

Leveraging AI and pedagogical competence to enhance learning interest and outcomes: evidence from Islamic university

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ABSTRACT

This study investigates the effects of artificial intelligence (AI)-supported intelligent educational systems and teacher pedagogical competence (TPC) on students' learning interest (LI) and learning outcomes (LO) in an Islamic higher education context. AI is operationalized as AI-supported learning system features embedded in institutional learning platforms, particularly natural language processing (NLP)-based automated feedback and AI-driven recommendation functionalities that support adaptive and personalized learning. The study was conducted at the As-Syifa Institute, Subang, Indonesia, involving 366 undergraduate students from the first, third, and fifth semesters. Data were analyzed using partial least squares-structural equation modeling (PLS-SEM) with SmartPLS 4 to examine the structural relationships among AI system use, TPC, LI, and LO. The results demonstrate that AI-supported learning system features have significant positive effects on both LI and LO. TPC also shows a strong direct effect and mediates the relationship between AI-supported systems and student outcomes. These findings highlight the importance of human-AI integration, indicating that pedagogical competence plays a critical role in translating AI system functionalities into meaningful educational benefits. This study contributes to the AI-in-education literature by providing empirical evidence on pedagogically mediated AI-supported learning systems and offers insights for the design and evaluation of adaptive and intelligent learning environments in higher education.

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1. INTRODUCTION

The development of artificial intelligence (AI) in the field of education signifies a major shift in teaching and learning approaches, especially in enhancing students' learning interest (LI) and learning outcomes (LO). AI has the potential to transform education through adaptive features and personalized learning, allowing instructional content to be tailored to students' needs and learning styles [1]. In this study,

AI is not understood merely as general educational technology, but as AI-supported intelligent educational systems that utilize data-driven mechanisms to provide adaptive learning support, automated feedback, and personalized learning experiences. However, the adoption of AI across educational contexts, including Islamic university, remains limited due to challenges such as technological access, teacher readiness, and deeply rooted pedagogical traditions. These challenges hinder the acceptance of AI-based learning innovations. Therefore, this study aims to explore how AI can be integrated with teacher pedagogical competence (TPC) to enhance LI and LO in Islamic university institutions in Indonesia.

The use of AI in education offers various models and technologies, from machine learning [2] to big data analysis [3], enabling AI to provide individualized recommendations and feedback to students [4]. Recent developments in AI-supported education emphasize intelligent systems such as natural language processing (NLP)-based automated feedback tools and AI-driven recommender systems, which analyze learner interactions to support adaptive and personalized instruction. For instance, adaptive learning technology in AI can analyze students' learning patterns and adjust the difficulty level of the material presented. This aligns with constructivist pedagogy, which emphasizes active interaction between students and content, fostering both cognitive and affective student engagement [5]. In the context of Islamic university, where instructional content is often historical and contextual [6], AI that can offer personalized feedback and recommendations can help students gain a deeper understanding of and appreciation for the material [7], while also strengthening their LI [8].

The integration of AI also enables the concept of a "super teacher", where technology extends teachers' capabilities to respond to students' needs more quickly and effectively. Rather than replacing teachers, AI-supported systems function as decision-support tools that assist educators in monitoring learning progress, providing feedback, and recommending instructional adjustments. With the assistance of AI, teachers can use tools like virtual reality (VR) and augmented reality (AR) to create experiential learning environments [9], allowing students to immerse themselves in settings reflective of the lesson content, such as historical contexts or significant locations in Islam. For example, VR in Islamic studies can take students on a "visit" to Mecca or Medina during the early centuries of Islam, enriching and dynamizing the learning experience [10]. However, technologies like VR, AR, and other AI tools are often costly and not easily accessible to every Islamic university. Consequently, technological infrastructure development is essential to ensure more equitable AI application in Islamic university. Teachers' pedagogical competence is a key factor in the successful implementation of AI in education [11]. According to Uerz *et al.* [12] that this competence encompasses teachers' ability to leverage technology in creating interactive and effective learning environments, as well as their capacity to deliver content that meets students' needs. Within AI-supported educational systems, pedagogical competence plays a critical role in determining how AI-generated feedback and recommendations are interpreted, contextualized, and integrated into instructional practices. In Islamic university, where character development, critical thinking, and spiritual understanding are focal points, pedagogical skills are crucial to ensuring the quality of AI-based instruction [13]. Variations in TPC levels among Indonesian teachers lead to differences in the effectiveness of AI application, ultimately affecting student LO and interest across regions and Islamic educational institutions [14].

Although AI offers significant opportunities, teachers' technological proficiency in Indonesia continues to face several challenges, particularly due to limited training [13], digital skills [10], and infrastructural support [15]. Ismail *et al.* [16] indicates that without adequate training, teachers often struggle to effectively utilize AI technology. Nahumury and Antony [17] indicate that in certain regions particularly Indonesia's frontier, outermost, and disadvantaged or *terdepan, terluar, and tertinggal* (3T) areas the limited availability of essential technological devices and reliable internet connectivity remains a substantial barrier. These circumstances underscore that the effectiveness of AI-supported intelligent systems in education is not determined solely by technological infrastructure, but is also highly contingent upon human factors, especially teachers' pedagogical competence and their readiness to engage with AI-mediated instructional environments. Therefore, Ismail *et al.* [16] considers it essential to implement specialized training designed to enhance teachers' technical and pedagogical skills in utilizing AI technology, so that this technology can be optimally employed to improve student LO and interest.

The synergy between AI and TPC is the central focus of this study, examining how their interaction shapes students' LI and LO in Islamic higher education. Unlike prior studies that examine AI integration in general higher education contexts, this study specifically addresses Islamic universities, where pedagogical traditions rooted in value-based learning, ustadz-student relational dynamics, and communal knowledge transmission create a distinctive instructional environment that fundamentally shapes how AI-supported systems are adopted and operationalized. This contextual distinctiveness constitutes the primary novelty of the present study no prior empirical work has simultaneously examined AI-supported intelligent systems and pedagogical competence as co-determinants of both LI and LO within this specific institutional and cultural setting. AI is positioned as a pedagogically mediated system whose influence on learning is shaped by

teachers' competence rather than autonomous algorithmic decision-making, offering a framework that is both theoretically grounded and contextually responsive to the realities of Indonesian Islamic higher education.

This study offers concrete recommendations for policymakers, educators, and administrators of Islamic universities in Indonesia seeking to develop AI-based educational approaches that are pedagogically relevant and locally responsive. These recommendations encompass sustained AI literacy programs within teacher professional development frameworks, equitable investment in digital infrastructure across Islamic institutions, and integration of digital pedagogical competence into national accreditation standards ensuring that AI adoption is systemic rather than ad hoc. The findings contribute to understanding how AI-supported intelligent educational systems can be designed and implemented within value-based educational contexts, serving as a foundation for policy development that supports equitable access to quality educational technology throughout Indonesia.

The primary objective of this study is to empirically examine the impact of AI integration and TPC on students' LI and LO within Islamic university. Specifically, this study conceptualizes AI as AI-supported intelligent educational systems such as NLP-based feedback and recommender systems and investigates how their effectiveness is mediated by teachers' pedagogical competence. Furthermore, the study aims to investigate the mediating role of LI in the relationship between the exogenous variables (AI and TPC) and the endogenous variable (LO).

The study specifically tests the following hypotheses:

- H1: the integration of AI positively affects students' LI in Islamic university.
- H2: the integration of AI positively affects students' LO in Islamic university.
- H3: TPC positively affects students' LI.
- H4: TPC positively affects students' LO.
- H5: students' LI positively affects their LO.

2. METHOD

2.1. Research design

This study adopts a quantitative research approach with a correlational design to examine the structural relationships among four key constructs in the context of Islamic higher education: AI, TPC, LI, and LO. The correlational design is employed to analyze naturally occurring variations in these constructs without experimental manipulation, allowing for an examination of how AI-supported educational systems and pedagogical competence are associated with students' LI and outcomes. In this study, AI is conceptualized as AI-supported intelligent educational systems, particularly NLP-based automated feedback tools and AI-driven recommender systems that support adaptive and personalized learning. Importantly, AI is treated as a contextual instructional system rather than a standalone algorithmic model, while TPC functions as a mediating human factor that shapes how AI-supported systems are implemented and utilized in instructional practice. LI and LO are positioned as endogenous variables reflecting students' affective engagement and academic achievement, respectively. The research model illustrating these hypothesized relationships is presented in Figure 1.

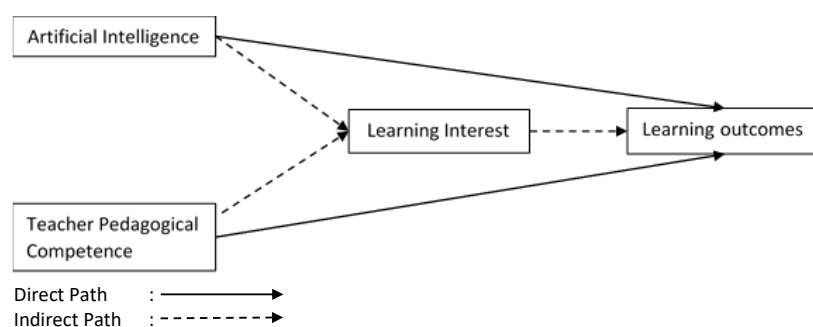


Figure 1. Hypothesized relationships between research variables

The proposed research model, as illustrated in Figure 1, tests both direct effects (AI → LI; AI → LO; TPC → LI; TPC → LO; and LI → LO) and indirect effects, particularly the mediating role of LI in explaining the influence of AI and TPC on LO. The direct paths reflect the independent contributions of AI-supported learning systems and TPC to students' LI and LO, while the indirect path captures the extent to which LI functions as a transmission mechanism between the exogenous constructs and academic

achievement. Together, these hypothesized relationships form a theoretically grounded framework that positions human-AI integration, mediated by learner engagement, as the central explanatory structure for understanding instructional effectiveness in Islamic higher education.

2.2. Sample and data collection

The study population comprised 366 undergraduate students enrolled at the As-Syifa Institute, Subang, Indonesia, during the 2023-2024 academic year. Participants were drawn from odd semesters of study, specifically 114 first-semester students, 120 third-semester students, and 132 fifth-semester students, representing the complete active student population across those semesters. This study employs a census-based sampling strategy, in which all members of the defined target population were included rather than a randomly drawn subset, thereby eliminating sampling error and ensuring complete representational coverage within the institutional context. While single-institution sampling inherently limits external generalizability, this design enables contextual depth and minimizes inter-institutional confounds that may obscure within-context mechanisms a methodological trade-off acknowledged as a limitation and addressed in the directions for future research.

Data were collected using a structured questionnaire administered during regular class sessions to maximize response rates. Prior to data collection, participants were informed about the objectives of the study, assured of voluntary participation, and guaranteed confidentiality and anonymity of their responses. All participants provided informed consent, and the data collection procedure adhered to ethical research standards with no personally identifiable information recorded.

2.3. Research instrument

This study employed a structured self-administered questionnaire as the primary research instrument to measure the latent constructs in the proposed model, namely AI, TPC, LI, and LO, within the context of Islamic higher education. The questionnaire was adapted from relevant literature in educational technology, pedagogy, and learning research to ensure conceptual alignment with established theoretical constructs rather than to develop a new measurement instrument. All items were adapted from previously validated instruments and modified to reflect the specific instructional context of Islamic higher education, ensuring contextual relevance without sacrificing construct fidelity.

The AI construct was operationalized as AI-supported intelligent educational systems and measured using four indicators comprising a total of fourteen items [18], [19], which reflect students' experiences with automated feedback, adaptive learning and recommendation, AI-supported learning interaction, and AI-supported instructional decision support. These indicators emphasize AI as a human-in-the-loop system, in which the effectiveness of AI-supported learning environments is shaped by pedagogical use rather than autonomous algorithmic decision-making. The TPC construct was measured using seven indicators consisting of twenty-one items adapted from technological pedagogical and content knowledge (TPACK) framework [20] and subsequent empirical extensions, representing lecturers' pedagogical abilities in managing learning processes, applying instructional strategies, integrating technology into teaching, providing feedback, and facilitating student engagement. The LI construct was assessed using four indicators with sixteen items adapted from the four-phase interest development model, capturing students' enthusiasm, attention, curiosity, and active involvement in learning activities [21]. Meanwhile, the LO construct was measured using three indicators [22], reflecting students' perceived academic achievement, mastery of learning materials, and ability to apply acquired knowledge. All questionnaire items were measured using a seven-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Prior to data collection, the instrument underwent a structured expert review process involving three subject matter experts in educational technology and Islamic pedagogy, who evaluated each item for clarity, relevance, and contextual appropriateness. Feedback from the expert review was incorporated to refine item wording and ensure alignment between indicators and their respective theoretical constructs. This expert validation process serves as the primary content validity procedure, complementing the statistical validity assessment conducted through partial least squares-structural equation modeling (PLS-SEM) measurement model evaluation. The choice of PLS-SEM over covariance-based structural equation modeling (CB-SEM) and its associated confirmatory factor analysis (CFA) procedure is justified on the grounds that this study is predictive and explanatory in orientation, involves a relatively complex model with multiple formative-reflective construct configurations, and operates within an emerging research context where theory is still being developed and refined. As established by Hair *et al.* [23], PLS-SEM is the appropriate analytical choice when research objectives emphasize prediction and theory development rather than strict model fit confirmation, and when composite-based reliability and convergent validity criteria including outer loadings, average variance extracted (AVE), Cronbach's alpha, and heterotrait-monotrait ratio (HTMT) are rigorously

evaluated as substitutes for CFA-based fit indices [23]. The reliability and construct validity of the instrument were subsequently confirmed through measurement model assessment, as reported in the results section.

2.4. Data analysis

Data were initially screened and summarized using IBM SPSS statistics to generate descriptive statistics, including means, standard deviations, and distributional properties of the observed variables. Subsequently, the data were analyzed using PLS-SEM with SmartPLS 4 to examine the relationships among AI, TPC, LI, and LO. PLS-SEM was selected due to its suitability for predictive-oriented models with multiple latent constructs and indicators and its robustness to non-normal data. In this study, PLS-SEM served solely as a statistical modeling technique, while AI was conceptualized as AI-supported intelligent educational systems embedded in the learning context. The analysis involved two main stages: evaluation of the measurement model and the structural model. Measurement model assessment included tests of convergent validity (outer loadings and AVE), discriminant validity (Fornell-Larcker criterion and cross-loadings), and internal consistency reliability (Cronbach's alpha and composite reliability). Structural model evaluation involved examining path coefficients, coefficients of determination (R^2), and bootstrapping procedures to assess the significance of direct effects. Indirect effects through LI were tested to examine its mediating role in the model, while TPC was treated as an exogenous predictor rather than a mediator. All structural analyses were conducted using SmartPLS 4.

3. RESULTS AND DISCUSSION

3.1. Structural model validation

To evaluate the adequacy of the measurement model, descriptive statistics, indicator loadings, and collinearity diagnostics were examined. Table 1 presents the descriptive statistics of the observed indicators, including the mean, standard deviation, skewness, excess kurtosis, outer loading values, and variance inflation factor (VIF), which together provide an initial assessment of data distribution, indicator reliability, and potential multicollinearity issues in the model. As shown in Table 1, mean values across all indicators range from 2.781 (LI3) to 5.984 (AI4), suggesting that respondents generally hold moderate to positive perceptions of AI-supported learning systems, TPC, LI, and LO. Notably, the LO construct (LO1–LO3) and TPC indicators (TPC1–TPC2) yield the highest mean scores, reflecting strong student agreement with items related to academic achievement and instructional quality. Standard deviation values range from approximately 1.37 to 2.03, indicating sufficient response variability across items and reducing concerns about range restriction in the data. Regarding distributional properties, skewness values for most indicators fall within the range of ± 1.0 , and excess kurtosis values remain within acceptable bounds, with the exception of AI4 (excess kurtosis = 1.543) and LI3 (skewness = 0.917), which exhibit slight departure from normality. However, given that PLS-SEM is a distribution-free estimation technique robust to non-normal data, these minor deviations do not compromise the validity of the analysis and are consistent with acceptable thresholds reported in variance-based structural equation modeling literature.

Table 1. Measurement model

Item	Mean	Std. deviation	Excess kurtosis	Skewness	Outer loadings	VIF
AI1	3.642	1.482	-0.562	0.121	0.703	1.512
AI2	4.918	1.396	-0.704	-0.278	0.828	1.688
AI3	4.387	1.714	-0.861	-0.312	0.747	1.634
AI4	5.984	1.367	1.543	-1.432	0.763	1.244
TPC1	5.167	1.521	-0.428	-0.603	0.934	1.402
TPC2	5.298	1.486	-0.361	-0.781	0.934	1.433
TPC3	4.682	1.692	-0.741	-0.448	0.683	1.712
TPC4	4.392	1.507	-0.581	-0.267	0.849	1.354
TPC5	4.271	1.824	-0.914	-0.379	0.872	1.618
TPC6	4.346	1.584	-0.732	-0.341	0.818	1.508
TPC7	4.927	1.536	-0.241	-0.657	0.449	1.493
LI1	3.418	1.912	-1.204	0.298	0.707	2.384
LI2	4.612	2.031	-1.086	-0.334	0.828	2.012
LI3	2.781	1.723	-0.256	0.917	0.883	1.946
LI4	4.853	1.781	-0.892	-0.421	0.875	2.176
LO1	4.317	1.905	-1.043	-0.237	0.966	2.118
LO2	4.689	1.742	-0.816	-0.356	0.966	2.084
LO3	4.104	1.963	-1.121	-0.184	0.701	2.041

In terms of indicator reliability, the majority of outer loadings exceed the recommended threshold of 0.70, confirming strong associations between observed indicators and their respective latent constructs. The

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strongest loadings are observed in the LO construct, where LO1 and LO2 both achieve loadings of 0.966, indicating highly consistent measurement of perceived academic achievement. Two indicators warrant specific attention: TPC7 (loading = 0.449) and TPC3 (loading = 0.683) fall below or near the conventional 0.70 threshold. TPC7 was retained based on its theoretical relevance to the pedagogical competence construct and its contribution to content validity, consistent with the recommendation by Hair *et al.* [23] that indicators with loadings between 0.40 and 0.70 may be retained if their removal does not substantially improve AVE. All VIF values remain under the critical threshold of 3.3, ranging from 1.244 to 2.384, confirming the absence of multicollinearity among indicators. Overall, the results in Table 1 confirm that the measurement model demonstrates acceptable distributional properties, indicator reliability, and collinearity diagnostics, thereby supporting its adequacy for subsequent construct-level validity assessment.

Following the evaluation of indicator-level properties, construct-level reliability and convergent validity of the measurement model were assessed. Table 2 summarizes the internal consistency and convergent validity statistics for all four latent constructs, including Cronbach's alpha, composite reliability (ρ_a and ρ_c), and AVE. These indices collectively determine whether each construct is measured with sufficient precision and whether its indicators converge adequately on the underlying theoretical dimension.

Table 2. Reliability statistics

Construct	Cronbach's alpha	Composite reliability (ρ_a)	Composite reliability (ρ_c)	AVE
AI	0.758	0.739	0.846	0.580
TPC	0.904	0.850	0.926	0.652
LI	0.844	0.781	0.895	0.683
LO	0.854	0.803	0.915	0.786

As shown in Table 2, all constructs demonstrate satisfactory internal consistency reliability. Cronbach's alpha values range from 0.758 (AI) to 0.904 (TPC), all exceeding the minimum recommended threshold of 0.70, which confirms acceptable reliability across constructs. Notably, the relatively lower alpha value for the AI construct (0.758) is expected given its broader operationalization across four distinct dimensions of AI-supported system features, which introduces greater inter-item heterogeneity compared to more narrowly defined constructs. Composite reliability values (ρ_c) range from 0.846 (AI) to 0.926 (TPC), all well above the 0.70 threshold, providing further confirmation of strong internal consistency. The ρ_a values, which apply a more conservative correction for indicator weights, also meet acceptable standards across all constructs, ranging from 0.739 to 0.850, reinforcing the robustness of the reliability estimates.

In terms of convergent validity, all AVE values exceed the recommended cutoff of 0.50, indicating that each construct explains the majority of the variance in its indicators rather than measurement error. The LO construct achieves the highest AVE (0.786), reflecting the strong convergence of its three indicators around a single coherent academic achievement dimension consistent with the high outer loadings of LO1 and LO2 (0.966) reported in Table 1. The AI construct yields the lowest AVE (0.580), which, while above the threshold, suggests that its four indicator dimensions capture a somewhat broader and more heterogeneous construct space, a characteristic inherent to multi-dimensional operationalizations of AI-supported educational systems. Overall, the results in Table 2 confirm that all constructs satisfy the criteria for internal consistency reliability and convergent validity, supporting the adequacy of the measurement model for subsequent discriminant validity assessment and structural analysis.

Following the confirmation of construct reliability and convergent validity, discriminant validity was assessed to examine the extent to which each latent construct is empirically distinct from the others. Two complementary approaches were employed: the Fornell-Larcker criterion and the HTMT, as recommended in contemporary PLS-SEM guidelines. Table 3 presents Fornell-Larcker matrix, in which diagonal values represent square root of each construct's AVE, and off-diagonal values represent inter-construct correlations.

Table 3. Fornell-Larcker criteria

Construct	AI	TPC	LI	LO
AI	0.861			
TPC	0.642	0.903		
LI	0.508	0.471	0.812	
LO	0.557	0.683	0.596	0.835

As shown in Table 3, discriminant validity is supported for all constructs. The square root of AVE for each construct exceeds its correlations with all other constructs: AI ($\sqrt{\text{AVE}} = 0.861$), TPC

($\sqrt{\text{AVE}} = 0.903$), LI ($\sqrt{\text{AVE}} = 0.812$), and LO ($\sqrt{\text{AVE}} = 0.835$). The highest inter-construct correlation is observed between TPC and LO ($r = 0.683$), which is nonetheless substantially lower than the diagonal value of TPC (0.903), confirming that TPC remains empirically distinct from LO despite their theoretically close relationship. Similarly, the correlation between AI and TPC ($r = 0.642$) falls well under both diagonal values (0.861 and 0.903), indicating that AI-supported systems and pedagogical competence represent distinct constructs rather than overlapping dimensions. These results confirm that each construct shares more variance with its own indicators than with any other construct in the model. To further validate discriminant validity using a more sensitive criterion, the HTMT ratio analysis was conducted, with results presented in Table 4.

Table 4. HTMT analysis

Construct	AI	TPC	LI	LO
TPC	0.781			
LI	0.624	0.552		
LO	0.698	0.864	0.743	

As shown in Table 4, all HTMT values fall below the conservative threshold of 0.90, providing additional support for discriminant validity across all construct pairs. The highest HTMT value is observed between TPC and LO (0.864), which, while approaching the threshold, remains within acceptable bounds and does not indicate problematic construct overlap. This elevated value is theoretically interpretable given the strong direct effect of pedagogical competence on LO documented in prior literature, and reflects genuine construct relatedness rather than measurement redundancy. The remaining HTMT values range from 0.552 (TPC–LI) to 0.781 (AI–TPC), all comfortably under the 0.90 threshold. Taken together, the Fornell-Larcker criterion and HTMT analysis consistently demonstrate that all four constructs AI, TPC, LI, and LO are empirically distinct, confirming the discriminant validity of the measurement model and supporting its adequacy for subsequent structural path analysis.

Having confirmed the discriminant validity of the measurement model, the explanatory power of the structural model was assessed by examining the R^2 for the two endogenous constructs. The R^2 value indicates the proportion of variance in each endogenous variable that is collectively explained by its predictor constructs within the model, serving as a primary indicator of the model's predictive accuracy. The endogenous constructs demonstrate high levels of explained variance. The R^2 value for LI is 0.872, indicating that 87.2% of its variance is jointly explained by AI-supported learning systems and TPC — a value classified as substantial according to Hair *et al.* [23], who propose 0.75 as the threshold for strong predictive power in PLS-SEM. The R^2 value for LO is even higher at 0.915, meaning that 91.5% of the variance in academic achievement is collectively accounted for by AI-supported systems, pedagogical competence, and LI reflecting the theoretically coherent and well-specified structure of the proposed model. These results confirm that the structural model exhibits strong predictive relevance and provides a robust empirical basis for subsequent hypothesis testing.

3.2. Path coefficients and structural model assessment

To provide an integrated view of the estimated model, Figure 2 visualizes the measurement and structural model outputs from SmartPLS 4, including indicator loadings with significance levels and the directional relationships among the latent constructs. This figure helps illustrate how AI-supported learning systems (AI) and TPC connect to LI and LO within the proposed model. Figure 2 shows that the model is organized around two exogenous constructs (AI and TPC) that jointly converge on LI, which subsequently channels into LO. The graphical layout highlights LI as the central linking construct between upstream inputs and downstream outcomes, indicating that the model is conceptually structured to capture both direct and interest-related pathways to LO. In other words, the figure makes clear that the framework is not a simple two-variable association, but a mediated structure in which LI functions as the principal intermediate mechanism connecting system-related and pedagogical factors with achievement-related outcomes.

From the measurement perspective, Figure 2 provides an at-a-glance view of indicator performance through outer loadings and their significance. Most indicators display loadings in the acceptable-to-strong range, suggesting that the constructs are generally well represented by their observed measures. At the same time, the visualization flags a small number of comparatively weaker indicators most notably within the pedagogical competence block indicating that not all observed items contribute equally to their latent construct. This information is useful for interpreting the measurement quality holistically, because it shows where construct measurement is strongest and where it is comparatively less stable. Overall, Figure 2 complements the tabulated bootstrapping results by presenting the model structure and measurement

contributions in a single integrated representation, thereby clarifying the role of LI as the model's key connecting construct and supporting the coherence of the proposed human-AI integration framework.

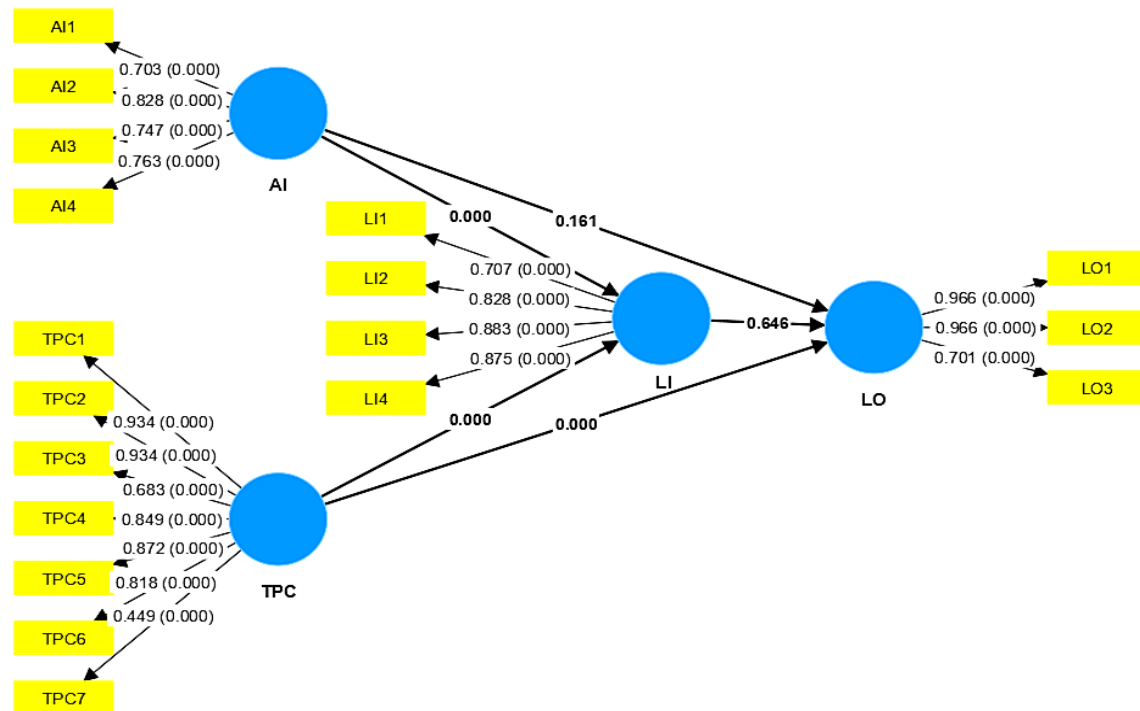


Figure 2. Path analysis results

To test the proposed hypotheses, the structural relationships among the latent constructs were examined using the bootstrapping procedure. Table 5 presents the path coefficients, standard deviations, and t-statistics, which provide statistical evidence for the significance and strength of the hypothesized relationships. As shown in Table 5, four of the five hypothesized relationships are statistically supported at the $t > 1.96$ significance threshold. AI-supported learning systems demonstrate a strong and significant positive effect on LI ($H1 : \beta = 0.550, t = 9.570$), confirming that AI system features operate most powerfully as engagement-enhancing mechanisms. However, the direct effect of AI on LO ($H2 : \beta = 0.221, t = 1.913$) falls under the significance threshold, suggesting that AI's contribution to academic achievement is predominantly indirect channeled through the mediating role of LI rather than through a direct instructional pathway. TPC emerges as the most influential predictor in the model, exhibiting significant positive effects on both LI ($H3 : \beta = 0.441, t = 7.640$) and LO ($H4 : \beta = 0.665, t = 6.467$), with the $TPC \rightarrow LO$ path representing the largest coefficient in the entire structural model.

LI demonstrates a positive effect on LO ($H5 : \beta = 0.646, t = 1.860$), with a t-value marginally under the conventional threshold. While this result warrants cautious interpretation, the substantial path coefficient indicates that LI remains a practically meaningful predictor of academic achievement, consistent with motivational theories of learning. Collectively, the bootstrapping results confirm that TPC and LI serve as the primary structural mechanisms through which AI-supported systems translate into improved LO, reinforcing the argument that effective AI integration in Islamic higher education requires strong pedagogical foundations rather than technological deployment alone.

Table 5. Hipotesis testing

Influence of variables	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T-statistics (O/STDEV)
AI → LO	0.221	0.227	0.157	1.913
AI → LI	0.550	0.558	0.058	9.570
TPC → LO	0.665	0.686	0.103	6.467
TPC → LI	0.441	0.434	0.058	7.640
LI → LO	0.646	0.067	0.204	1.860

3.3. Discussion

This research aims to bridge a gap in understanding the integration of AI and TPC concerning LI and LO in Islamic university. The rapid evolution of AI has reshaped educational landscapes, often challenging teacher competencies across Islamic university. Prior research has leveraged AI to enhance LI [24] and LO [25], yet limited studies explore how AI and TPC collectively improve both LI and LO. Previous studies have generally examined these variables separately: investigating AI's impact on LI or LO or evaluating TPC's influence on LO. This study uniquely examines how the integration of AI and TPC serves as a unified force that impacts both LI and LO within Islamic university, emphasizing the need for cohesive competency in AI use. Unlike prior studies that treat AI primarily as a supportive educational tool, this study conceptualizes AI as an intelligent system embedded within institutional learning platforms, where functionalities such as NLP-based automated feedback and recommendation mechanisms operate as adaptive decision-support components. By empirically examining how these AI system features interact with pedagogical competence, the study shifts the focus from technology adoption toward system-level effectiveness, positioning AI not as a standalone innovation but as a human-mediated intelligent infrastructure.

AI, as an advanced learning tool, has not yet been fully utilized in Islamic classrooms, often due to a lack of emphasis from educators in aligning teaching practices with technology. Studies suggest that AI positively impacts LI when instructional content is thoughtfully curated to resonate with students' age and context [26]. Our findings align with previous research, showing that regular AI usage encourages students' intrinsic motivation, fostering swift access to information. This connection between learning motivation and LI reaffirms H1, confirming that AI enhances LI by supporting students in exploring new information quickly and efficiently [27]. From a systems perspective, this suggests that AI-supported learning platforms function effectively as engagement-enhancing mechanisms when their adaptive features such as personalized content delivery and automated feedback loops are pedagogically aligned. Rather than merely increasing access to information, AI appears to operate as structured scaffolding that dynamically responds to learner interaction patterns, thereby strengthening LI as an intermediate system output.

Similarly, the findings show that AI is significantly related to LO, reinforcing that increased AI utilization in learning processes amplifies LO outcomes [28]. AI's accessibility transcends traditional barriers of time and place, fostering more independent, transparent learning experiences that, in turn, elevate LO [29]. Consistent with other research, our results suggest that tools like AI facilitate meaningful knowledge acquisition, as shown by studies across various fields, including Islamic university [30]–[32]. These findings support H2, affirming a positive correlation between AI use and LO in learning. However, the structural pattern of results indicates that AI's contribution to LO is strengthened when mediated by pedagogical competence and LI, suggesting that AI functionalities alone are insufficient without instructional integration. This reinforces a human-in-the-loop interpretation, in which AI operates as enabling architecture whose impact on performance depends on pedagogical alignment.

The interplay between TPC and LI is evident. The study shows that the more proficient teachers are with AI, the more students' LI is positively impacted [33]. Since AI relies on users' competence, teachers' inability to skillfully use AI can reduce LI, despite AI's potential benefits. This research aligns with prior studies demonstrating the effect of TPC on LI [18]. Effective TPC requires not only AI application in classrooms but also alignment with current developments, relevant content, and timely feedback [34]. This study validates these points and supports H3. Within intelligent learning ecosystems, pedagogical competence functions as the operational interface that translates algorithmic outputs into meaningful instructional strategies. Without sufficient pedagogical mediation, AI-generated recommendations and automated feedback mechanisms risk remaining underutilized, limiting their systemic effectiveness.

Challenges remain regarding teacher competence with AI, particularly in Islamic university, where AI is often perceived as an unfamiliar tool [35], [36]. Previous studies frequently cite accessibility and openness to change as key factors in AI adoption within education [37]. However, our findings highlight that the primary barrier is not merely accessibility but rather teachers' openness to new teaching approaches [38]. This underscores the need to prioritize the development of TPC in AI to ensure that technology can optimally enhance LO. Limited TPC in AI utilization also diminishes the appeal of Islamic university to tech-savvy younger generations, thereby creating an urgent need for equal distribution of digital infrastructure across institutions and intensive training for educators to master these skills [39], [40]. Consistent with these findings, H4 is supported by data showing that teachers' ability to utilize AI plays a critical role in increasing students' LI and LO. From an intelligent system design perspective, these findings imply that AI implementation strategies in Islamic higher education should integrate technological deployment with structured pedagogical capacity building, ensuring that adaptive system features operate within culturally responsive and instructionally coherent frameworks.

Research in general educational contexts also emphasizes that successful AI integration largely depends on educators' readiness and willingness to adapt to new technologies [10]. However, in Islamic university, this challenge is more complex due to cultural differences and values that sometimes restrict

technology-based innovation [41]. Nevertheless, there is significant potential to enhance LI and LO through AI if institutional support in the form of training and facilities is sufficiently provided. Our study aligns with this view, offering evidence that investments in TPC, particularly concerning AI, can bridge the technological gap in Islamic university. Furthermore, a strategy emphasizing a holistic approach in AI training integrating Islamic values into the learning process will enrich students' learning experiences and increase the relevance and competitiveness of Islamic university in the digital era.

H5 is also supported, revealing that LI significantly affects LO. Previous studies consistently underscore the interconnectedness of LI and LO, suggesting that heightened interest in learning naturally leads to improved outcomes [32], [38]. It is worth noting that in the present study, the LI → LO path yields a marginally significant t-value (1.860), which while below the conventional threshold, reflects the substantial residual explanatory power already captured by TPC and AI in the model rather than a fundamental weakness of the LI construct. LI, often sparked by curiosity and intrinsic engagement, fosters cognitive focus and attentiveness, which in turn enhances knowledge retention and application skills, ultimately boosting LO [42], [43]. When students' curiosity is engaged and their interest sustained, cognitive processes such as memory consolidation and analytical thinking are activated, thereby promoting higher LO [44]. This relationship has been highlighted in educational psychology literature, where LI is often identified as a crucial predictor of academic achievement, particularly in learning environments that support active and interest-based learning. Within the present structural model, LI operates not merely as a motivational construct but as a functional transmission channel through which AI-supported systems and pedagogical competence translate into measurable LO, reinforcing its role as a system-level mediator.

Moreover, the findings align with motivational theory, which posits that students with high levels of LI are more inclined to set academic goals, maintain persistence, and engage in self-regulation, factors that further contribute to positive LO [45]. This study's context within Islamic university adds a unique dimension, as Islamic university often emphasize intrinsic motivation and values-based learning, which can amplify LI and subsequently strengthen LO. However, while previous research consistently shows a positive correlation between LI and LO, some studies suggest that excessive interest without structured guidance may occasionally lead to superficial learning [46], as students might focus on more engaging content at the expense of broader curriculum requirements. This potential limitation, however, did not emerge in the findings, suggesting that LI, when strategically cultivated within structured pedagogical frameworks, continues to be a critical determinant of LO. Future studies could explore the nuanced dynamics between LI and LO across different educational settings, examining how various instructional methods may further enhance or moderate this relationship.

This study contributes both theoretical and practical implications to the fields of AI integration, TPC, and Islamic university. Theoretically, it emphasizes that modern AI, rich in features, necessitates TPC for enhancing both LI and LO. The unique contribution of this study lies in demonstrating that the synergy of AI and TPC can concurrently elevate LI and LO, a connection previously unexplored in Islamic university research. More specifically, this study empirically validates a pedagogically mediated intelligent system model, where AI effectiveness is structurally contingent upon human instructional competence. By demonstrating that AI impact is amplified through pedagogical alignment and mediated by LI, the findings extend beyond technology acceptance models and contribute to the design and evaluation of adaptive learning platforms and intelligent tutoring systems in higher education. Practically, this study provides actionable insights for educators and institutions, highlighting the need to prioritize competence-building over mere feature exploration. Furthermore, it advocates for improving digital infrastructure across educational institutions and expanding AI training channels for both teachers and students to strengthen knowledge transfer and pedagogical competence.

4. CONCLUSION

This study concludes that AI-supported learning systems significantly contribute to students' LI and LO in Islamic higher education when strategically aligned with strong TPC. The structural model indicates that AI does not operate as an autonomous instructional substitute; rather, its effectiveness depends on pedagogical integration and learner engagement, with LI functioning as the principal mediating mechanism through which AI system features translate into improved academic performance. TPC serves as a critical enabling factor that strengthens the instructional relevance of adaptive AI functionalities, reinforcing a human-centered intelligent learning framework that extends AI-in-education research beyond technology adoption perspectives toward system-level effectiveness in AI-enhanced learning ecosystems. These findings offer concrete implications for Islamic higher education stakeholders: institutions should establish sustained AI literacy programs within teacher professional development curricula, prioritize equitable investment in digital infrastructure, and advocate for national accreditation frameworks that embed

digital pedagogical competence as a measurable standard ensuring that AI adoption is culturally responsive, institutionally supported, and pedagogically coherent rather than ad hoc. However, this study is limited by its single-institution context, reliance on self-reported survey data, and the inclusion of only four primary constructs, which may restrict generalizability across broader Islamic higher education settings. Future research should expand institutional coverage across multiple Islamic universities, incorporate longitudinal or multi-source data, and integrate additional variables such as digital literacy, AI usage intensity, and instructional design quality to provide a more comprehensive understanding of how intelligent learning systems and pedagogical competence interact across diverse educational environments.

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C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this study, as no new data were generated or analyzed. However, the authors have provided the measurement instrument used in this research as supplementary material at <https://drive.google.com/drive/folders/1CMe5BWTD0AyclEJvAdc-MUeSigc8JBtW>.

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