







Blended Learning and Learning Outcomes: The Mediating Role of Student Engagement in Indonesian Secondary Education

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Abstract

Blended learning has increasingly been adopted in secondary education as a strategic response to the demand for more effective and contemporary instructional practices; however, the mechanisms through which it influences academic achievement remain insufficiently explained. This study examines student engagement as a mediating process linking blended learning to learning outcomes, shifting the focus from technological integration toward learner-centered mechanisms. A cross-sectional quantitative design was employed using survey data from 300 secondary school students. Data were analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4, involving assessment of measurement reliability and validity, followed by structural model and mediation analysis with 5,000 bootstrap resamples. The results demonstrate that blended learning has a significant positive effect on student engagement and learning outcomes, while student engagement also exerts a strong positive influence on learning outcomes. Mediation analysis confirms that student engagement partially mediates the relationship between blended learning and academic performance. These findings indicate that blended learning enhances learning outcomes both directly and indirectly by fostering students' cognitive and behavioral involvement. Overall, the study highlights student engagement as a key mechanism through which blended learning environments translate instructional design into meaningful educational gains in secondary education contexts.

1. Introduction

Heightened demands for instructional continuity and adaptability have reshaped contemporary pedagogical practice, creating conditions in which blended learning has assumed a central role in modern education. The rapid transition triggered by the COVID-19 pandemic further intensified this shift, as digital platforms such as Edmodo were deployed to preserve alignment between in-person instruction and online learning environments (Sefriani et al., 2021). In this setting, blended learning can be characterized as a deliberate integration of classroom-based teaching with online modalities, enabling institutions to accommodate large and heterogeneous student cohorts while remaining responsive to varied learning preferences. Evidence from multiple educational contexts indicates that this integrative arrangement supports learner autonomy, reinforces motivational orientations, and contributes to improved academic performance (Ramalingam et al., 2021). Beyond its technological dimension, blended learning reconfigures instructional interactions by redistributing control, feedback, and participation across learning spaces. Such reconfiguration highlights the pedagogical value of blended learning as a means of sustaining engagement and achievement rather than merely extending access to digital tools.

Learning achievement within blended learning environments is now widely viewed as contingent upon the level of learners' active participation in instructional activities. This interpretation positions learner engagement as a foundational mechanism through which blended instructional designs translate pedagogical inputs into meaningful educational outcomes. Within this perspective, student engagement occupies a pivotal analytical position because it captures how students invest behaviorally, emotionally, and cognitively in instructional activities, thereby shaping both academic achievement and learning satisfaction (Hosseini et al., 2022). Extensive empirical literature consistently demonstrates that stronger engagement is associated with higher levels of persistence and improved academic outcomes, indicating that blended learning environments can promote engagement through digitally supported features such as interactive tasks and timely feedback mechanisms (Fauziah et al., 2021; Halverson & Graham, 2019). Evidence from focused intervention studies

further shows that well-designed blended learning strategies are effective in activating cognitive and behavioral engagement, which serve as critical precursors to academic success (Khilji, 2022; She et al., 2021). Viewed collectively, these findings position engagement not merely as a learner characteristic but as a central process through which blended learning exerts its educational influence.

Research on blended learning has predominantly concentrated on higher education settings, where its technological integration and pedagogical benefits have been widely examined. While these studies consistently demonstrate that blended learning enhances academic performance and learner engagement, comparatively limited empirical attention has been devoted to secondary education contexts, particularly among adolescent learners whose motivational and developmental characteristics differ substantially from those of university students. In particular, the role of student engagement as an intervening mechanism through which blended learning influences academic outcomes remain underexplored at the secondary level (Getenet et al., 2024). Although prior investigations confirm positive associations between blended learning practices and achievement, they frequently emphasize direct relationships without systematically examining the mediating processes that translate instructional design into measurable performance gains. This imbalance has constrained a deeper understanding of how engagement develops in younger populations and how it operates within blended instructional frameworks. Furthermore, at the methodological level, research in this domain has seldom employed advanced analytical techniques capable of modeling complex structural relationships, such as Partial Least Squares Structural Equation Modeling (PLS-SEM). In contrast to studies relying primarily on conventional statistical approaches, the adoption of PLS-SEM offers greater precision in disentangling the direct and indirect pathways linking blended learning, student engagement, and learning outcomes in secondary education settings (Mulyatiningsih et al., 2023).

Enhanced academic performance within blended learning settings can be interpreted as the outcome of an interconnected instructional sequence in which learner engagement occupies a pivotal position. Instructional structures that offer adaptable learning trajectories and incorporate multimedia-enriched content tend to stimulate greater levels of student involvement, thereby creating conditions that facilitate stronger academic achievement (Vega et al., 2023). The presence of Learning Management Systems further amplifies this process by supporting interaction through tools such as online discussions and digital assessments, which intensify learners' participation in instructional activities (Fauziah et al., 2021; Basori et al., 2023). Accumulating empirical evidence confirms that engagement operates as an intervening mechanism between blended learning and achievement, with more engaged learners consistently attaining superior academic results (Craig et al., 2021). From this perspective, the educational effectiveness of blended learning extends beyond the mere incorporation of technology to encompass its capacity to sustain meaningful and continuous learner engagement throughout the learning process.

Understanding the educational value of blended learning depends on recognizing not only its immediate instructional contributions but also the pathways through which these contributions emerge. Accordingly, the analysis is organized around four interrelated dimensions: the association between blended learning and learning outcomes, the extent to which blended learning shapes student engagement, the influence of engagement on academic outcomes, and the empirical verification of engagement as a mediating mechanism within blended learning environments. Examining these dimensions concurrently enables a more integrated explanation of how instructional design features interact with learners' active involvement to influence academic performance. This integrated perspective shifts the emphasis away from isolated associations toward the underlying processes that give blended learning its practical effectiveness. An additional implication is that such a process-oriented framework supports more theoretically grounded interpretations of instructional impact. These considerations are particularly salient in secondary education settings, where sustaining student engagement is central to achieving consistent instructional success.

2. Method

2.1. Research Method

A quantitative analytical strategy grounded in Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to explore the associations linking blended learning, student engagement, and learning outcomes. The selection of this method reflects its capacity to handle multifaceted relational structures, its suitability for analyses involving moderate sample sizes, and its stability under conditions where normality assumptions are not fully met (Halim et al., 2021; Bandara & Jayaweera, 2024). Estimation and validation procedures were implemented using SmartPLS 4, which facilitated the simultaneous examination of measurement quality and structural linkages within the conceptual model. This integrated methodological configuration supports a rigorous investigation of interconnected educational constructs while preserving consistency across different stages of model evaluation.

2.2. Research Design and Approach

Students' perceptions of blended learning, their levels of engagement, and their perceived learning outcomes were captured within a single time point through a cross-sectional survey design. Within this framework, three reflective latent constructs blended learning, student engagement, and learning outcomes were operationalized using multiple observed indicators (Alammary, 2024). Structuring the model in this manner allowed both direct relationships and mediation pathways to be examined concurrently, supporting an integrated analysis of the hypothesized associations. This design choice strengthens interpretive coherence by aligning measurement and structural evaluation within the same analytical cycle. As a result, the approach provides a methodologically efficient means of examining complex relationships among instructional conditions and learner responses within the proposed conceptual framework.

2.3. Data Collection

Ethically sound data collection was achieved through the use of a web-based survey composed of standardized statements designed to be easily understood by secondary school students. Learners enrolled in blended learning programs across multiple grade levels provided their responses using a five-point Likert format anchored from "strongly disagree" to "strongly agree." In line with established institutional guidelines, participation was entirely voluntary, and all submissions were anonymized to protect respondent confidentiality (Low et al., 2023). Before completing the questionnaire, participants were informed about the research objectives, data protection procedures, and their unrestricted right to discontinue participation at any stage. Such procedural transparency is essential for safeguarding ethical integrity and minimizing response bias in educational research contexts.

2.4. Measurement Instrument

The measurement instrument was structured to reflect the latent constructs embedded within the proposed research framework. Indicators of blended learning (X) were represented by four items addressing students' evaluations of instructional clarity, course organization, perceived usefulness, and overall instructional quality. Student engagement (Y1) was operationalized through nine indicators encompassing behavioral participation, cognitive involvement, and emotional engagement during learning activities (ElSayad et al., 2021). Perceived learning outcomes (Y2) were captured using three items related to improvements in knowledge acquisition, skill development, and academic performance (Romli et al., 2023). All items were deliberately phrased in a positive manner and adapted for readability to support accurate comprehension and minimize response bias.

The reliability and validity of the measurement model were subsequently evaluated using established PLS-SEM criteria. All indicator loadings exceeded 0.93, demonstrating strong indicator reliability. Internal consistency was confirmed through Cronbach's alpha, composite reliability, and rho_A values ranging from 0.962 to 0.986, well above the recommended threshold of 0.70. Convergent validity was supported by Average Variance Extracted (AVE) values between 0.888 and 0.929, exceeding the accepted minimum criterion of 0.50. Discriminant validity was verified using the Heterotrait-Monotrait (HTMT) ratio, with all values falling below 0.85. These results indicate that the instrument demonstrates robust psychometric properties within the present sample.

2.5. Sample and Demographics

The dataset comprised 300 valid questionnaire responses, with participant characteristics structured to reflect a realistic secondary school population. Male students represented the majority of the sample (70%), whereas female students accounted for the remaining 30%. Representation across grade levels was proportionally distributed, with 35% of respondents drawn from the first grade, 42% from the second grade, and 23% from the third grade. The age distribution aligned with typical developmental ranges for secondary education, including 173 students aged 15–16 years and 127 students aged 17–18 years. Such demographic alignment supports the contextual relevance of the sample for examining learning processes within secondary school settings.

Levels of exposure to blended learning aligned closely with students' grade placement. A total of 105 students, largely drawn from the first grade, reported limited experience ranging from 0.5 to 1.5 years. Moderate experience, defined as 1.0 to 2.0 years and predominantly represented by second-grade students, was reported by 126 participants. The remaining 69 students, mainly in the third grade, indicated more extensive experience of between 2.0 and 3.0 years. This distribution produced a sample that was both diverse and reflective of typical developmental trajectories within secondary education. Moreover, the inclusion of 300 respondents surpassed the minimum sample size thresholds recommended for PLS-SEM analysis, thereby ensuring sufficient statistical power for reliable model estimation (H. Chen & Isa, 2024)

Figure 1 illustrates the demographic distribution of the 300 participants involved in the study. Based on gender, male students slightly outnumber female students, with 210 males and 90 females. Regarding grade

level, participants are distributed across first, second, and third grades, with the largest proportion coming from the second grade (126 students), followed by the third grade (105 students) and the first grade (69 students). In terms of age, most students fall within the 15–16 and 17–18 age ranges. Exposure to blended learning is also categorized into low, medium, and high levels, with the medium category representing the largest group, indicating moderate prior experience.

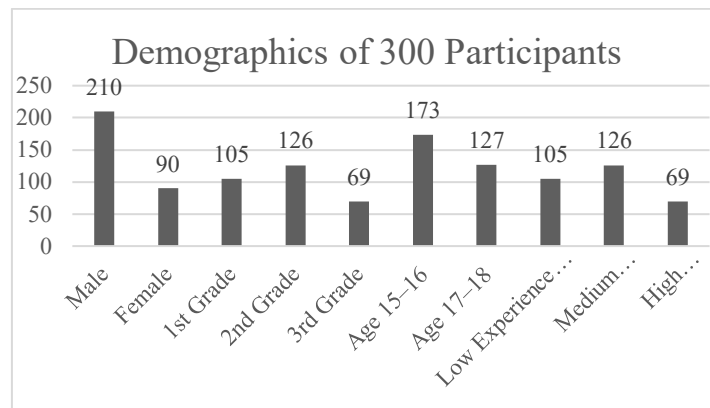


Figure 1. Demographic Data

2.6. Data Analysis and Model Evaluation

Model evaluation was conducted through a sequential analytical process consistent with established PLS-SEM conventions. Emphasis was first placed on verifying the adequacy of the measurement model, including the assessment of indicator reliability, internal consistency, and both convergent and discriminant validity. Attention then shifted to the structural component, where relationships among constructs were examined through path coefficient estimation, coefficients of determination (R^2), effect size indices, and bootstrapped significance tests, alongside the evaluation of indirect (mediating) effects. Organizing the analysis in this manner allowed measurement quality to be established before interpreting structural relationships. This staged procedure strengthens inferential clarity by ensuring that conclusions regarding structural paths are grounded in well-specified measurement properties.

All analyses were conducted using SmartPLS 4, which facilitated the execution of the PLS algorithm and a bootstrapping procedure based on 5,000 resamples. Key outputs such as outer loading values, composite reliability indices, Average Variance Extracted (AVE), heterotrait–monotrait (HTMT) ratios, and mediation estimates were systematically examined to confirm the stability, rigor, and interpretability of the empirical findings.

2.6.1. Measurement Model Evaluation

Establishing the adequacy of the measurement model preceded any examination of structural associations. To this end, indicator loadings were evaluated to ensure that each observed measure contributed meaningfully to its intended latent construct. Reliability was examined using Cronbach’s alpha and composite reliability indices, while convergent validity was assessed through Average Variance Extracted (AVE), applying the conventional acceptance threshold of 0.50 (Nja et al., 2023). The distinctiveness of the constructs was then verified via the Heterotrait–Monotrait (HTMT) ratio to confirm non-overlapping conceptual boundaries. This sequence of checks ensures that subsequent interpretations of structural paths rest on sound measurement foundations and reduces the risk of confounded inferences.

2.6.2. Structural Model Evaluation

Once the measurement properties were established as satisfactory, attention shifted to the structural component of the model. At this stage, the hypothesized relationships were examined by estimating the direct effects connecting blended learning with student engagement and learning outcomes, alongside the indirect effect transmitted through student engagement as a mediating construct. Statistical inference for each structural path relied on bootstrapped t-values and associated p-values, while explanatory strength was evaluated using coefficients of determination (R^2) for the endogenous variables (Wafik et al., 2024). Additional diagnostic evidence was obtained through the inspection of effect size indicators (f^2), predictive relevance measures (Q^2), and bootstrapped confidence intervals. Collectively, these analytical checks provide a rigorous basis for interpreting both the stability and predictive adequacy of the proposed structural model.

3. Results and Discussion

3.1. Results

The outcomes presented here stem from a systematic assessment of both the measurement and structural components, following established methodological guidance for Partial Least Squares Structural Equation Modeling (PLS-SEM) as articulated by Hair et al. (2019). The discussion is organized by first addressing the quality of the measurement model through evaluations of indicator loadings, internal consistency, and convergent as well as discriminant validity, before turning to the analysis of structural paths, explanatory strength, and mediation mechanisms. To further substantiate the soundness of the estimated model, bootstrap distributions and related diagnostic plots were carefully examined. This structured reporting sequence facilitates a transparent interpretation of results while ensuring alignment between methodological rigor and substantive inference.

3.1.1. Measurement Model

3.1.1.1. Indicator Reliability

Indicator reliability was assessed through an examination of the outer loading values associated with each observed item. As shown in Table 1, all loadings were above 0.93, substantially exceeding the commonly accepted minimum criterion of 0.70. This pattern of consistently elevated loadings suggests that the indicators provide a strong and accurate representation of their respective latent constructs.

Table 1. Outer Loadings (Selected Indicators)

Construct	Indicator	Loading (O)	STDEV	t-value	p
Blended Learning	X1	0.950	0.006	168.94	0.000
Blended Learning	X2	0.958	0.005	188.26	0.000
Blended Learning	X3	0.950	0.006	145.94	0.000
Blended Learning	X4	0.944	0.007	144.70	0.000
Student Engagement	Y1_1	0.946	0.006	163.50	0.000
Student Engagement	Y1_2	0.944	0.007	131.70	0.000
Student Engagement	Y1_3	0.946	0.006	153.85	0.000
Student Engagement	Y1_4	0.944	0.006	158.84	0.000
Student Engagement	Y1_5	0.942	0.007	132.72	0.000
Student Engagement	Y1_6	0.935	0.008	121.83	0.000
Student Engagement	Y1_7	0.944	0.007	140.63	0.000
Student Engagement	Y1_8	0.935	0.007	122.88	0.000
Student Engagement	Y1_9	0.946	0.007	143.61	0.000
Learning Outcomes	Y2_1	0.961	0.005	200.16	0.000
Learning Outcomes	Y2_2	0.967	0.004	266.19	0.000
Learning Outcomes	Y2_3	0.963	0.004	225.89	0.000

Such robust loading magnitudes are characteristic of rigorously developed educational instruments that target clearly articulated constructs, including learner engagement and perceptions of instructional quality. Comparable findings have been reported in studies of digital learning environments, where affective and cognitive engagement measures frequently exhibit high indicator loadings, underscoring the conceptual stability of these constructs across diverse instructional settings.

3.1.1.2. Internal Consistency and Convergent Validity

Reliability of the measurement instruments was established by examining several indices of internal consistency, namely Cronbach's alpha, composite reliability, and rho_A (see Table 2). Across all constructs, the obtained coefficients fell between 0.962 and 0.986, clearly exceeding the commonly cited benchmark of 0.70 and reflecting a very high degree of consistency among the indicators. Such magnitudes suggest that the items operate cohesively in representing their respective latent variables rather than capturing random measurement error. This level of reliability provides a solid empirical basis for proceeding to subsequent structural analyses without concern for instability in the measurement model.

Table 2. Reliability and Convergent Validity

Construct	Cronbach's α	Composite Reliability (CR)	rho_A	AVE
Blended Learning	0.974	0.964	0.965	0.904
Student Engagement	0.986	0.984	0.985	0.888
Learning Outcomes	0.975	0.962	0.962	0.929

Elevated reliability coefficients are frequently observed in educational studies utilizing structural equation modeling with reflective measurement models, particularly when the indicators are contextually coherent, and respondents draw upon comparable learning experiences. The robust reliability estimates obtained in the present study are consistent with prior research on perceptions of blended learning and student engagement, where levels of internal consistency exceeding 0.90 have likewise been reported.

Evidence of convergent validity was established through Average Variance Extracted (AVE) estimates between 0.888 and 0.929, which markedly exceeded the recommended minimum criterion of 0.50. These elevated AVE levels indicate that the latent constructs account for a substantial share of variance in their respective indicators. This pattern is consistent with the results reported by Alamri et al. (2023), who likewise identified strong AVE values in their assessment of digital learning readiness.

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3.1.1.4. Discriminant Validity

Evidence for discriminant validity was established using the Heterotrait–Monotrait (HTMT) approach. All calculated HTMT coefficients fell within a range of 0.413 to 0.533, well below the conservative threshold of 0.85, thereby satisfying accepted methodological standards (see Table 3). This pattern confirms that each latent construct captures a unique conceptual domain rather than overlapping substantively with others. The clear separation among constructs strengthens confidence in the interpretability of subsequent structural relationships derived from the model.

Table 3. HTMT Matrix (0)

Construct Pair	HTMT (0)	2.5%	97.5%
Learning Outcomes ↔ Blended Learning	0.421	0.314	0.523
Student Engagement ↔ Blended Learning	0.413	0.312	0.508
Student Engagement ↔ Learning Outcomes	0.533	0.442	0.617

Establishing robust discriminant validity is particularly important in educational SEM research, given the potential conceptual proximity between constructs such as student engagement and learning outcomes. The distinct empirical separation identified among the constructs in this study accords with earlier evidence suggesting that, despite their interrelated nature, engagement and academic achievement remain analytically distinguishable; they constitute distinct theoretical entities within blended and online learning contexts.

Collectively, these findings affirm the adequacy of the measurement model in terms of reliability and validity, thereby offering a solid basis for subsequent analysis of the hypothesized structural relationships.

3.1.2. Structural Model

The structural model was assessed through a bootstrapping procedure based on 5,000 resamples. The results of this analysis, including standardized path coefficients (β), standard errors (STDEV), corresponding t-values, and significance levels (p-values) for each hypothesized relationship, are presented in Table 4.

Table 4. Structural Path Coefficients

Hypothesis	Path	β (O)	STDEV	t-value	p
H1	Blended Learning → Student Engagement	0.403	—	8.362	0.000
H2	Student Engagement → Learning Outcomes	0.424	—	8.586	0.000
H3	Blended Learning → Learning Outcomes	0.236	—	4.508	0.000

Analysis of the structural model yielded clear empirical confirmation for all proposed linkages. In particular, the association between blended learning and student engagement was positive and statistically robust ($\beta = 0.403, p < .001$), underscoring the relevance of instructional design features for fostering learners' active involvement. This evidence aligns with earlier theoretical and empirical work suggesting that hybrid instructional configurations are conducive to heightened participation and motivational engagement. Elements such as flexible access to content, diversified instructional resources, and multiple channels for interaction appear to reduce barriers to participation and support sustained engagement over time. From a conceptual perspective, these results substantiate the argument that the deliberate integration of digital and face-to-face modalities can systematically influence engagement-related learning behaviors. An additional implication is that engagement should be treated as a design-sensitive outcome rather than a purely learner-driven attribute within blended learning environments.

Student engagement was found to be a statistically significant predictor of learning outcomes ($\beta = 0.424, p < .001$), reinforcing its well-documented function as a critical contributor to academic achievement. This result is consistent with evidence reported in both online and blended learning research. Gains in learning outcomes associated with engagement are especially pronounced in technology-supported instructional settings that promote meaningful interaction and deeper cognitive engagement.

Moreover, blended learning exhibited a significant positive direct influence on learning outcomes ($\beta = 0.236, p < .001$). This finding supports evidence from prior meta-analytic studies indicating that blended instructional approaches tend to yield superior academic results compared with conventional teaching methods, largely attributable to improved access to instructional resources and the availability of self-regulated, pace-adjustable learning opportunities. Taken together, the results reinforce the instructional effectiveness of blended learning approaches when implemented in secondary education contexts.

3.1.3. Explained Variance (R^2)

Concerning explained variance, the coefficient of determination (R^2) for the endogenous construct Student Engagement is 0.163. This indicates that the predictor variables included in the model are able to explain 16.3% of the variance in Student Engagement, while the remaining 83.7% is influenced by other factors outside the research model. Meanwhile, the R^2 value for Learning Outcomes is 0.316, meaning that 31.6% of the variance in learning outcomes can be explained by the variables incorporated in the model. Thus, the explanatory power of the model for Learning Outcomes is relatively stronger than for Student Engagement, although both results still indicate opportunities for model development through the inclusion of additional relevant variables.

A proportion of variance equivalent to 16.3% for student engagement and 31.6% for learning outcomes was explained by the proposed structural model. Interpreted through Chin's (1998) guidelines, coefficients of determination approaching 0.33 denote moderate explanatory power, whereas values near 0.19 are typically categorized as weak. Viewed from this perspective, the R^2 estimates obtained here reflect a modest explanatory capacity, a pattern frequently reported in educational and behavioral research where learner outcomes emerge from the interaction of numerous contextual and personal influences. Comparable ranges have been observed in technology-mediated learning studies that model engagement and achievement concurrently. For example, Zhang et al. (2023). An R^2 magnitude in the vicinity of 0.16 has been interpreted as reflecting a moderate level of explanatory power, a characterization that is closely aligned with the results obtained in the current analysis. This level of explained variance is commonly regarded as acceptable in educational and behavioral research, where outcomes are influenced by multiple interacting factors. By contrast, substantially higher explanatory levels have been reported in more narrowly defined contexts, such as the R^2 value of 75.4 documented by Khatri et al. (2023). This divergence illustrates that R^2 magnitudes are highly sensitive to research context and construct specification. From an analytical standpoint, the explanatory performance of the current model remains theoretically defensible given the inherently multifactorial nature of student learning processes.

The mediation analysis revealed a statistically significant indirect pathway through which blended learning influenced learning outcomes by way of student engagement ($\beta = 0.171, p < .001$), as reported in the study and learning outcomes persisted, thereby indicating that student engagement functions as a partial mediator within the proposed model.

Concerning the indirect effect, the indirect path from Blended Learning (BL) to Learning Outcomes (LO) through Student Engagement (SE) shows a beta coefficient (β) of 0.171. The t-statistic value of 6.238 with a

significance level (p) of 0.000 (< 0.05) indicates that the indirect effect is positive and statistically significant. These findings suggest that Student Engagement acts as a significant mediator that strengthens the relationship between Blended Learning and Learning Outcomes. Therefore, the more effectively blended learning is implemented in enhancing student engagement, the greater its contribution to improving learning outcomes.

Interpretation. The indirect effect is positive and significant ($p < .001$). Because the direct effect (BL \rightarrow LO) remains significant alongside a significant indirect effect, student engagement functions as a partial mediator (supporting H4).

These results are consistent with established perspectives in educational psychology and learning analytics, where a substantial body of research demonstrates that student engagement frequently operates as an intervening mechanism linking instructional design to academic achievement. In this regard, engagement serves as the process through which blended learning facilitates more intensive cognitive processing and, consequently, higher levels of academic performance.

The evidence of partial mediation indicates that, although blended learning exerts a direct influence on learning outcomes, its overall effect is strengthened through students' emotional, cognitive, and behavioral involvement in the learning process. This interpretation aligns with contemporary views that conceptualize engagement as a pivotal "gateway construct," through which the benefits of instructional design are more fully realized.

3.1.4. Bootstrap Distributions and Diagnostic Charts

The bootstrap histogram analyses revealed well-defined and stable sampling distributions across all direct relationships as well as the indirect pathway. Notably, none of the bootstrapped estimates intersected the zero line, providing strong evidence for the statistical significance and robustness of the estimated structural paths. Such diagnostic procedures are widely advocated in SEM research as a means of strengthening confidence in model validity.

Within the domain of technology-enhanced learning, bootstrap-based visual diagnostics are frequently utilized to assess parameter stability, particularly for mediation effects that may be sensitive to sampling fluctuations. The clear, unimodal distribution patterns identified in this study indicate an appropriately specified model with reliable parameter estimates. As illustrated in Figure 2, the bootstrapped distribution for the Blended Learning \rightarrow Learning Outcomes path approximates a normal shape and is centered around $\beta \approx 0.236$, with negligible density near or beyond zero. This pattern confirms the presence of a stable and substantively meaningful positive effect.

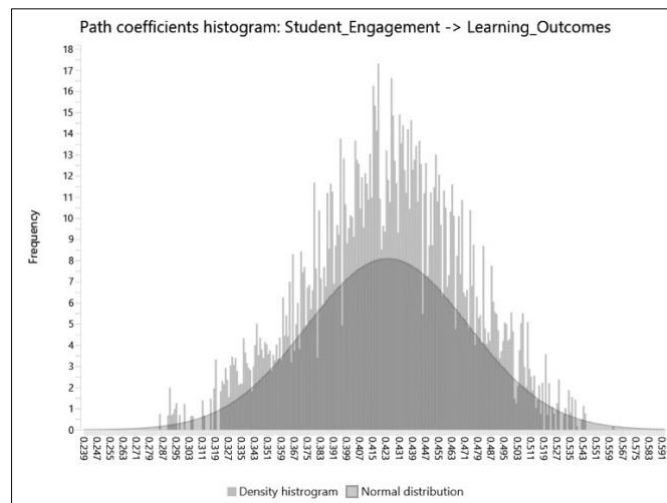


Figure 2. Bootstrap Distribution (n = 5,000) for The Path Coefficient Student Engagement \rightarrow Learning Outcomes

Figure 3 shows the bootstrapped histogram for Blended Learning \rightarrow Student Engagement, centered at $\beta \approx 0.403$ with a narrow spread, indicating high precision.

Figure 4 shows the bootstrapped histogram for Student Engagement \rightarrow Learning Outcomes, centered at $\beta \approx 0.424$; the narrow distribution confirms stability and precision.

Figure 5 shows the distribution for the indirect effect (BL → SE → LO), centered at $\beta \approx 0.171$, demonstrating a consistently positive indirect influence.

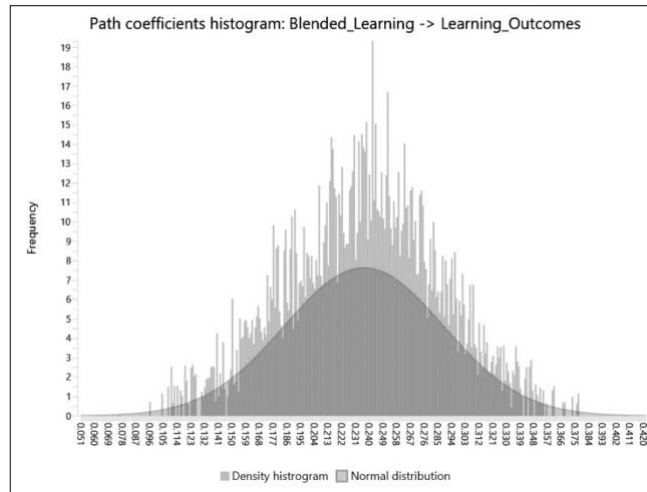


Figure 3. Bootstrap Distribution (n = 5,000) for the Path Coefficient Blended Learning → Learning Outcomes

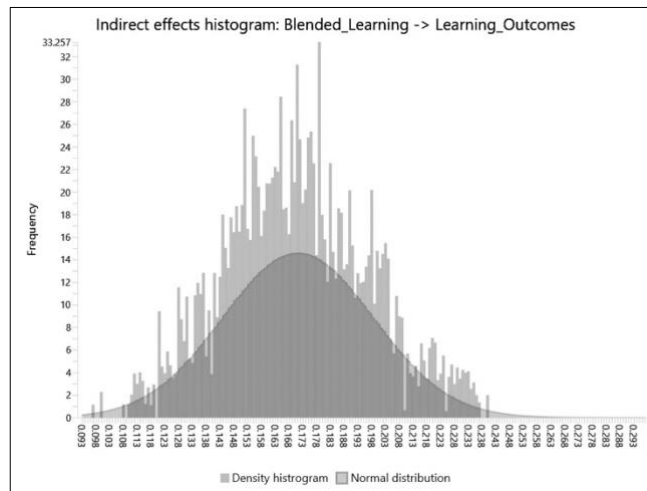


Figure 4. Bootstrap Distribution (n = 5,000) for the Path Coefficient Blended Learning → Student Engagement

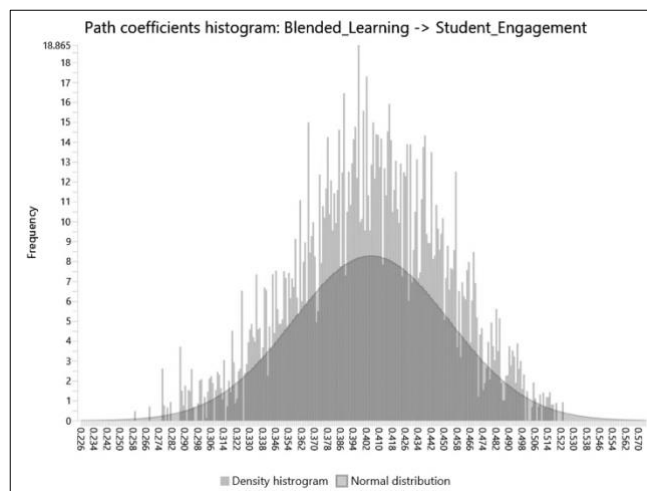


Figure 5. Bootstrap Distribution (n = 5,000) for the Specific Indirect Effect Blended Learning → Student Engagement → Learning Outcomes

When considered holistically, the psychometric evidence demonstrates that the measurement model attains a high standard of reliability while satisfying accepted benchmarks for convergent and discriminant validity. Evaluation of the structural relations likewise confirms all proposed associations, showing that blended learning is linked to improved learning outcomes through both a direct pathway and an indirect pathway operating via student engagement as a partial mediator. This configuration lends support to theoretical accounts that conceptualize engagement as a central process through which instructional design exerts its influence on academic achievement. The observed pattern is consistent with earlier empirical studies highlighting the instructional advantages of blended learning and the centrality of engagement in educational success. An additional implication is that analytical frameworks integrating design-related and learner-centered processes offer a more comprehensive basis for interpreting instructional effectiveness.

3.2. Discussion

Enhanced learning outcomes at the secondary level appear closely tied to the combined influence of instructional design and learner participation. Evidence from the analysis indicates that blended learning strengthens academic performance by simultaneously fostering higher levels of student engagement. These findings can be theoretically interpreted through the lens of Self-Determination Theory (SDT), which posits that learning environments promoting autonomy, competence, and relatedness tend to cultivate intrinsic motivation and sustained engagement. Within blended learning settings, flexibility in accessing materials and pacing instruction supports students' sense of autonomy; structured feedback and multimodal resources reinforce perceptions of competence; and interaction through both digital and face-to-face components nurtures relatedness. The convergence of these psychological supports appears to create a learning ecosystem in which students are more actively invested in academic tasks. In this sense, blended learning functions not merely as a delivery format but as a motivational environment that facilitates deeper engagement and stronger educational outcomes, consistent with earlier empirical findings (Argyriou et al., 2022).

Academic success in instructional settings is closely linked to the extent to which learners are actively involved in the learning process. From the SDT perspective, engagement reflects the internalization of learning goals that occurs when students experience supportive instructional conditions. Students who sustain attention, invest personal effort, and participate consistently whether online or in traditional classrooms are likely responding to learning contexts that satisfy their psychological needs. This internalized engagement promotes deeper cognitive processing and conceptual understanding, ultimately supporting stronger academic performance. Such an interpretation reinforces the view that engagement is not merely a behavioral outcome but a motivational mechanism through which instructional environments translate into measurable achievement. This theoretical framing aligns with empirical evidence identifying engagement as a central predictor of academic success (Widowati et al., 2023).

The evidence demonstrating that blended learning affects learning outcomes through both direct pathways and indirect mechanisms mediated by student engagement further strengthens this interpretation. SDT suggests that instructional structures capable of supporting autonomy and competence may exert direct positive effects on performance, while simultaneously fostering engagement as a motivational bridge. Blended learning environments offer structural advantages including flexible arrangements, diversified instructional resources, and interactive modalities that can directly facilitate comprehension. At the same time, these environments cultivate motivational conditions that encourage learners to invest effort and regulate their own learning processes. This dual pathway is consistent with findings reported by Kim et al. (2019), who show that engagement serves as a conduit through which technology-enhanced instruction improves achievement.

The identification of partial mediation indicates that student engagement constitutes an important, though not exclusive, mechanism connecting blended learning to academic achievement. In SDT terms, while motivational engagement amplifies the impact of instructional design, structural pedagogical features may independently influence performance by enhancing clarity, organization, and cognitive accessibility. This finding implies that blended learning frameworks can generate academic benefits both through direct instructional quality and through the motivational activation of learners. Students experiencing higher autonomy support and meaningful interaction derive additional gains, underscoring the importance of intentionally designed learning experiences that foster psychological need satisfaction through interactive tasks, prompt feedback, and supportive environments.

Taken together, the results highlight blended learning as an instructional approach whose effectiveness can be theoretically grounded in motivational principles. By aligning instructional design with the psychological needs identified in Self-Determination Theory, blended learning environments can strengthen engagement and facilitate improved academic attainment in secondary education. The findings, contribute not only empirical evidence but also theoretical insight, demonstrating how blended instructional formats operate as motivationally supportive systems that transform design features into meaningful learning gains (Chen et al., 2022).

3.3. Implications

The findings of this study offer several important implications for educational practice and theory. From a practical perspective, the results highlight that the effectiveness of blended learning depends not only on technological integration but also on its capacity to actively engage students. Educational institutions should therefore design blended learning environments that emphasize interactive activities, timely feedback, and opportunities for collaboration, as these elements are critical in fostering student engagement and improving learning outcomes. Teachers are encouraged to adopt instructional strategies that balance structured guidance with learner autonomy, ensuring that students remain cognitively and behaviorally involved throughout the learning process.

From a theoretical standpoint, this study reinforces the relevance of Self-Determination Theory (SDT) in explaining how instructional design influences learning outcomes through motivational mechanisms. The identification of student engagement as a partial mediator confirms that engagement serves as a key process linking instructional approaches to academic achievement. This contributes to the growing body of literature by providing empirical evidence from secondary education, a context that has received comparatively less attention. Furthermore, the study demonstrates the value of using PLS-SEM in modeling complex relationships, offering a more nuanced understanding of both direct and indirect effects in educational research.

3.4. Limitations

Despite its contributions, this study is subject to several limitations that should be acknowledged. First, the use of a cross-sectional research design limits the ability to establish causal relationships among the variables. Future studies are recommended to employ longitudinal designs to better capture changes in student engagement and learning outcomes over time. Second, the data were collected using self-reported measures, which may introduce response bias and affect the accuracy of the findings. Incorporating objective measures, such as academic records or observational data, could enhance the robustness of future research.

Third, the study was conducted within a single educational context, which may limit the generalizability of the results to other settings. Expanding the sample to include diverse schools or different educational levels would provide a more comprehensive understanding of blended learning effectiveness. Finally, the model explains a moderate proportion of variance in learning outcomes, indicating that additional factors such as self-regulation, motivation, and digital literacy may also play important roles. Future research should therefore consider integrating these variables to develop a more comprehensive explanatory model.

4. Conclusion

The findings of this study demonstrate that the effectiveness of blended learning in secondary education is influenced not only by its structural and organizational design but also by its ability to promote active student engagement. Blended learning contributes to improved academic achievement through well-structured instructional arrangements while simultaneously creating learning environments that sustain meaningful participation. Student engagement functions as a significant mediating mechanism that strengthens the instructional impact of blended learning, positioning it as a core element in fostering meaningful learning experiences rather than merely a complementary component. The presence of partial mediation indicates that, although engagement enhances the positive effects of blended learning, instructional design and pedagogical organization retain a direct and independent influence on learning outcomes. These findings underline the importance of developing balanced learning environments that integrate structured guidance with opportunities for learner autonomy. Practically, effective implementation of blended learning requires deliberate instructional planning, including interactive activities, constructive feedback, and collaborative learning opportunities to maintain motivation and sustained involvement. Nevertheless, the study acknowledges certain limitations, particularly the reliance on self-reported data and the focus on a single educational setting, which may restrict broader generalization. Future research is therefore encouraged to adopt longitudinal approaches, involve more diverse samples, and incorporate additional learner-related variables such as self-regulation, motivation, and digital readiness. Overall, blended learning emerges as a flexible and adaptive instructional framework capable of enhancing educational outcomes when strategically aligned with approaches that actively engage learners.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript to generate scientific insights, analyses, conclusions, or recommendations.

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