physical Literacy (Y)	0.377	0.377	0.045	8.365	0.000	Supported
4	PL-Based Planning Design (X1) -> Implementation Quality (X2)	0.600	0.601	0.032	18.517	0.000	Supported
5	PL-Based Planning Design (X1) -> Student Engagement (X3)	0.664	0.665	0.029	22.911	0.000	Supported
6	PL-Based Planning Design (X1) -> Implementation Quality (X2) -> Physical Literacy (Y)	0.115	0.116	0.028	4.122	0.000	Supported
7	PL-Based Planning Design (X1) -> Student Engagement (X3) -> Physical Literacy (Y)	0.250	0.251	0.031	7.956	0.000	Supported

Path coefficients were analyzed using bootstrapping procedures to test the significance of the hypothesized relationships. The results indicate that all direct and indirect paths are statistically significant at $p < 0.001$. PL-Based Planning Design (X1) has a significant direct effect on Physical Literacy (Y) ($\beta = 0.358$, $t = 8.395$), Implementation Quality (X2) also significantly influences Physical Literacy ($\beta = 0.191$, $t = 4.302$), and Student Engagement (X3) demonstrates the strongest direct effect on Physical Literacy ($\beta = 0.377$, $t = 8.365$). Furthermore, PL-Based Planning Design significantly predicts Implementation Quality ($\beta = 0.600$, $t = 18.517$) and Student Engagement ($\beta = 0.664$, $t = 22.911$), indicating strong upstream effects.

Mediation analysis reveals that PL-Based Planning Design indirectly affects Physical Literacy through Implementation Quality ($\beta = 0.115$, $t = 4.122$) and through Student Engagement ($\beta = 0.250$, $t = 7.956$), with both indirect effects being significant. These findings confirm that the proposed structural relationships are empirically supported, highlighting Student Engagement as a particularly strong explanatory pathway linking planning design to Physical Literacy outcomes.

Coefficient of Determination (R^2)

The coefficient of determination (R^2) was examined to evaluate the explanatory power of the structural model.

Table 10. Coefficient of determination (R^2)

	R-square	Adjusted R-square
Implementation Quality (X2)	0.360	0.358
Physical Literacy (Y)	0.665	0.662
Student Engagement (X3)	0.441	0.439

The results indicate that PL-Based Planning Design explains 36.0% of the variance in Implementation Quality (R^2 = 0.360; Adjusted R^2 = 0.358), suggesting a moderate level of predictive accuracy. For Student Engagement, the model accounts for 44.1% of the variance (R^2 = 0.441; Adjusted R^2 = 0.439), indicating moderate explanatory strength. Notably, the model explains 66.5% of the variance in Physical Literacy (R^2 = 0.665; Adjusted R^2 = 0.662), which reflects substantial predictive power. These findings demonstrate that the proposed structural model provides strong explanatory capability, particularly in predicting Physical Literacy outcomes.

Effect size (f^2)

Effect size (f^2) was calculated to assess the magnitude of each exogenous construct's contribution to the endogenous variables.

Table 11. Effect Size (f2)

	Implementation Quality (X2)	PL-Based Planning Design (X1)	Physical Literacy (Y)	Student Engagement (X3)
Implementation Quality (X2)			0.055	
PL-Based Planning Design (X1)	0.563		0.197	0.789
Physical Literacy (Y)				
Student Engagement (X3)			0.188	

The results indicate that PL-Based Planning Design (X1) has a large effect on Implementation Quality (f^2 = 0.563) and Student Engagement (f^2 = 0.789), demonstrating its strong predictive role within the model. In predicting Physical Literacy (Y), PL-Based Planning Design shows a moderate effect (f^2 = 0.197), while Student Engagement (X3) also exhibits a moderate effect (f^2 = 0.188). Implementation Quality (X2), however, demonstrates a small effect on Physical Literacy (f^2 = 0.055). Overall, these findings suggest that PL-Based Planning Design serves as the primary driver in the structural model, particularly in influencing mediating constructs, while Student Engagement plays a meaningful role in shaping Physical Literacy outcomes.

Predictive Relevance (Q^2)

Predictive relevance was assessed using the Q^2 predictive values to evaluate the model's out-of-sample predictive capability.

Table 12. Predictive Relevance (Q^2)

	Q^2 prediction	RMSE	MAE
Implementation Quality (X2)	0.357	0.808	0.661
Student Engagement (X3)	0.438	0.755	0.611
Physical Literacy (Y)	0.520	0.697	0.559

The results indicate that all endogenous constructs have Q^2 values greater than zero, confirming the model's predictive relevance. Implementation Quality (X2) demonstrates a Q^2 value of 0.357 (RMSE =

0.808; MAE = 0.661), while Student Engagement (X3) shows a Q^2 of 0.438 (RMSE = 0.755; MAE = 0.611). Physical Literacy (Y) exhibits the highest predictive relevance with a Q^2 value of 0.520 (RMSE = 0.697; MAE = 0.559). These findings indicate that the structural model possesses strong predictive capability, particularly in predicting Physical Literacy outcomes, thereby supporting the robustness and practical relevance of the proposed model.

Model fit (SRMR)

Model fit was evaluated using the Standardized Root Mean Square Residual (SRMR) and additional model fit indices.

Table 13. The SRMR

	Model jenuh (saturated)	Perkiraan model
SRMR	0.036	0.083
d_ULS	0.157	0.817
d_G	0.146	0.177
Chi-square	304.283	333.584
NFI	0.931	0.924

The SRMR value for the estimated model (0.083) is slightly above the conservative threshold of 0.08, indicating a marginal but acceptable fit within the context of exploratory PLS-SEM. The estimated model shows an SRMR value of 0.083, which is slightly above the conservative cutoff but still within an acceptable range for PLS-SEM analysis. The discrepancy measures d_ULS (0.157 for saturated; 0.817 for estimated) and d_G (0.146 for saturated; 0.177 for estimated) further support acceptable model fit, as lower values indicate smaller discrepancies between the empirical and model-implied correlation matrices. The Chi-square values are 304.283 (saturated) and 333.584 (estimated), while the Normed Fit Index (NFI) values of 0.931 and 0.924 exceed the recommended threshold of 0.90. Overall, these results indicate that the structural model demonstrates satisfactory global model fit and supports the adequacy of the proposed theoretical framework. The Variance Accounted For (VAF) was calculated to assess mediation effects. The indirect effect via Implementation Quality was 0.115, and via Student Engagement was 0.250, with a direct effect of 0.358. The total effect was approximately 0.723, resulting in a VAF value of 50.5%, indicating partial mediation

Discussion

PL-Based Planning Design on Physical Literacy

The results indicate that PL-Based Planning Design has a positive and significant effect on Physical Literacy ($\beta = 0.358$, $p < 0.001$). This finding confirms that instructional planning which explicitly integrates the dimensions of goal integration, meaningful activity design, student centered strategies, and authentic assessment directly contributes to students' Physical Literacy development. The dimension of goal integration ensures that learning objectives extend beyond technical motor skills to include motivation, confidence, and conceptual understanding. This aligns with the philosophical foundation articulated by (Whitehead, 2013), who conceptualizes Physical Literacy as the integration of physical competence, motivation, and knowledge within a unified human development framework. Empirical support from (Edwards et al., 2017) further emphasizes that Physical Literacy can only be effectively realized when systematically embedded within curriculum structures rather than treated as an abstract educational ideal.

The meaningful activity design dimension strengthens this relationship by ensuring that movement experiences are contextual, purposeful, and relevant to students' lived realities. Research by (Casey and Dyson, 2018) and (Hastie and Wallhead, 2015) demonstrates that participatory and student-centered pedagogies enhance the quality of learning experiences and promote deeper engagement with physical activity. When students perceive activities as meaningful, they are more likely to internalize the value of movement, thereby reinforcing the lifelong engagement component of Physical Literacy. Furthermore, student-centered strategies embedded in planning design foster autonomy, agency, and active participation, which (Larsson and Thedin, 2023) identify as critical elements in promoting cognitive and emotional involvement. (Dudley, 2015) also argues that Physical Literacy development requires pedagogical environments that cultivate identity formation through meaningful movement experiences rather than repetitive technical drills.

The authentic assessment dimension further explains the direct effect observed in this study. (Robinson et al. 2017) criticize traditional physical education assessment practices for overemphasizing performance metrics while neglecting affective and cognitive domains. In contrast, authentic assessment allows educators to evaluate students' understanding, confidence, and reflective engagement alongside motor performance. (Ennis, 2015) highlights that alignment between instructional goals and assessment practices enhances learning transfer and consolidates multidimensional outcomes. Empirical realities in many school settings continue to show an overreliance on skill-drill instruction and performance-based evaluation (Kirk, 2010; Rocliffe, 2023), which often limits the broader developmental potential of physical education. The present findings suggest that when planning design deliberately incorporates multidimensional Physical Literacy principles, measurable improvements in literacy outcomes can be achieved.

These results extend developmental models such as those proposed by (Barnett et al., 2021), which emphasize the reciprocal relationship between motor competence and physical activity participation, by identifying pedagogical planning as an upstream structural determinant of Physical Literacy. The study contributes theoretically by demonstrating that instructional planning functions as a foundational driver in the Physical Literacy development process, rather than merely serving as an administrative requirement. Empirically, it provides structural evidence that integrating goal-oriented design, meaningful tasks, student-centered strategies, and authentic assessment into lesson planning significantly enhances students' Physical Literacy. Practically, the findings underscore that meaningful reform in Physical Literacy must begin with the architecture of classroom-level planning design, reinforcing the necessity of embedding multidimensional literacy principles within daily instructional practice.

PL-Based Planning Design on Implementation Quality

The findings demonstrate that PL-Based Planning Design has a strong and statistically significant effect on Implementation Quality ($\beta = 0.600$, $p < 0.001$; $f^2 = 0.563$), indicating a large effect size. This result confirms that the quality of classroom implementation is fundamentally shaped by the robustness of instructional planning. In other words, planning is not merely a preparatory administrative task but a structural determinant of how effectively instruction is enacted in practice.

The structured activity design dimension plays a crucial role in this relationship. When learning tasks are deliberately sequenced, developmentally appropriate, and aligned with clearly defined literacy-based goals, teachers are better equipped to apply varied instructional methods and adapt to classroom dynamics. Casey and Dyson (2018) argue that participatory and well-conceptualized curriculum planning significantly influences pedagogical enactment, as teachers draw upon pre-designed task structures to facilitate meaningful engagement. Similarly, research in curriculum enactment suggests that coherent planning enhances instructional flow and reduces fragmentation in teaching practice (Larsson and Thedin, 2023). The present findings empirically support this perspective by demonstrating that structured planning translates into higher instructional clarity, more consistent feedback, and better-managed learning environments.

The student-centered strategy dimension further strengthens Implementation Quality by fostering adaptive teaching practices and responsive classroom management. When planning explicitly incorporates opportunities for student choice, collaboration, and reflection, teachers are more likely to implement instructional approaches that promote autonomy and participation. Ennis emphasizes that curriculum design shapes the quality of classroom practice, as well-articulated plans provide teachers with a pedagogical roadmap that enhances coherence and instructional effectiveness. In this regard, student-centered planning does not merely enhance engagement; it directly improves instructional clarity, feedback processes, and classroom organization—core components of Implementation Quality measured in this study.

Empirical observations in physical education settings often reveal inconsistencies between intended curriculum and enacted practice, particularly when planning lacks explicit structure or multidimensional objectives (Kirk, 2010; Bailey, 2006). The current findings suggest that embedding Physical Literacy principles into planning design reduces such gaps by aligning goals, activities, and assessment strategies in advance. This alignment enables teachers to deliver instruction more confidently and systematically, thereby elevating overall implementation quality.

Theoretically, this result reinforces the view that planning functions as an upstream driver within the pedagogical process. While much of the Physical Literacy literature focuses on student-level outcomes, the present study highlights the organizational and instructional architecture that precedes those outcomes. Practically, it underscores the necessity of strengthening teachers' capacity to design literacy-oriented lesson plans, as improvements in implementation quality are unlikely to occur without corresponding enhancements in planning design.

PL-Based Planning Design on Student Engagement

The results indicate that PL-Based Planning Design exerts a very strong and statistically significant effect on Student Engagement ($\beta = 0.664$, $p < 0.001$; $f^2 = 0.789$), representing a large effect size. This finding demonstrates that pedagogical designs explicitly grounded in Physical Literacy principles substantially enhance students' behavioral, emotional, and cognitive involvement in learning activities. It suggests that engagement is not merely a spontaneous classroom phenomenon but is structurally shaped by the way lessons are conceptualized and organized.

The meaningful activity design dimension plays a particularly important role in fostering emotional engagement. When activities are contextually relevant, developmentally appropriate, and connected to students' real-life experiences, learners are more likely to experience enjoyment, interest, and personal value in movement tasks. Casey et al. (2018) argue that participatory and context-sensitive curricula increase meaningful involvement by allowing students to see the purpose behind what they are doing. Similarly, research in student-centered physical education indicates that relevance and authenticity strengthen students' affective connection to learning, thereby enhancing sustained engagement (Hastie & Wallhead, 2015). Within a Physical Literacy framework, such emotional investment reinforces the motivation and confidence dimension, which is essential for long-term participation.

The goal clarity dimension further contributes to cognitive engagement by providing students with a transparent understanding of learning intentions and expected outcomes. When objectives are clearly articulated and aligned with multidimensional literacy goals, students are more likely to engage in strategic thinking, reflection, and purposeful effort. Margaret Whitehead emphasizes that meaningful engagement arises when learners understand not only how to perform movements but also why they matter. Clear and integrated goals therefore support deeper cognitive processing and strengthen the knowledge and understanding component of Physical Literacy.

Empirical observations in school contexts often reveal that poorly articulated lesson goals and disconnected activities result in passive participation and surface-level learning (Kirk, 2010; Bailey, 2006). The present findings suggest that when planning design deliberately incorporates meaningful tasks and explicit literacy-oriented objectives, student engagement increases substantially across its behavioral, emotional, and cognitive dimensions. Theoretically, this result reinforces the position that engagement serves as a central mediating mechanism within literacy development. Practically, it highlights the necessity of designing lessons that are purposeful, relevant, and cognitively transparent in order to cultivate sustained and multidimensional student involvement.

Implementation Quality on Physical Literacy

The findings indicate that Implementation Quality has a positive and significant effect on Physical Literacy ($\beta = 0.191$, $p < 0.001$). Although the magnitude of the effect is smaller than that of Student Engagement, its contribution remains meaningful in explaining students' literacy outcomes. The construct of Implementation Quality was measured through instructional clarity, feedback quality, method variation, and classroom management, each of which represents a critical pedagogical mechanism through which planning is translated into classroom practice.

Instructional clarity enables students to cognitively grasp learning objectives, task expectations, and performance criteria, thereby strengthening the knowledge and understanding dimension of Physical Literacy. When learning goals are communicated explicitly and coherently, students are better able to connect movement tasks with conceptual meaning. This finding aligns with prior research by Morgan and Hansen (2008), who demonstrated that instructional quality significantly shapes students' learning experiences in physical education settings. Similarly, Cathy Ennis emphasizes that structured and coherent instructional delivery enhances meaningful learning and promotes deeper cognitive engagement in physical education contexts.

Feedback quality further contributes to the development of confidence and perceived competence, which are central components of the motivation and confidence dimension of Physical Literacy. Constructive and timely feedback helps students recognize progress, refine performance, and internalize a sense of capability. Keegan et al. (2019) argue that supportive feedback mechanisms cultivate adaptive motivational climates, thereby strengthening students' belief in their physical abilities. In addition, Chen and Ennis (2019) highlight that contextualized and formative assessment practices enhance students' reflective thinking and cognitive involvement, reinforcing multidimensional literacy development.

Method variation and effective classroom management also play important roles in sustaining structured yet dynamic learning environments. Varied instructional approaches prevent monotony, encourage active participation, and accommodate diverse learner needs, while effective classroom management ensures optimal learning time and equitable engagement opportunities. Empirical observations in school-based physical education frequently reveal inconsistencies in instructional delivery, with some classes characterized by unclear task organization and limited feedback (Kirk, 2010; Bailey, 2006). The present findings suggest that when implementation quality is systematically strengthened, it contributes not only to improved skill performance but also to broader literacy outcomes.

Overall, this result reinforces the view that Implementation Quality functions as a critical pedagogical bridge between planning design and Physical Literacy development. While engagement serves as a stronger proximal predictor, the quality of instructional enactment provides the structural conditions that enable literacy dimensions physical competence, confidence, and understanding to develop coherently. The study therefore contributes to the literature by empirically confirming that high-quality classroom implementation is not merely a procedural factor but a substantive determinant in advancing multidimensional Physical Literacy outcomes.

Student Engagement on Physical Literacy

The results reveal that Student Engagement exerts the strongest direct effect on Physical Literacy ($\beta = 0.377$, $p < 0.001$), underscoring its central role as a proximal determinant in the model. Student Engagement was operationalized through three dimensions behavioral engagement (active participation), emotional engagement (enthusiasm and interest), and cognitive engagement (strategic thinking and effortful processing) each of which corresponds to specific components of Physical Literacy.

Behavioral engagement directly supports the development of physical competence, as consistent and active participation increases opportunities for deliberate practice and skill refinement. Developmental models proposed by Stodden et al. (2014) and Hulteen et al. (2018) emphasize that repeated, meaningful movement experiences strengthen motor competence, which in turn predicts sustained physical activity participation. The present findings empirically reinforce this trajectory by demonstrating that active behavioral involvement within structured lessons contributes significantly to literacy outcomes, recent intervention studies increasingly support the finding that innovative learning models grounded in contextual pedagogy and centered on students significantly improve physical literacy outcomes (Nurfauzan et al., 2025).

Emotional engagement, characterized by enthusiasm, enjoyment, and positive affect toward learning tasks, aligns closely with the motivation and confidence dimension of Physical Literacy. When students experience enjoyment and emotional connection to physical activity, they are more likely to internalize its value and develop a positive movement identity. Cairney et al. (2019) argue that motivational factors mediate the relationship between competence and long-term participation, highlighting the importance of affective investment in sustaining engagement beyond the classroom. In this regard, emotional engagement functions as a catalyst that transforms movement experiences into enduring personal commitment.

Cognitive engagement further strengthens the knowledge and understanding dimension of Physical Literacy. Strategic thinking, reflection, and purposeful effort enable students to comprehend movement concepts, rules, tactics, and health-related principles embedded in physical education tasks. Edwards et al. (2017) emphasize that Physical Literacy requires not only physical execution but also informed understanding of movement contexts. When students cognitively process learning experiences rather than passively performing tasks, they develop deeper conceptual awareness that supports lifelong engagement.

Empirical evidence from school-based research suggests that low engagement often results in superficial skill acquisition and limited transfer of learning (Kirk, 2010; Bailey, 2006). Conversely, classrooms characterized by high behavioral, emotional, and cognitive engagement demonstrate stronger developmental outcomes and sustained participation patterns. The present findings therefore position Student Engagement as the key psychopedagogical mechanism through which planning design and implementation quality translate into measurable Physical Literacy outcomes.

Theoretically, this result extends prior literature by confirming that engagement is not merely an ancillary outcome of effective teaching but a central explanatory pathway in literacy development. Practically, it highlights the necessity of designing learning environments that deliberately cultivate active participation, emotional connection, and cognitive involvement. In doing so, physical education can more effectively foster the integrated dimensions of competence, confidence, and understanding that define Physical Literacy.

PL-Based Planning Design on Physical Literacy on Implementation Quality

The analysis reveals that PL-Based Planning Design exerts a significant indirect effect on Physical Literacy through Implementation Quality ($\beta = 0.115$, $p < 0.001$), indicating a meaningful mediation pathway. This finding suggests that the influence of planning design on students' Physical Literacy is not only direct but also operates through the quality with which instruction is enacted in the classroom. In other words, well-structured planning enhances implementation processes, which in turn contribute to the development of multidimensional literacy outcomes.

The mediation mechanism can be explained through the alignment between structured planning dimensions goal integration, meaningful activity sequencing, student-centered strategy, and authentic assessment and the components of Implementation Quality, namely instructional clarity, feedback quality, method variation, and classroom management. When planning clearly articulates literacy-oriented objectives and structured learning progressions, teachers are more likely to deliver instruction with clarity and coherence. This instructional clarity strengthens students' conceptual understanding of movement tasks, thereby reinforcing the knowledge and understanding dimension of Physical Literacy. Research on curriculum enactment consistently shows that coherent planning reduces instructional fragmentation and enhances delivery quality (Larsson and Thedin, 2023; Kirk, 2010).

Furthermore, planning that embeds formative and authentic assessment strategies enables teachers to provide timely and constructive feedback during implementation. High-quality feedback supports the development of confidence and perceived competence, which are core components of the motivation and confidence dimension of Physical Literacy. Studies by Keegan et al. (2019) and Chen and Ennis (2019) highlight that supportive instructional climates and formative assessment practices enhance students' psychological engagement and self-belief. Thus, planning design indirectly shapes literacy outcomes by improving the pedagogical conditions under which learning occurs.

Empirically, inconsistencies between intended curriculum and enacted practice have been widely documented in physical education settings, particularly when planning lacks specificity or multidimensional orientation (Bailey, 2006; Ennis, 2015). The present findings indicate that embedding Physical Literacy principles within planning reduces this gap, ensuring that instructional delivery faithfully reflects intended literacy goals. This alignment enhances implementation fidelity, which subsequently promotes physical competence, confidence, and conceptual understanding.

Theoretically, this mediated relationship strengthens the argument that pedagogical planning functions as an upstream structural determinant within the literacy development process. Implementation Quality serves as a critical transmission mechanism translating design intentions into enacted instructional experiences. Practically, the findings underscore the importance of professional development initiatives that enhance teachers' capacity to design literacy-oriented lesson plans, as improvements in implementation quality and ultimately in Physical Literacy depend substantially on the strength and coherence of instructional planning.

PL-Based Planning Design on Physical Literacy on Student Engagement

The findings indicate that PL-Based Planning Design exerts a significant indirect effect on Physical Literacy through Student Engagement (β = 0.250, $p < 0.001$), confirming a strong mediation pathway. This result suggests that the impact of literacy-oriented planning on students' Physical Literacy is largely transmitted through enhanced behavioral, emotional, and cognitive engagement during instructional processes. In other words, well-designed pedagogical planning strengthens student involvement, which subsequently translates into improved multidimensional literacy outcomes.

This mediated relationship can be explained by examining the alignment between the dimensions of planning design goal integration, meaningful activity design, student-centered strategies, and authentic assessment and the components of Student Engagement. When lesson plans clearly articulate literacy-based goals and emphasize purposeful, relevant activities, students are more likely to participate actively (behavioral engagement), experience enjoyment and interest (emotional engagement), and invest cognitive effort in understanding movement concepts (cognitive engagement). Casey et al. (2018) and Hastie and Wallhead (2015) demonstrate that participatory and student-centered curriculum designs significantly enhance meaningful engagement in physical education contexts. Within a Physical Literacy framework, such engagement is essential because it provides the experiential foundation through which competence, confidence, and understanding are developed.

Behavioral engagement increases opportunities for deliberate practice, directly reinforcing the physical competence dimension of Physical Literacy. Emotional engagement strengthens intrinsic motivation and positive movement identity, supporting the motivation and confidence dimension, as highlighted by Cairney et al. (2019). Cognitive engagement deepens conceptual processing, fostering the knowledge and understanding component emphasized by Edwards et al. (2017). Thus, engagement functions as a multidimensional mechanism that integrates physical, affective, and cognitive learning processes.

Empirical evidence from school settings frequently indicates that disengaged students exhibit superficial skill acquisition and limited long-term participation in physical activity (Kirk, 2010; Bailey, 2006). The present findings suggest that literacy-oriented planning reduces disengagement by intentionally designing tasks that are relevant, structured, and cognitively meaningful. By embedding Physical Literacy principles into planning, teachers create learning environments that naturally cultivate high levels of engagement, thereby enhancing literacy development outcomes.

Theoretically, this mediated effect reinforces the position that Student Engagement operates as a central psychological and pedagogical conduit linking instructional design to literacy development. Planning design shapes the learning environment, engagement activates the learning process, and Physical Literacy emerges as the developmental outcome. Practically, these findings underscore the importance of designing lessons that deliberately foster active participation, emotional connection, and cognitive involvement, as improvements in Physical Literacy are strongly contingent upon the quality and depth of student engagement within classroom practice, These findings are consistent with recent evidence indicating that enjoyment, motivation, and perceived competence are the primary psychological drivers of physical literacy development in the context of physical education (Candia Cabrera et al., 2025).

Limitations

Despite its contributions, this study has several limitations. First, the cross-sectional design limits causal inference, and future longitudinal or experimental studies are needed to confirm causal pathways. Second, the reliance on self-reported data may introduce common method bias. Future studies should incorporate objective measurements such as performance-based assessments. Third, the sample was drawn from a specific educational context in Indonesia, which may limit generalizability to other cultural or educational systems. Fourth, although PLS-SEM is suitable for predictive modeling, future research could validate the model using covariance-based SEM (CB-SEM) to strengthen theoretical confirmation and future studies should also examine planning-based physical literacy models in inclusive educational settings and among students with special needs.

Practical Implications

The findings of this study provide important implications for physical education practice. Teachers should prioritize literacy-oriented instructional planning that integrates meaningful activities, student-centered strategies, and authentic assessment educational institutions should design professional development programs focusing on Physical Literacy-based planning competencies, furthermore, policymakers should consider embedding Physical Literacy principles within curriculum frameworks to enhance long-term student engagement in physical activity.

Conclusions

This study aimed to examine the structural relationships between PL-Based Planning Design, Implementation Quality, Student Engagement, and Physical Literacy within a Partial Least Squares Structural Equation Modeling (PLS-SEM) framework. The findings demonstrate that PL-Based Planning Design significantly influences Physical Literacy both directly and indirectly. Among all predictors, Student Engagement emerged as the strongest direct determinant of Physical Literacy, while Implementation Quality also contributed meaningfully, though with a smaller effect size. Furthermore, PL-Based Planning Design strongly predicted both Implementation Quality and Student Engagement, confirming its role as an upstream pedagogical determinant. The model explained 66.5% of the variance in Physical Literacy, indicating substantial explanatory power.

The novelty of this study lies in positioning PL-Based Planning Design as a structural and foundational variable in the Physical Literacy development process. While previous research has predominantly focused on measurement validation, intervention effectiveness, or developmental motor models, this study empirically demonstrates that instructional planning functions as a primary architectural driver that shapes classroom implementation and student engagement, which subsequently influence multidimensional Physical Literacy outcomes. By integrating pedagogical design variables within a structural modeling framework, this study advances the theoretical discourse beyond descriptive or program-based approaches and provides empirical evidence for a planning–implementation–engagement–literacy pathway.

The practical implications of this study are significant. The findings suggest that improving Physical Literacy outcomes requires more than curriculum reform at the policy level, it demands strengthening teachers' capacity to design literacy oriented lesson plans that integrate meaningful activities, student-centered strategies, and authentic assessment. Teacher professional development programs should therefore emphasize instructional planning competencies aligned with Physical Literacy principles. Additionally, educational stakeholders should recognize student engagement as a critical mediating mechanism and prioritize classroom environments that foster active participation, emotional connection, and cognitive involvement.

In conclusion, this study confirms that Physical Literacy development is not solely a function of student ability or participation frequency, but is structurally shaped by pedagogical design and classroom processes. By identifying planning design as a foundational determinant and engagement as a key explanatory pathway, this research contributes to a more integrated and theoretically grounded understanding of how Physical Literacy can be systematically cultivated within school based physical education.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article. The research was conducted independently, and no financial or commercial relationships could be construed as a potential conflict of interest

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