

Original Article

Instructional Quality, Student Engagement, and Skill Development as Predictors of Learning Outcomes in Online Physical Education: A Structural Equation Model of Senior High School Learners

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Abstract. The rapid shift to online learning during the COVID-19 pandemic raised critical questions about the effectiveness of digital instruction in subjects that are inherently physical and experiential. This study modeled the relationships among instructional quality, student engagement, physical activity and skill development, and learning outcomes in online physical education (PE) among senior high school students in the Philippines using Structural Equation Modeling (SEM). Four latent constructs were examined: Instructional Quality (IQ), Student Engagement (SE), Physical Activity and Skill Development (PASD), and Learning Outcomes in Physical Education (LOPE). A cross-sectional survey was administered to 171 students drawn from two private schools in southern Metro Manila and Cavite Province. Most participants learned through a synchronous platform, with asynchronous delivery serving a supplementary role; the findings therefore characterize online PE as actually experienced by this cohort rather than a controlled comparison of the two modalities. Data were analyzed through reliability analysis, bivariate correlations, and covariance-based SEM with maximum likelihood estimation using semopy in Python. All four constructs demonstrated strong internal consistency and convergent validity, and discriminant validity was satisfied. The model showed acceptable fit ($\chi^2/df = 2.142$, CFI = 0.923, TLI = 0.911, RMSEA = 0.082) and explained 95.9% of the variance in learning outcomes. All six hypothesized paths were statistically significant, with instructional quality emerging as the strongest antecedent of student engagement and student engagement as the strongest antecedent of skill development. Notably, although the structural relationships were uniformly strong, students rated their overall learning outcomes in online PE as low in absolute terms, indicating that a well-specified instructional model does not by itself overcome the constraints of delivering embodied learning through a screen. Findings carry implications for curriculum design and digital pedagogy in blended and online PE.

Keywords: *Instructional quality; Learning outcomes; Online physical education; Physical activity and skill development; Structural Equation Modeling.*

The integration of digital technologies into education has significantly reshaped teaching and learning, particularly with the widespread adoption of online learning modalities. This transformation accelerated during the COVID-19 pandemic, which compelled educational institutions worldwide to shift from face-to-face instruction to remote environments with little preparation. While online learning has been successfully

implemented across many academic disciplines, its application in Physical Education (PE) presents distinctive challenges due to its inherently experiential and movement-oriented nature.

Physical Education plays a vital role in holistic student development, encompassing physical fitness, cognitive growth, and socio-emotional well-being (Padua et al., 2024). The subject demands active participation, physical execution, and embodied learning that are difficult to replicate in virtual environments. Online PE delivery raises serious concerns about instructional effectiveness—particularly in fostering active participation, skill acquisition, and sustained engagement. Empirical evidence indicates that online PE classes often result in reduced interaction and passive participation, as learners tend to complete tasks without meaningful physical involvement (Yu & Jee, 2021).

Despite these challenges, recent scholarship suggests that online and blended learning can be effective when supported by appropriate instructional strategies. Blended learning has been shown to significantly enhance physical fitness and performance outcomes compared to traditional approaches (Wang et al., 2024). Similarly, learners' acceptance of online platforms—shaped by perceived usefulness and ease of use—plays a crucial role in engagement (Lobo et al., 2024). These findings suggest that effectiveness depends not solely on delivery mode but on instructional design quality.

Student engagement remains a critical determinant of learning success online. Research demonstrates a strong relationship between students' interest and their level of engagement in physical activities, with motivation significantly influencing participation and learning outcomes (Padua et al., 2024). In online PE settings, engagement is further mediated by instructional quality, learning activity structure, and the availability of interactive opportunities. Student-related factors such as academic preparedness, time management, and environmental conditions have also been identified as predictors of success in online PE (Goad, 2018).

Environmental and contextual factors further modulate online PE effectiveness. Access to reliable internet connectivity, availability of resources, and technological infrastructure significantly affect meaningful participation. Using SEM, prior research demonstrated that student characteristics and learning infrastructure have substantial effects on online PE program success (Rihatno & Nuraini, 2023). Teacher capacity to adopt and implement effective online strategies also matters, with perceived usefulness, ease of use, and social influence affecting teachers' engagement with distance teaching (Huang et al., 2025).

The two dominant modes of online delivery differ in ways that matter specifically for PE. Synchronous instruction, delivered through live video-conferencing platforms, preserves real-time teacher observation, immediate corrective feedback on movement execution, and the social presence of classmates—affordances that approximate the co-regulation of a gymnasium setting, but that depend on stable bandwidth and on learners having sufficient physical space at home to perform movements on camera. Asynchronous instruction, delivered through learning management systems and recorded demonstrations, offers scheduling flexibility, repeated viewing of skill models, and tolerance of unstable connectivity, but removes the real-time feedback loop through which motor errors are ordinarily detected and corrected, shifting the burden of accuracy and accountability onto the learner's own self-regulation. Each mode therefore trades a different affordance against a different constraint, and neither is straightforwardly superior; what appears to separate effective from ineffective online PE is the quality of instructional design within the chosen mode (Rihatno & Nuraini, 2023). In the Philippine setting, these differences are compounded by uneven connectivity: national estimates placed internet penetration at roughly three-quarters of the population at the start of 2024 (Kemp, 2024), so the bandwidth-intensive synchronous mode is not equally available to all learners. The present study accordingly treats the delivery platform as a contextual characteristic of the learning environment rather than as an experimental factor.

These relationships can be understood through an integrated theoretical framework. Technology adoption in online learning is explained through the Technology Acceptance Model (TAM), which posits that perceived usefulness and ease of use influence behavioral intentions toward technology (Davis, 1989). This is complemented by the Unified Theory of Acceptance and Use of Technology (UTAUT), which emphasizes social influence and facilitating conditions (Venkatesh et al., 2003). Within the present study, TAM and UTAUT are treated not merely as accounts of platform adoption but as explanations of the antecedent conditions that make embodied PE learning possible online: when learners perceive a synchronous or asynchronous platform as useful and easy to use, and when facilitating conditions such as stable connectivity and institutional support are present, they become more

willing to attempt the movement demonstrations, skill rehearsals, and interactive tasks through which physical competencies are acquired. Technology acceptance is thus positioned as a gateway to the Instructional Quality and Student Engagement constructs rather than as an end in itself. Social Cognitive Theory further explains that learning occurs through reciprocal interactions among personal factors, behavior, and environment (Bandura, 1986). This principle of reciprocal determinism maps directly onto the study's model: personal factors (learner motivation and self-efficacy, reflected in Student Engagement), behavioral factors (physical execution and skill rehearsal, reflected in Physical Activity and Skill Development), and environmental factors (instructional design, platform, and connectivity, reflected in Instructional Quality) interact continuously, such that a deficit in any one domain—for instance, weak instructional scaffolding or an unstable home environment—constrains the others and, ultimately, learning outcomes. ADDIE is incorporated not as a theoretical lens but as a complementary instructional-design framework; because it is a procedural model for systematically analyzing, designing, developing, implementing, and evaluating instruction (Yu & Jee, 2021) rather than an explanatory theory of behavior, it is used here to justify the operationalization of Instructional Quality and to structure how the online PE learning experience was conceptualized, while the explanatory burden of the model rests on TAM, UTAUT, and Social Cognitive Theory. These frameworks are individually incomplete for the PE context: TAM and UTAUT were developed to predict technology use and say little about the motivational and embodied dimensions that are central to movement learning, whereas Social Cognitive Theory, though attentive to motivation and agency, does not by itself address the technological-acceptance barriers of online delivery. Their integration in this study is therefore deliberate and compensatory, with each framework supplying what the others omit.

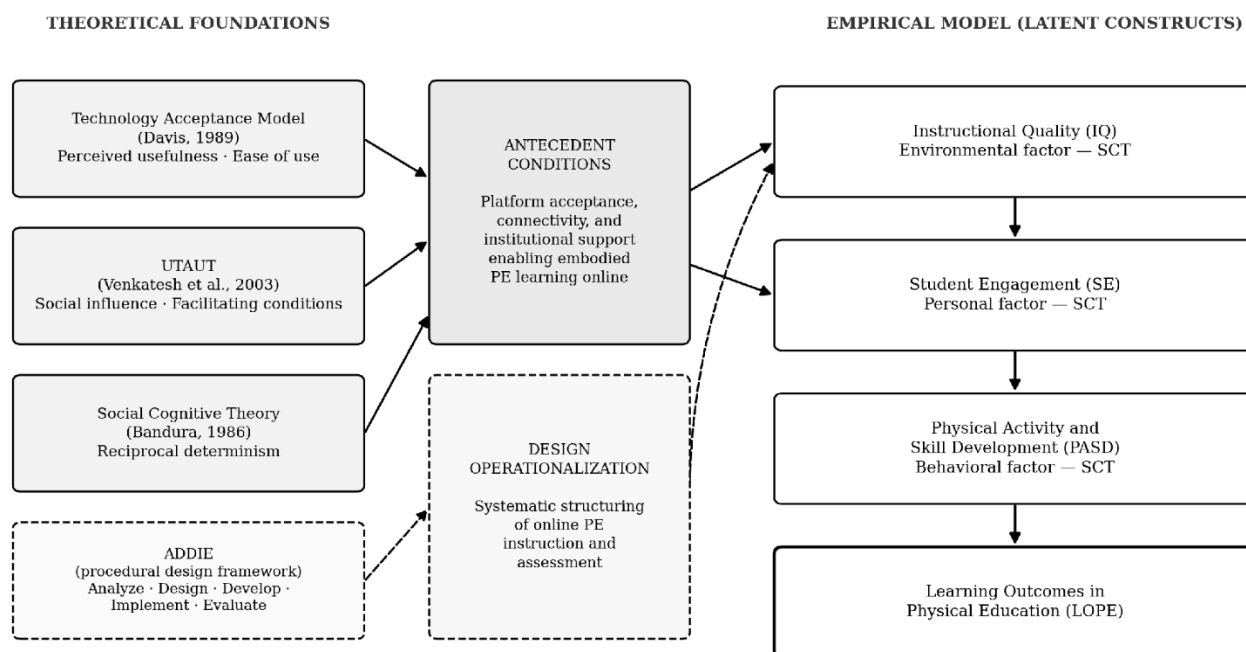


Figure 1. Integrated Conceptual Framework Linking Technology-Acceptance and Social-Cognitive Theory to the Four Latent Constructs
Note. Solid arrows denote explanatory theoretical contributions; broken arrows denote the procedural (ADDIE) contribution to construct operationalization. The three explanatory frameworks are integrated compensatorily: TAM and UTAUT account for the technology-acceptance antecedents of online participation, whereas Social Cognitive Theory accounts for the motivational and embodied dimensions of movement learning that acceptance models were not designed to address.

Structural Equation Modeling (SEM) provides a robust framework for simultaneously examining multiple direct and indirect effects among latent variables. Despite growing literature on online PE, there remains a gap in integrating instructional quality, student engagement, physical activity and skill development, and learning outcomes into a unified explanatory model for senior high school students in the Philippine context. This study addresses that gap by examining six hypotheses: (H1) Instructional quality significantly predicts student engagement; (H2) Instructional quality significantly predicts physical activity and skill development; (H3) Student engagement significantly predicts physical activity and skill development; (H4) Student engagement significantly predicts learning outcomes; (H5) Physical activity and skill development significantly predicts learning outcomes; and (H6) Instructional quality has a significant direct effect on learning outcomes. The purpose of this study is therefore to specify and test an integrated structural model in which instructional quality, student engagement, and physical activity and skill development jointly account for learning outcomes in online PE among Filipino

senior high school learners. The study is significant on three counts. Theoretically, it extends technology-acceptance and social-cognitive accounts into a subject area whose embodied demands those frameworks were not built to address. Methodologically, it supplies a validated multi-construct measurement model for online PE that subsequent studies can replicate, extend, or test across school types. Practically, it identifies where in the instructional chain limited design effort yields the greatest return, giving PE teachers, curriculum designers, and school administrators an empirical basis for prioritization as blended and online delivery persist in the post-pandemic period.

Methodology

Research Design

The researchers employed a quantitative, cross-sectional survey design using Structural Equation Modeling (SEM) to test hypothesized relationships among latent variables and to assess direct and indirect effects within the proposed model. A cross-sectional survey design gathers data from a defined population at a single point in time in order to describe the distribution of, and the relationships among, variables as they occur without manipulation (Creswell & Creswell, 2018), which suits the present aim of modeling naturally occurring associations in online PE rather than evaluating an intervention. SEM was selected for its capacity to simultaneously analyze multiple relationships among observed and latent constructs and provide measures of model fit appropriate for the complex educational relationships under investigation. It should be emphasized, however, that although SEM can estimate hypothesized direct and indirect pathways, the cross-sectional design captures all constructs at a single point in time and therefore yields only a static snapshot rather than temporal or dynamic evidence. Consequently, the structural paths reported in this study describe covariation and theoretically motivated directionality rather than causal effects; the design cannot establish temporal precedence or rule out reverse causation among Instructional Quality, Student Engagement, Physical Activity and Skill Development, and Learning Outcomes. This limitation is acknowledged explicitly and is revisited in the Conclusion.

Participants and Sampling Technique

Participants comprised 171 senior high school students enrolled in online PE classes at two private senior high schools—one located in southern Metro Manila and one in Cavite Province, Philippines. The sample included Grade 11 ($n = 65$, 38.0%) and Grade 12 ($n = 106$, 62.0%) students with direct exposure to online PE delivery. Female students comprised 67.3% ($n = 115$) and male students 29.2% ($n = 50$) of the sample; 6 respondents (3.5%) identified with other gender categories. Mean age was 17.43 years ($SD = 0.95$, range: 16–21).

The researchers employed a non-probability convenience sampling technique based on participants' accessibility and documented experience with online PE instruction. Convenience sampling is defensible where the defining eligibility criterion is possession of a specific experience rather than representativeness of a general population (Etikan, Musa, and Alkassim, 2016). In this study, eligibility required documented enrollment in online PE, a condition that no accessible sampling frame identified, so probability selection from a national roster of senior high school students was not feasible within the study's timeframe and resources. Because this non-probability approach does not give every senior high school student an equal probability of selection, the findings are subject to selection bias and cannot be assumed to generalize to the broader Philippine senior high school population. In particular, both participating schools are private institutions located in southern Metro Manila and Cavite, and their students may differ systematically—in socioeconomic status, device ownership, and internet access—from learners in public schools or in rural and less-connected regions. The results should therefore be interpreted as context-specific rather than nationally representative. The sample size of $N = 171$ was evaluated against the 10:1 observations-to-free-parameters guideline (Kline, 2016) and the $N \geq 150$ minimum for models of this complexity (Hair, Black, Babin, and Anderson, 2019). While the ratio of 3.5:1 falls below the ideal 10:1 (Bentler & Chou, 1987), simulation evidence indicates that Maximum Likelihood estimation remains stable with $N \geq 150$ for models with strong factor loadings and few latent variables (Marsh, Balla, and Hau, 1996). The strong reliability estimates ($\alpha = 0.826\text{--}0.925$) observed in this sample further support parameter estimate stability.

Research Instrument

Data were collected using a researcher-developed questionnaire administered through an online survey platform. The instrument comprised two sections: (1) demographic profile capturing age, gender, grade level, learning platform, and internet accessibility; and (2) four latent construct scales using a 5-point Likert response format (1 = Strongly Disagree to 5 = Strongly Agree): Instructional Quality (IQ; 5 items) assessed instructional material

quality, clarity of explanations, assessment effectiveness, hands-on learning opportunities, and course organization; Student Engagement (SE; 6 items) measured active participation, motivation, online discussion quality, collaborative activity, gamification features, and exercise motivation; Physical Activity and Skill Development (PASD; 4 items) evaluated new skill development, correct exercise execution, regularity of practice, and instructor guidance; and Learning Outcomes in Physical Education (LOPE; 5 items) assessed depth of fitness understanding, practical skill improvement, lifestyle motivation, knowledge applicability, and overall perceived effectiveness.

Content validity was established through expert review by specialists in PE and educational research. Following expert review, the instrument underwent iterative refinement: items flagged for ambiguity or redundancy were reworded or removed, and the revised questionnaire was pilot-tested with a small group of senior high school students comparable to the target respondents but excluded from the final sample. Feedback from this pilot regarding item clarity, comprehension of the response format, and completion time was used to finalize item wording prior to full administration, and the strong internal-consistency estimates subsequently obtained ($\alpha = 0.826\text{--}0.925$) support the adequacy of this refinement process. Construct validity was assessed using Average Variance Extracted ($AVE \geq 0.50$), and discriminant validity was confirmed via the Fornell and Larcker (1981) criterion. Reliability was evaluated through Cronbach's Alpha ($\alpha \geq 0.70$) and Composite Reliability ($CR \geq 0.70$). Because all latent constructs were measured through self-reported Likert responses, the data are susceptible to response biases, including social desirability, whereby students may over-report favorable engagement or effort, and acquiescence, or the tendency to agree with items regardless of their content. These biases, together with the marginal Harman single-factor result reported below, indicate that some degree of common method variance cannot be excluded, and the self-report findings should be interpreted with this limitation in mind.

Data Gathering Procedure

The online questionnaire was distributed via shared links provided by class advisers at both schools. Prior to responding, participants were informed of the study's purpose, confidentiality, and the voluntary nature of their participation. Informed consent was obtained electronically. Data collection was conducted within a two-week window; incomplete entries were removed prior to analysis, yielding a final usable sample of $N = 171$. It is recognized that distributing the survey through class advisers, who occupy a position of authority relative to students, may have introduced an element of perceived obligation or subtle coercion, such that some students could have felt implicitly pressured to participate. To mitigate this risk, advisers were instructed to present participation as entirely optional; no course credit, grade adjustment, or other incentive was attached to responding; the shared link could be disregarded without any academic consequence; and responses were collected anonymously so that non-participation could not be identified. Residual social pressure nonetheless cannot be fully ruled out and is acknowledged as a limitation of the recruitment procedure.

Data Analysis Procedure

Data were analyzed using a two-step approach consistent with Anderson and Gerbing's (1988) recommendation for covariance-based SEM. Step 1 involved Confirmatory Factor Analysis (CFA) to evaluate standardized factor loadings, reliability (Cronbach's α and CR), and validity (AVE and Fornell-Larcker discriminant validity criterion). Step 2 involved structural model estimation to test the six hypothesized paths, reporting unstandardized (b) and standardized (β) path coefficients, standard errors, and z -values. The SEM was implemented in *semopy* (Meshcheryakov & Igolkina, 2021), a Python-based library using Maximum Likelihood estimation. Model fit was evaluated using χ^2/df (< 3.0), CFI (≥ 0.90), TLI (≥ 0.90), RMSEA (≤ 0.08), and GFI (≥ 0.85) criteria (Hu & Bentler, 1999; Kline, 2016). To assess common method variance, Harman's (1976) single-factor test was performed; the first unrotated factor accounted for 54.75% of total variance, marginally exceeding the 50% threshold, warranting interpretive caution (Podsakoff et al., 2003). VIF diagnostics were computed following Kock's (2015) full collinearity procedure. Statistical significance was set at $p < .05$.

The model was specified formally as a system of measurement (outer) and structural (inner) equations. In the measurement model, each observed indicator is expressed as a function of the latent construct it reflects plus item-specific measurement error, as shown in Equation 1, where x_i is the observed response to item i , λ_i is the standardized factor loading of that item on latent construct ξ , and ε_i is the measurement error associated with the item. The error variance of each indicator is therefore an explicit parameter of the model rather than an assumption, and the reliability and validity coefficients reported in Table 3 summarize how much of each construct's variance is attributable to true score rather than to ε .

$$X_i = \lambda_i \xi + \varepsilon_i \quad \text{Eq 1.}$$

The structural model comprises three simultaneous equations corresponding to the three endogenous constructs. Equations 2 to 4 express Student Engagement, Physical Activity and Skill Development, and Learning Outcomes in Physical Education, respectively, where γ denotes a path from the exogenous construct Instructional Quality, β denotes a path from an endogenous construct, and ζ denotes the structural disturbance (unexplained variance) of each equation. Equation 4 makes the mediation structure explicit: LOPE is regressed simultaneously on IQ, SE, and PASD, so γ_3 is the direct association of instructional quality with learning outcomes net of the two mediators, while the indirect associations run through the products $\gamma_1\beta_2$, $\gamma_2\beta_3$, and $\gamma_1\beta_1\beta_3$.

$$SE = \gamma_1 IQ + \zeta_1 \quad \text{Eq 2.}$$

$$PASD = \gamma_2 IQ + \beta_1 SE + \zeta_2 \quad \text{Eq 3.}$$

$$LOPE = \gamma_3 IQ + \beta_2 SE + \beta_3 PASD + \zeta_3 \quad \text{Eq 4.}$$

Ethical Considerations

This study adhered to established ethical standards in educational research. Participation was entirely voluntary, and respondents were informed of their right to withdraw at any time without consequence. No personally identifiable information beyond what was voluntarily disclosed was collected. All responses were treated with strict confidentiality and used solely for academic purposes, in accordance with the principles of the Declaration of Helsinki.

Results and Discussion

Demographic Profile of Respondents

Table 1 presents the demographic characteristics of the 171 participants. The majority identified as female (67.3%) and were enrolled in Grade 12 (62.0%). Microsoft Teams was the predominant learning platform (78.4%), while most students reported moderate internet accessibility (73.7%). Notably, 8.2% of respondents reported low or unstable internet access—a finding with important implications for online learning equity, particularly in technology-dependent subjects such as PE. The predominance of Microsoft Teams, a synchronous platform, suggests that live instruction was the primary delivery mode, though asynchronous resources through Canvas (18.7%) supplemented the learning experience.

Table 1. Frequency and Percentage Distribution of Respondents According to Demographic Profile (N = 171)

Variable	Category	n (%)
Gender	Female	115 (67.3%)
	Male	50 (29.2%)
	Other or undisclosed	6 (3.5%)
Grade Level	Grade 11	65 (38.0%)
	Grade 12	106 (62.0%)
Learning Platform	Microsoft Teams	134 (78.4%)
	Canvas	32 (18.7%)
	Zoom/Other	5 (2.9%)
Internet Accessibility	High	31 (18.1%)
	Moderate	126 (73.7%)
	Low	7 (4.1%)
	Unstable	7 (4.1%)

Note. n = frequency; (%) = percentage of total sample. Gender categories reported by fewer than five respondents were collapsed into a single category to prevent deductive disclosure in a sample of this size. Percentages may not total 100 owing to rounding.

Level of Online PE Learning Constructs

Table 2 presents item-level and construct-level descriptive statistics. Composite mean scores were interpreted using a five-point scale classification: 1.00–1.79 = Very Low, 1.80–2.59 = Low, 2.60–3.39 = Moderate, 3.40–4.19 = High, 4.20–5.00 = Very High. Instructional Quality obtained the highest composite mean ($M = 2.77$, $SD = 0.84$, Moderate), followed by Student Engagement ($M = 2.63$, $SD = 0.87$, Moderate), Physical Activity and Skill Development ($M = 2.56$, $SD = 0.95$, Moderate), and Learning Outcomes in PE ($M = 2.40$, $SD = 1.03$, Low). These

findings indicate that, while teachers made deliberate instructional efforts, the overall perceived effectiveness of online PE remained limited—consistent with reports that online PE frequently results in reduced engagement and attenuated learning outcomes compared to face-to-face instruction (Yu & Jee, 2021).

At the item level, IQ1—quality of instructional materials ($M = 3.07$)—received the highest rating, while IQ4—hands-on learning experiences ($M = 2.42$)—was lowest, reflecting the structural limitation of delivering PE through a screen. Hands-on, embodied movement learning, a cornerstone of PE pedagogy, cannot be adequately replicated through asynchronous videos or synchronous virtual sessions (Huang et al., 2025). Within SE, gamification features (SE5; $M = 2.98$) and group activities (SE4; $M = 2.96$) were comparatively stronger, while motivation to perform physical activities (SE2; $M = 2.25$) remained critically low—consistent with the diminished intrinsic motivation documented when students are physically separated from gymnasium environments and peers (Padua et al., 2024). For PASD, instructor guidance (PASD4; $M = 3.06$) was the strongest indicator, while regular independent practice (PASD3; $M = 2.29$) was the weakest, reflecting the accountability gap inherent in remote learning. Among LOPE items, practical applicability of PE knowledge in daily life (LOPE4; $M = 2.70$) was highest, while overall perceived effectiveness (LOPE5; $M = 2.24$) remained low.

Table 2. Descriptive Statistics of Item Indicators and Latent Constructs ($N = 171$)

Item	Indicator	<i>M</i>	<i>SD</i>	Level
Instructional Quality (IQ)				
IQ1	The instructional materials enhanced my understanding of PE.	3.07	1.00	Moderate
IQ2	My online PE classes provided clear explanations of physical activities.	2.74	1.02	Moderate
IQ3	Online assessments effectively measured what I learned.	2.58	1.13	Moderate
IQ4	My online PE classes offered hands-on learning experiences.	2.42	1.13	Low
IQ5	The course structure was well-organized and easy to follow.	3.04	1.02	Moderate
	<i>IQ Composite Mean</i>	2.77	0.84	Moderate
Student Engagement (SE)				
SE1	I was actively engaged in my online PE sessions.	2.74	1.22	Moderate
SE2	My online PE classes motivated me to perform physical activities.	2.25	1.13	Low
SE3	Online discussions helped improve my learning experience.	2.47	1.14	Low
SE4	Group activities made my online PE classes more engaging.	2.96	1.25	Moderate
SE5	Gamification (leaderboards, badges) enhanced my participation in PE.	2.98	1.21	Moderate
SE6	My online PE classes encouraged me to exercise outside of class.	2.39	1.20	Low
	<i>SE Composite Mean</i>	2.63	0.87	Moderate
Physical Activity and Skill Development (PASD)				
PASD1	I developed new physical skills through my online PE classes.	2.36	1.19	Low
PASD2	I could perform exercises correctly based on online instructions.	2.54	1.23	Moderate
PASD3	I practiced the exercises demonstrated in my online classes regularly.	2.29	1.09	Low
PASD4	My PE instructor provided sufficient guidance for skill development.	3.06	1.09	Moderate
	<i>PASD Composite Mean</i>	2.56	0.95	Moderate
Learning Outcomes in Physical Education (LOPE)				
LOPE1	I gained a deeper understanding of physical fitness through online PE.	2.46	1.14	Low
LOPE2	Online PE classes helped me improve my practical physical skills.	2.32	1.09	Low
LOPE3	My motivation to exercise and maintain a healthy lifestyle increased due to online PE.	2.30	1.17	Low
LOPE4	The knowledge I gained in online PE is useful for my daily life.	2.70	1.23	Moderate
LOPE5	Overall, my PE learning experience was effective despite being online.	2.24	1.22	Low
	<i>LOPE Composite Mean</i>	2.40	1.03	Low

Note. *M* = Mean; *SD* = Standard Deviation. Rating scale: 1.00–1.79 = Very Low; 1.80–2.59 = Low; 2.60–3.39 = Moderate; 3.40–4.19 = High; 4.20–5.00 = Very High.

Reliability and Construct Validity

Table 3 presents reliability and validity indicators. All constructs exceeded the Cronbach's Alpha threshold of 0.70 ($\alpha = 0.826$ – 0.925), indicating strong internal consistency. Composite Reliability ranged from 0.859 to 0.941, surpassing the $CR \geq 0.70$ criterion. AVE values ranged from 0.543 to 0.771, all meeting the ≥ 0.50 threshold, confirming convergent validity. For discriminant validity, the square root of each construct's AVE ($\sqrt{AVE} = 0.737$ – 0.878) exceeded all inter-construct correlation values ($r = 0.700$ – 0.847), satisfying the Fornell and Larcker (1981) criterion and confirming that each construct captures a distinct dimension of the online PE experience. Collectively, these values meet the conventional thresholds for reflective measurement models in behavioral research (Hair et al., 2019), indicating that the measurement model is adequate to support structural estimation.

Table 3. Reliability and Construct Validity Indicators (N = 171)

Construct	α	CR	AVE	$\sqrt{\text{AVE}}$
Instructional Quality	0.850	0.882	0.626	0.791
Student Engagement	0.826	0.859	0.543	0.737
Physical Activity & Skill Dev.	0.847	0.878	0.689	0.830
Learning Outcomes in PE	0.925	0.941	0.771	0.878

Note. α = Cronbach's Alpha; CR = Composite Reliability; AVE = Average Variance Extracted; $\sqrt{\text{AVE}}$ = Square Root of AVE. Recommended thresholds: $\alpha \geq 0.70$, CR ≥ 0.70 , AVE ≥ 0.50 .

Correlation Among Latent Constructs

Table 4 presents the bivariate correlations. All coefficients were positive, large in magnitude, and statistically significant ($p < .001$). The strongest correlation was between PASD and LOPE ($r = 0.847$), confirming that students who developed greater physical skills reported markedly better learning outcomes. The SE–LOPE correlation ($r = 0.827$) similarly underscores the centrality of student engagement. IQ correlated positively with all constructs, most strongly with LOPE ($r = 0.780$), establishing instructional quality as a pervasive predictor of online PE learning. These inter-construct relationships are theoretically consistent with Social Cognitive Theory, wherein personal motivation (reflected in SE), behavioral engagement (PASD), and environmental conditions (IQ) reciprocally shape learning (Bandura, 1986).

Table 4. Bivariate Correlation Matrix Among Latent Constructs (N = 171)

Construct	IQ	SE	PASD	LOPE
1. Instructional Quality (IQ)	—			
2. Student Engagement (SE)	0.700**	—		
3. Physical Activity & Skill Dev. (PASD)	0.736**	0.757**	—	
4. Learning Outcomes in PE (LOPE)	0.780**	0.827**	0.847**	—

Note. ** $p < .001$, two-tailed. All correlations are significant at the .001 level. IQ = Instructional Quality; SE = Student Engagement; PASD = Physical Activity and Skill Development; LOPE = Learning Outcomes in Physical Education.

Structural Equation Modeling Results

Prior to hypothesis testing, model fit was evaluated. Table 5 presents the fit indices. The chi-square to degrees-of-freedom ratio ($\chi^2/df = 2.142$) was within the acceptable range (< 3.0). Both CFI (0.923) and TLI (0.911) exceeded the 0.90 threshold. The RMSEA (0.082) was marginally above the 0.08 cut-off; however, this is consistent with the known sensitivity of RMSEA to sample size and model complexity, particularly in social science models with moderate N (MacCallum et al., 1996). Taken together, these indices indicate acceptable overall model fit.

Table 5. SEM Model Fit Indices

χ^2	df	χ^2/df	CFI	TLI	RMSEA
351.33	164	2.142	0.923	0.911	0.082

Acceptable thresholds: $\chi^2/df < 3.0$; CFI ≥ 0.90 ; TLI ≥ 0.90 ; RMSEA ≤ 0.08

Note. χ^2/df = chi-square to degrees-of-freedom ratio; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation. Fit thresholds per Hu and Bentler (1999) and Kline (2016).

Table 6 presents the standardized path coefficients from the full SEM estimated via Maximum Likelihood. All six hypothesized paths were statistically significant. IQ was significantly positively associated with SE (H1: $b = 1.019$, $SE = 0.148$, $\beta = 0.828$, $z = 6.91$, $p < .001$), confirming that higher instructional quality predicts stronger student engagement—the strongest single path in the model. The particularly strong IQ $\rightarrow$ SE path suggests that the quality of instruction is the primary lever through which teachers can increase student engagement in online settings. This aligns with TAM-based perspectives: when students perceive instructional design as purposeful and organized, they engage more actively (Davis, 1989; Lobo et al., 2024).

IQ also significantly predicted PASD (H2: $b = 0.441$, $SE = 0.188$, $\beta = 0.283$, $z = 2.35$, $p = .019$), indicating that instructional quality is directly linked to students' physical skill acquisition. SE significantly predicted PASD (H3: $b = 0.833$, $SE = 0.168$, $\beta = 0.657$, $z = 4.95$, $p < .001$), establishing the dual role of IQ and SE as antecedents of physical activity and skill development. The high β for SE $\rightarrow$ PASD reinforces that sustained engagement is a near-necessary condition for meaningful skill development in online PE—consistent with the evidence that blended and interactive approaches significantly enhance physical fitness outcomes (Wang et al., 2024).

SE significantly predicted LOPE (H4: $b = 0.590$, $SE = 0.152$, $\beta = 0.486$, $z = 3.87$, $p < .001$), and PASD significantly predicted LOPE (H5: $b = 0.344$, $SE = 0.110$, $\beta = 0.359$, $z = 3.13$, $p = .002$), confirming both as direct antecedents of

learning outcomes. IQ retained a significant direct positive association with LOPE even after controlling for SE and PASD (H6: $b = 0.266$, $SE = 0.127$, $\beta = 0.178$, $z = 2.10$, $p = .036$), though this direct association is the most modest in the model, indicating that the greater part of instructional quality's association with learning outcomes is transmitted indirectly through student engagement and skill development rather than directly. The model accounted for 68.6% of the variance in Student Engagement ($R^2 = 0.686$), 82.0% of the variance in Physical Activity and Skill Development ($R^2 = 0.820$), and 95.9% of the variance in Learning Outcomes in Physical Education ($R^2 = 0.959$). These values are internally consistent with the standardized path coefficients reported in Table 6. Because Instructional Quality is the sole predictor of Student Engagement, R^2 for that construct equals the square of its standardized path, and the explained variance in the remaining endogenous constructs follows from the standardized paths and the correlations among their predictors. All three values are reported consistently in the note to Table 6 and in Figure 2.

Table 6. SEM Path Coefficients for Hypothesized Structural Relationships ($N = 171$)

H	Path	b	SE	β	Z	Decision
H1	IQ $\rightarrow$ SE	1.019	0.148	0.828	6.91**	Supported
H2	IQ $\rightarrow$ PASD	0.441	0.188	0.283	2.35*	Supported
H3	SE $\rightarrow$ PASD	0.833	0.168	0.657	4.95**	Supported
H4	SE $\rightarrow$ LOPE	0.590	0.152	0.486	3.87**	Supported
H5	PASD $\rightarrow$ LOPE	0.344	0.110	0.359	3.13*	Supported
H6	IQ $\rightarrow$ LOPE (direct)	0.266	0.127	0.178	2.10*	Supported

Note. b = unstandardized path coefficient (ML estimation); SE = standard error; β = standardized path coefficient; z = critical ratio. * $p < .05$. ** $p < .001$. IQ = Instructional Quality; SE = Student Engagement; PASD = Physical Activity and Skill Development; LOPE = Learning Outcomes in Physical Education. Explained variance in the endogenous constructs: $R^2 = 0.686$ for SE, $R^2 = 0.820$ for PASD, and $R^2 = 0.959$ for LOPE.

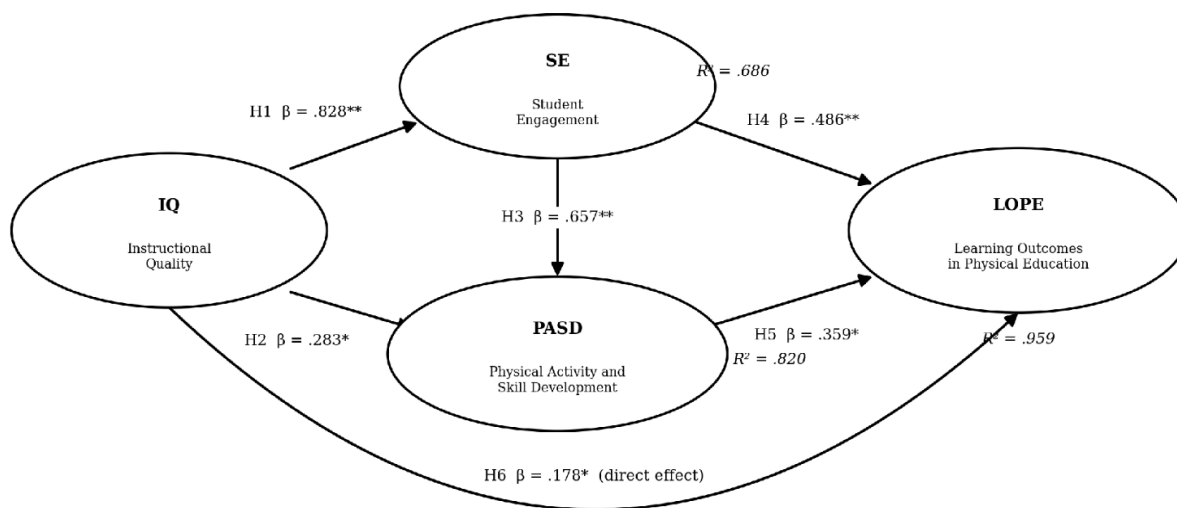


Figure 2. Structural Model of Online Physical Education Learning with Standardized Path Coefficients ($N = 171$)

Note. Standardized coefficients from covariance-based SEM with maximum likelihood estimation. All six hypothesized paths were statistically significant. Model fit: $\chi^2/df = 2.142$, CFI = 0.923, TLI = 0.911, RMSEA = 0.082. Measurement (outer) model indicators are omitted for legibility; factor loadings, reliability, and validity coefficients are reported in Table 3. * $p < .05$. ** $p < .01$. *** $p < .001$.

That instructor guidance (PASD4; $M = 3.06$) was the highest-rated PASD indicator while regular independent practice (PASD3; $M = 2.29$) was lowest points to a critical implementation gap: students valued teacher guidance but rarely translated it into consistent autonomous practice. This pattern is consistent with the reduced monitoring and accountability inherent in remote learning environments, where self-regulation becomes essential but often remains underdeveloped (Goad, 2018). The PASD $\rightarrow$ LOPE path ($\beta = 0.359$) thus reinforces that closing this practice gap—through structured self-monitoring tools, home exercise logs, or peer accountability mechanisms—is critical to improving online PE outcomes.

A tension runs through these results that warrants explicit interpretation. The structural model performs strongly—every hypothesized path is statistically significant, the constructs are reliably measured, and the

antecedents account for a substantial share of variance in learning outcomes—yet the absolute level of those outcomes is low (LOPE composite $M = 2.40$; overall perceived effectiveness, LOPE5, $M = 2.24$). The two findings are not contradictory. R^2 describes how much of the variation in learning outcomes is explained by variation in instructional quality, engagement, and skill development, but it carries no information about where along the response scale those outcomes fall. What the model demonstrates is that the levers available to teachers operate as theorized; what the descriptive means demonstrate is that, in this setting, those levers were not pulled far enough to lift outcomes out of the low band. The item-level pattern locates the ceiling precisely: hands-on learning experiences (IQ4, $M = 2.42$) and regular independent practice (PASD3, $M = 2.29$) were the weakest indicators within their respective constructs, and both concern embodied execution rather than information transfer. This points to a structural rather than a pedagogical limitation—the difficulty of delivering movement learning through a screen, where the teacher cannot observe, correct, or physically scaffold execution (Yu & Jee, 2021; Huang et al., 2025). High instructional quality in an online environment therefore appears to raise learning outcomes reliably but from a constrained baseline, which argues for hybrid configurations that reserve embodied components for face-to-face contact rather than for further optimization of online delivery alone.

Consistent with the framing of this study, the delivery platform was treated as a contextual characteristic of the learning environment rather than as an experimental factor, and the results should not be read as a comparison of synchronous against asynchronous PE. A formal comparison was not statistically defensible. Microsoft Teams, primarily associated with synchronous delivery, was the platform for 78.4% of respondents, while Canvas accounted for 18.7%; the asynchronous subgroup ($n = 32$) therefore falls well below the sample size required for multi-group SEM, in which each group must independently support estimation of the full measurement and structural model. Reporting a group comparison at that cell size would have yielded unstable and potentially misleading estimates. What the platform distribution does support is a descriptive observation: engagement and skill-development indicators were uniformly moderate to low across the sample, consistent with the interpretation that modality alone does not determine effectiveness and that the quality of instructional design within a modality is the operative factor (Rihatno & Nuraini, 2023). Synchronous delivery offers real-time interaction and feedback but demands stable internet connectivity—a structural barrier for the 8.2% reporting low or unstable access—whereas asynchronous delivery accommodates that constraint at the cost of immediate corrective feedback. A hybrid configuration anchored by high-quality instructional design may therefore represent the more workable arrangement in resource-variable contexts, although establishing this claim requires the modality-comparative design recommended below.

Conclusion

This study provides empirical evidence that instructional quality, student engagement, and physical activity and skill development are significantly and positively associated with learning outcomes in online physical education among senior high school students. The full structural model demonstrated acceptable fit and accounted for a substantial proportion of the variance in learning outcomes, indicating that these constructs are best understood as an integrated, sequentially mediated system rather than as independent influences. Within that system, instructional quality is associated with learning outcomes both directly and indirectly through its associations with student engagement and skill development, while student engagement is in turn associated with physical skill development and, through it, with learning outcomes. Because the design is cross-sectional, these relationships are described throughout as associations rather than as effects: the data establish patterns of covariation consistent with the hypothesized ordering, but they cannot establish temporal precedence or rule out reverse causation among the constructs.

This explanatory strength should not be mistaken for an endorsement of online delivery. In absolute terms, students rated their overall learning outcomes in online PE as low, and the weakest indicators across the model were precisely those concerning hands-on execution and regular independent practice. The model therefore identifies which instructional levers matter without implying that pulling them proved sufficient: online PE as experienced by these students was, on the whole, perceived as ineffective even where instruction was comparatively well designed. Delivery mode itself did not appear to be the deciding factor. Most participants learned through a synchronous platform, with asynchronous resources in a supplementary role, and ratings were uniformly modest across platforms, which locates the binding constraint in the medium's limited capacity to support embodied learning rather than in the choice between live and self-paced formats.

These findings carry practical implications for PE teachers, curriculum designers, and school administrators. Investment in high-quality instructional design—clear movement demonstrations, scaffolded skill progression, formative assessment, and interactive learning activities—is essential for effective online PE. Equally critical are strategies to sustain student motivation and engagement in the absence of physical co-presence, including gamified tasks, collaborative activities, and regular self-monitoring tools. Limitations include the convenience sample drawn from two private schools, the cross-sectional design that precludes causal inference, and the marginal Harman single-factor result suggesting some common method variance, as well as reliance on self-reported Likert measures subject to social-desirability and acquiescence bias and recruitment through class advisers that may have generated a degree of perceived obligation to participate. Future research should employ probability sampling across diverse school types and regions, longitudinal or quasi-experimental designs comparing synchronous and asynchronous delivery, and multi-source data collection to strengthen causal claims. The principal contribution of this study is a validated, integrated measurement and structural model of online PE learning for the Philippine senior high school context, together with evidence that instructional quality functions as the upstream lever in that system while embodied practice remains its binding constraint. As educational systems continue to evolve in the post-pandemic digital era, ensuring equitable access and instructional quality in online PE will remain a priority.

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