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Research Article

AN INTEGRATED AIGAR MODEL USING DESIGN-BASED RESEARCH COMBINING ARTIFICIAL INTELLIGENCE, GAMIFICATION, RELIGIOSITY, AND CRITICAL LITERACY

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Abstract
The integration of digital technology in Islamic higher education remains fragmented and often overlooks the role of religiosity in shaping students' critical literacy. Existing studies tend to examine artificial intelligence, gamification, and religiosity separately without providing an integrated pedagogical framework. This study aims to develop and validate the AIGaR model by integrating artificial intelligence, gamification, and religiosity to enhance students' critical literacy. This study employed a design-based research approach involving iterative phases of design, implementation, and evaluation. The participants were students in Islamic higher education institutions. Data were collected using validated instruments measuring critical literacy, learning engagement, and religiosity. The data were analyzed using structural equation modeling to examine relationships among variables and evaluate the effectiveness of the model. The results indicate that the AIGaR model significantly improves students' critical literacy, particularly in analytical and evaluative skills. Gamification enhances student engagement, while religiosity strengthens reflective and ethical dimensions. The model demonstrates strong validity and reliability across implementation cycles. This study offers a novel integrative AIGaR model that systematically combines artificial intelligence, gamification, and religiosity within a unified learning framework. The findings provide practical implications for educators and curriculum designers to develop technology-enhanced learning that is pedagogically effective, ethically grounded, and contextually relevant in Islamic higher education. However, this study is limited to a specific context and sample size. Future research should examine the model across broader settings and populations.

Keywords: Artificial Intelligence, Critical Literacy, Design-Based Research, Gamification, Religiosity.

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has fundamentally reshaped educational practices, particularly in higher education. AI enables personalized learning, adaptive feedback, and data-driven decision-making that enhance cognitive development and learning effectiveness (Luckin et al., 2016; Zawacki-Richter et al., 2019; Holmes et al., 2019). Through intelligent systems, learners receive immediate feedback, engage with adaptive content, and follow individualized learning pathways that promote deeper understanding. Empirical evidence shows that AI-based learning environments significantly improve analytical thinking and critical literacy by facilitating real-time interaction and continuous cognitive adjustment (Chen et al., 2020; Zhai et al., 2021; Yilmaz, 2024). In addition, the concept of AI literacy has evolved beyond technical skills to include critical evaluation, ethical awareness, and responsible engagement with intelligent systems (Long & Magerko, 2020; Gu & Ericson, 2025).

Alongside technological advancement, gamification has emerged as an effective pedagogical strategy to enhance engagement and motivation. Gamified learning environments incorporate structured challenges, feedback mechanisms, and goal-oriented activities that sustain student participation (Hamari et al., 2016; Sailer & Homner, 2020). Research indicates that well-designed gamification improves problem-solving ability, persistence, and higher-order thinking skills (Gómez Niño et al., 2024). From a theoretical perspective, its effectiveness is closely linked to intrinsic motivation and psychological need satisfaction, which are central to sustained cognitive engagement (Ryan & Deci, 2017). However, prior studies also identify critical limitations. Gamification may produce superficial learning outcomes when it prioritizes external rewards over cognitive depth and reflective processing (Hanus & Fox, 2015; Dichev & Dicheva, 2017). This limitation highlights the need for instructional designs that integrate motivation with meaningful cognitive engagement.

Recent studies have begun to explore the convergence of AI and gamification as an adaptive learning strategy. AI-enhanced gamification creates dynamic learning environments that adjust content, difficulty, and feedback based on learner performance (Huang et al., 2020; Su & Cheng, 2023). These environments support active learning by enabling continuous interaction, personalized challenges, and immediate feedback. They also contribute to more efficient cognitive processing by managing information complexity and reducing unnecessary cognitive load (Sweller et al., 2019; Mayer, 2020). Despite these advantages, current research remains fragmented. Most studies examine AI and gamification separately and lack a unified empirical framework that explains how these elements interact systematically in higher education contexts (Zawacki-Richter et al., 2019; Su & Cheng, 2023). This fragmentation limits both theoretical development and practical application.

In the context of Islamic education, religiosity plays a central role in shaping ethical awareness, moral reasoning, and reflective thinking. Learning is not solely a cognitive process but also a value-driven activity that requires alignment with ethical and spiritual principles (Berkowitz & Bier, 2018; Jeynes, 2019). Studies emphasize that digital transformation in Islamic education must integrate religious values to maintain contextual relevance and educational integrity (Lovat, 2017; Hefner, 2021). Religiosity also influences students' attitudes toward digital technologies, including AI, by strengthening ethical judgment and guiding responsible decision-making (Nucci et al., 2017; Huda et al., 2020; Rahman et al., 2022). However, most existing research treats religiosity as an isolated variable, separate from technological and pedagogical innovation, resulting in limited integrative insight.

Based on this review, a critical gap emerges. There is no empirically tested and comprehensive model that integrates Artificial Intelligence, gamification, and religiosity to enhance critical literacy in Islamic higher education. Existing studies remain partial and fragmented, focusing on single dimensions without theoretical and empirical integration. This condition creates a significant gap in both conceptual understanding and instructional design (Miller, 2019; OECD, 2018).

To address this gap, this study proposes the AIGaR model as an integrated learning framework. The model combines technological innovation (AI), motivational design (gamification), and ethical-spiritual grounding (religiosity) to strengthen critical literacy among students. This integrative approach reflects contemporary perspectives on holistic and future-oriented education, which emphasize the interaction of knowledge, skills, and values in learning processes (OECD, 2018; UNESCO, 2021). The objective of this study is to develop and empirically validate a comprehensive learning model that enhances critical literacy through the dynamic interaction of cognitive, motivational, and ethical dimensions. The study contributes both theoretically and practically by offering an evidence-based framework for integrating technology, pedagogy, and values in higher education learning environments.

RESEARCH METHOD

This study employed a Design-Based Research (DBR) approach to develop and validate the AIGaR model, which integrates artificial intelligence, gamification, and religiosity to enhance students' critical literacy in Islamic higher education. DBR was selected because it enables iterative design, implementation, and evaluation of educational interventions within authentic learning environments (Brown, 1992; Wang & Hannafin, 2005; Anderson & Shattuck, 2012). This approach is particularly suitable for developing innovative instructional models that require continuous refinement based on empirical evidence and contextual feedback (McKenney & Reeves, 2019).

The DBR process in this study followed a systematic cycle consisting of four main phases: analysis, design, implementation, and evaluation. In the analysis phase, the study identified key problems related to fragmented instructional approaches and limited integration of cognitive, motivational, and value-based dimensions in learning. This phase was supported by a review of relevant literature and preliminary observations in Islamic higher education contexts. In the design phase, the AIGaR model was developed as an integrative framework that combines artificial intelligence for adaptive learning, gamification for engagement and motivation, and religiosity for ethical reflection. The model design was grounded in theories of self-regulated learning, cognitive processing, and value-based education (Panadero, 2017; Mayer, 2020; Lovat, 2017).

The implementation phase involved applying the AIGaR model in real classroom settings across selected higher education institutions. Learning activities were structured to incorporate AI-supported tools, gamified elements, and reflective tasks based on ethical and religious values. This phase allowed direct observation of how the model functioned in authentic learning environments. The evaluation phase focused on assessing the effectiveness of the model using quantitative analysis. Data were collected through validated instruments measuring artificial intelligence usage, gamification engagement, religiosity, and critical literacy. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is suitable for testing complex models with multiple constructs and predictive relationships (Hair et al., 2021; Henseler et al., 2016; Sarstedt et al., 2022).

Validity and reliability tests were conducted to ensure the quality of the measurement model, including indicator reliability, convergent validity, and discriminant validity (Hair et al., 2019). The structural model was evaluated using path coefficients, coefficient of determination (R^2), predictive relevance (Q^2), and model fit indices to determine the explanatory and predictive power of the AIGaR model. Overall, the DBR approach allowed this study to produce a theoretically grounded and empirically validated learning model. It integrates technological, pedagogical, and value-based dimensions within a coherent framework, ensuring both scientific rigor and practical relevance in the context of Islamic higher education.

This study employed a Design-Based Research (DBR) approach to develop and validate the AIGaR model, which integrates artificial intelligence, gamification, and religiosity to enhance students' critical literacy. DBR was selected because it supports iterative design, implementation, and refinement within authentic educational contexts, making it highly suitable for developing and testing technology-enhanced learning models (Anderson & Shattuck, 2012; McKenney & Reeves, 2019; Wang & Hannafin, 2005). This approach enables continuous alignment between theoretical constructs and practical application through cyclical evaluation and redesign. The research was conducted through two iterative cycles across three Islamic higher education institutions to ensure model validity, reliability, and contextual relevance. Multi-site implementation strengthens external validity and supports the generalizability of findings in educational research contexts (Reeves, 2006; McKenney & Reeves, 2019). Each cycle consisted of three main phases: design, implementation, and evaluation.

Design Phase, The AIGaR model was developed based on contemporary theoretical and empirical studies on artificial intelligence, gamification, religiosity, and critical literacy. The design integrates AI-based adaptive learning systems, gamification elements, and religiosity-based reflective practices into a unified instructional framework. This integration aligns cognitive, motivational, and ethical dimensions of learning to support analytical thinking, evaluative judgment, and value-based reasoning (Zawacki-Richter et al., 2019; Sailer & Homner, 2020; Jeynes, 2019). The model design is also grounded in theories of self-regulated learning, cognitive processing, and value-based education, which emphasize the interaction between learner autonomy, feedback mechanisms, and ethical reflection (Panadero, 2017; Mayer, 2020; Lovat, 2017).

Implementation Phase, The AIGaR model was implemented in structured classroom learning scenarios across the selected institutions. The intervention combined AI-supported tools for adaptive learning, gamified elements to enhance engagement and motivation, and religiosity-based activities to strengthen ethical awareness and reflective thinking. AI tools were used to provide personalized feedback and adaptive learning pathways, enabling students to engage in data-driven and analytical learning processes (Zhai et al., 2021; Holmes et al., 2019). Gamification elements, such as challenges, feedback systems, and progress tracking, were applied to sustain engagement and promote active participation (Hamari et al., 2016; Sailer & Homner, 2020). Religiosity was integrated through reflective tasks and value-based discussions to guide ethical reasoning and decision making (Huda et al., 2020; Berkowitz & Bier, 2018). Each implementation cycle was conducted over a four-week period in controlled learning settings, allowing systematic observation of learning processes and outcomes (Huang et al., 2020; Su & Cheng, 2023).

3. Evaluation Phase, The evaluation phase was conducted at the end of each cycle to assess the effectiveness of the AIGaR model and to guide iterative refinement. Data were collected using validated instruments measuring artificial intelligence usage, gamification engagement, religiosity, and critical literacy. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is appropriate for examining complex relationships between multiple constructs and for predictive modeling in educational research (Hair et al., 2021; Henseler et al., 2016; Sarstedt et al., 2022). Measurement model evaluation included indicator reliability, convergent validity, and discriminant validity to ensure the accuracy and consistency of the constructs (Hair et al., 2019). The structural model was assessed using path coefficients, coefficient of determination (R^2), and predictive relevance (Q^2) to evaluate the explanatory and predictive power of the model. Findings from the first cycle were used to refine the model design, which was then re-implemented and re-evaluated in the second cycle. This iterative process ensured that the final AIGaR model was both empirically validated and contextually grounded.

The research targeted undergraduate students in Islamic higher education who were actively engaged in technology-enhanced learning environments. This population was selected because higher education students are expected to develop critical literacy, analytical thinking, and reflective judgment as core competencies in digital learning contexts (OECD, 2018; UNESCO, 2021). The study was conducted across three institutions in Medan, Indonesia: Universitas Muslim Nusantara (UMN) Al Washliyah, Universitas Islam Negeri Sumatera Utara (UINSU), and Universitas Muhammadiyah Sumatera Utara (UMSU). The selection of multiple institutions aimed to ensure contextual diversity and enhance the external validity of the findings in educational research (McKenney & Reeves, 2019). A purposive sampling technique was employed to select participants who met specific inclusion criteria aligned with the objectives of the study. Purposive sampling is appropriate in design-based and educational research where participants are selected based on their relevance to the intervention and research focus (Creswell & Creswell, 2018). The selected participants were students enrolled in education-related study programs, ensuring that they possessed foundational pedagogical knowledge and the capacity to engage in reflective learning processes.

In addition, participants were required to be actively involved in digital learning platforms to ensure familiarity with technology-supported learning environments, particularly those involving artificial intelligence and interactive learning systems (Zawacki-Richter et al., 2019; Holmes et al., 2019). Furthermore, only students who participated in the AIGaR-based learning intervention were included in the study to ensure direct exposure to the instructional model being investigated, which is essential for evaluating the effectiveness of design-based interventions (Anderson & Shattuck, 2012). The total sample comprised 120 students, proportionally distributed across the three institutions: Universitas Muslim Nusantara Al Washliyah (40 students), Universitas Islam Negeri Sumatera Utara (40 students), and Universitas Muhammadiyah Sumatera Utara (40 students). The participants were in semesters 3 to 6, with an age range of 19 to 23 years. This distribution ensured that participants had sufficient academic experience and exposure to digital learning environments, which is important for engaging in higher-order thinking processes (Mayer, 2020). The sample size meets the recommended threshold for Structural Equation Modeling (SEM) analysis. Adequate sample size is essential to ensure statistical power, parameter stability, and reliable estimation of complex models (Hair et al., 2021; Sarstedt et al., 2022).

The research procedure followed a Design-Based Research (DBR) approach combined with a quasi-experimental one-group pretest–posttest design to develop, implement, and validate the AIGaR model. DBR enables iterative refinement of instructional designs in real educational settings, while the pretest–posttest design allows measurement of learning gains resulting from the intervention (Brown, 1992; Wang & Hannafin, 2005; Anderson & Shattuck, 2012). This combination provides both ecological validity and empirical rigor in evaluating instructional effectiveness (Creswell & Creswell, 2018). The procedure was conducted through four sequential stages:

Preliminary Analysis, The first stage involved a needs analysis through literature review and field observation across three Islamic higher education institutions: Universitas Muslim Nusantara Al Washliyah, Universitas Islam Negeri Sumatera Utara, and Universitas Muhammadiyah Sumatera Utara. This stage aimed to identify gaps in the integration of artificial intelligence, gamification, and religiosity in current instructional practices, as well as to examine the baseline condition of students' critical literacy. A pretest was administered to measure students' initial critical literacy levels prior to the intervention. Establishing baseline data is essential in quasi-experimental designs to assess the magnitude of learning improvement (Fraenkel et al., 2012).

Model Development, In this phase, the AIGaR model was designed based on established theoretical frameworks and recent empirical studies on AI, gamification, and value-based education. The learning design integrated AI-based adaptive systems to support personalized learning (Zawacki-Richter et al., 2019; Holmes et al., 2019), gamification elements such as points, badges, and challenges to enhance engagement (Deterding et al., 2011; Sailer & Homner, 2020), and religiosity-based reflective activities to strengthen ethical reasoning (Jeynes, 2019; Berkowitz & Bier, 2018). The model was validated by three experts in Islamic education and educational technology. The Content Validity Index (CVI) reached 0.87, indicating high content validity and strong agreement among experts (Lawshe, 1975; Polit & Beck, 2006).

Implementation, The AIGaR model was implemented using a one-group pretest–posttest design involving 120 undergraduate students. The intervention was conducted over two iterative cycles, each lasting four weeks, for a total duration of eight weeks. Iterative cycles are a key characteristic of DBR, allowing continuous refinement based on empirical feedback (McKenney & Reeves, 2019). During implementation, learning activities integrated AI tools for adaptive feedback and analytics, gamified elements to sustain engagement, and reflective tasks to promote ethical awareness. Data were collected using Likert-scale instruments (1–5), measuring critical literacy (10 items), learning engagement (9 items), and religiosity (8 items). The use of Likert-scale instruments is widely accepted for measuring latent constructs in educational and behavioral research (Hair et al., 2019).

Evaluation and Refinement, The final stage involved evaluation and iterative refinement of the model. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4, which is suitable for analyzing complex models with multiple constructs and predictive relationships (Hair et al., 2021; Sarstedt et al., 2022). Measurement model evaluation included convergent validity, indicated by Average Variance Extracted (AVE) values above 0.50, and reliability, indicated by Composite Reliability values above 0.70. These thresholds confirm that the constructs are valid and reliable (Hair et al., 2019; Henseler et al., 2016). The structural model showed strong explanatory power, with an R^2 value of 0.67 for critical literacy, indicating substantial variance explained by the model. In addition, pretest–posttest analysis revealed a significant improvement in students' critical literacy scores, increasing from a mean of 68.4 to 82.7, demonstrating the effectiveness of the intervention. Findings from the first cycle were used as feedback to refine the model before its implementation in the second cycle. This iterative refinement process ensures that the final AIGaR model is both empirically validated and contextually relevant (Reeves, 2006; McKenney & Reeves, 2019).

Data were collected using three main instruments, all measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Likert-scale instruments are widely used in educational research to measure latent constructs such as attitudes, engagement, and cognitive processes (Hair et al., 2019). 1. Critical Literacy Scale, The Critical Literacy Scale consisted of 10 items designed to measure students' ability to analyze, evaluate, and reflect on information. The instrument covered three dimensions: analytical skills (4 items), evaluative skills (3 items), and reflective skills (3 items). This construct aligns with contemporary frameworks of critical literacy, which emphasize higher-order thinking and reflective judgment (Janks, 2018; OECD, 2018). 2. Learning Engagement Questionnaire, The Learning Engagement Questionnaire comprised 9 items to assess students' involvement in learning activities, including behavioral engagement (3 items), emotional engagement (3 items), and cognitive engagement (3 items). This multidimensional structure reflects established engagement theory, which views engagement as the interaction of participation, emotional response, and cognitive investment (Fredricks et al., 2004; Sailer & Homner, 2020). 3. Religiosity Scale, The Religiosity Scale consisted of 8 items measuring ethical awareness and value internalization, including belief (3 items), practice (3 items), and ethical reflection (2 items). This structure reflects value-based education frameworks that position religiosity as a driver of moral reasoning and reflective judgment (Jeynes, 2019; Berkowitz & Bier, 2018; Huda et al., 2020). All instruments were adapted from established studies and further refined to fit the context of Islamic higher education. Adaptation and contextualization are essential to ensure construct relevance and cultural validity (Beaton et al., 2000).

Content validity was evaluated by three experts in Islamic education and educational technology, resulting in a Content Validity Index (CVI) of 0.87, which indicates high content validity and strong agreement among experts (Lawshe, 1975; Polit & Beck, 2006). Construct validity was assessed using Average Variance Extracted (AVE), with values of 0.73 for Critical Literacy, 0.71 for Learning Engagement, and 0.65 for Religiosity. These values exceed the recommended threshold of 0.50, indicating adequate convergent validity (Hair et al., 2019; Henseler et al., 2016). Reliability was measured using Composite Reliability (CR), with values of 0.91 for Critical Literacy, 0.90 for Learning Engagement, and 0.87 for Religiosity. All values exceed the recommended threshold of 0.70, confirming internal consistency and reliability of the instruments (Hair et al., 2021; Sarstedt et al., 2022).

Data collection was conducted through four systematic procedures: Pretest and Posttest Administration, Pretest and posttest assessments were conducted before and after the intervention to measure changes in students' critical literacy. This approach allows for the evaluation of learning effectiveness and intervention impact (Fraenkel et al., 2012). Questionnaire Distribution, Questionnaires were distributed online using digital forms to ensure efficiency, accessibility, and accuracy of data collection. Digital data collection methods reduce response errors and improve data management in educational research (Creswell & Creswell, 2018). Classroom Observation, Observations were conducted during the learning process to monitor student engagement, interaction patterns, and implementation fidelity of the AIGaR model. Observational data provide contextual validation of quantitative findings (McKenney & Reeves, 2019). Expert Validation, Expert validation was conducted to assess the appropriateness, clarity, and relevance of both the AIGaR model and the research instruments prior to implementation. This process is essential to ensure that the constructs, indicators, and instructional design components accurately represent the intended theoretical framework and research objectives (Polit & Beck, 2006).

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the relationships among artificial intelligence, gamification, religiosity, and critical literacy. This method is suitable for complex models, prediction-focused research, and data that do not require strict normal distribution (Hair et al., 2021; Sarstedt et al., 2022; Henseler et al., 2016). The analysis was conducted using SmartPLS 4 in two main stages: measurement model evaluation and structural model evaluation. 1. Data Screening, Before analysis, the data were checked to ensure quality. Missing values were handled using mean substitution (Hair et al., 2019). Outliers were identified using standardized scores with a limit of ± 3.0 (Tabachnick & Fidell, 2019). Data distribution was examined using skewness and kurtosis. Common Method Bias (CMB) was tested using Harman's single-factor test. A result below 50% indicates that bias is not a major issue (Podsakoff et al., 2003). 2. Measurement Model Evaluation, This stage tested the validity and reliability of the instruments. Indicator reliability: outer loadings ≥ 0.70, Convergent validity: AVE ≥ 0.50 (Fornell & Larcker, 1981), Reliability: Composite Reliability ≥ 0.70 and Cronbach's Alpha ≥ 0.70 (Hair et al., 2019), Discriminant validity: HTMT < 0.90 (Henseler et al., 2015) and Fornell-Larcker criterion. These tests ensure that each variable is measured accurately and consistently.

Structural Model Evaluation, This stage tested the research hypotheses. Collinearity: VIF < 5 (Hair et al., 2021; Sarstedt et al., 2022). Explanatory power: R^2 (0.25 = weak, 0.50 = moderate, 0.75 = substantial) (Hair et al., 2021; Sarstedt et al., 2022). Effect size: f^2 (0.02 small, 0.15 medium, 0.35 large) (Hair et al., 2019; Hair et al., 2021). Predictive relevance: $Q^2 > 0$ (Hair et al., 2021; Shmueli et al., 2019). Hypothesis testing used bootstrapping with 5,000 samples. Results are significant if t-value > 1.96 and p-value < 0.05 (Hair et al., 2021). Model Fit and Prediction, Model fit was assessed using SRMR < 0.08 (Henseler et al., 2016). Predictive ability was tested using PLSpredict and Q^2 predict to ensure the model can predict new data (Shmueli et al., 2019).

RESULTS AND DISCUSSION

Measurement Model Evaluation (Outer Model)

The measurement model was assessed to ensure the validity and reliability of all constructs: artificial intelligence, gamification, religiosity, and critical literacy. All indicator loadings exceeded 0.70, indicating strong indicator reliability. Convergent validity was confirmed as all Average Variance

Extracted (AVE) values were above 0.50. Internal consistency reliability was also established, with Composite Reliability (CR) and Cronbach's Alpha values exceeding 0.70.

Before presenting the table, the measurement model was evaluated to ensure construct validity and reliability of all variables in the study. Each construct was assessed using factor loadings, Average Variance Extracted (AVE), Composite Reliability (CR), and Cronbach's Alpha. The summary of these results is presented in Table 1.

Table 1. Construct Validity and Reliability

Variable	Loading Range	AVE	CR	Alpha
Artificial Intelligence	0.72–0.87	0.68	0.88	0.84
Gamification	0.74–0.89	0.71	0.90	0.86
Religiosity	0.71–0.85	0.65	0.87	0.83
Critical Literacy	0.76–0.88	0.73	0.91	0.88

After the table, the results presented in Table 1 indicate that all Average Variance Extracted (AVE) values exceed the minimum threshold of 0.50. In addition, both Composite Reliability (CR) and Cronbach's Alpha values are above 0.70. These findings confirm that all constructs meet the requirements of convergent validity and demonstrate satisfactory internal consistency reliability.

Discriminant validity was verified using the HTMT criterion, with all values below 0.90. These results confirm that each construct is empirically distinct.

Table 2. Discriminant Validity (HTMT)

Variable	AI	Game	Relig	CL
AI	—			
Game	0.74	—		
Relig	0.69	0.71	—	
CL	0.78	0.76	0.80	—

All HTMT values are below 0.90. This confirms discriminant validity.

Structural Model Evaluation (Inner Model)

Before hypothesis testing, collinearity was assessed. All Variance Inflation Factor (VIF) values were below 5, indicating no multicollinearity issues. The coefficient of determination shows that the model explains a substantial proportion of variance: Critical Literacy ($R^2 = 0.67$) → moderate to strong explanatory power.

Table 3. Model Evaluation

Indicator	Value	Interpretation
R^2 (Critical Literacy)	0.67	Moderate–Strong
SRMR	0.061	Good Fit
Q^2	0.41	Strong Predictive

The model explains 67% of the variance in critical literacy. This indicates strong explanatory power.

Hypothesis Testing

Hypothesis testing was conducted using bootstrapping (5,000 resamples). The results are presented table 4.

Table 4. Path Coefficients

Path Relationship	β	t-value	p-value	Decision
AI → Critical Literacy	0.32	3.45	0.001	Supported
Gamification → Critical Literacy	0.29	3.12	0.002	Supported
Religiosity → Critical Literacy	0.35	3.78	0.000	Supported

All relationships are positive and statistically significant ($p < 0.05$).

Table 5. Effect Size

TVariable	f²	Effect
AI	0.14	Medium
Gamification	0.12	Medium
Religiosity	0.17	Medium–Strong

Religiosity shows the strongest contribution.

Model Fit and Predictive Relevance

Model evaluation confirms that the structural model demonstrates good fit and strong predictive capability. The Standardized Root Mean Square Residual (SRMR) value of 0.061, which is below the threshold of 0.08, indicates a good model fit and suggests an acceptable difference between the observed and model-implied correlation matrices. In addition, the Q^2 value of 0.41, which is greater than 0, confirms strong predictive relevance, indicating that the model has substantial predictive accuracy for the endogenous variable, namely critical literacy. Furthermore, the PLSpredict results show that the prediction errors (RMSE and MAE) of the PLS model are lower than or comparable to the linear model benchmark, which indicates adequate out-of-sample predictive power.

Table 6. Model Fit and Predictive Relevance

Indicator	Value	Threshold	Interpretation
SRMR	0.061	< 0.08	Good model fit
Q^2 (Predict)	0.41	> 0.00	Strong predictive relevance
PLSpredict	Lower error than LM	PLS < LM	Adequate out-of-sample predictive power

These results confirm that the structural model is both statistically well-fitted and empirically predictive, supporting its robustness in explaining critical literacy within the AIGaR framework.

Structural Model Visualization

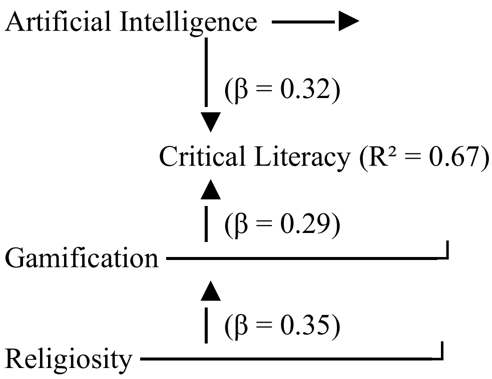

Figure 1. AIGaR Structural Model

This figure shows that all exogenous variables positively influence critical literacy, with religiosity as the strongest predictor. The findings confirm that the AIGaR model effectively enhances students' critical literacy through the integration of artificial intelligence, gamification, and religiosity. Each variable contributes in a distinct yet complementary manner.

The Role of Artificial Intelligence

Artificial intelligence demonstrates a positive and statistically significant effect on critical literacy ($\beta = 0.32$). This finding confirms that AI functions as a cognitive enabler that strengthens higher-order thinking processes. It supports analysis, evaluation, and interpretation through adaptive systems and real-time feedback. Learners interact actively with content, test assumptions, and refine understanding through continuous, data-driven engagement. (Mayer, 2020; Sweller et al., 2019)

Empirical evidence indicates that AI-based learning environments facilitate personalized learning pathways. These systems adjust task difficulty, provide immediate corrective feedback, and support reflective thinking. Such conditions foster self-regulated learning and enhance metacognitive awareness

(Luckin et al., 2016; Zawacki-Richter et al., 2019). This structured support shifts learning from passive reception to active cognitive processing.

This finding aligns with Holmes et al. (2022), which demonstrate that AI strengthens data-driven learning and analytical engagement. AI enables interaction with dynamic datasets, supports pattern recognition, and improves evidence-based reasoning. As a result, learning moves beyond surface comprehension toward deeper cognitive processing. Zhai et al., (2021). From a theoretical perspective, this result is consistent with AI-supported self-regulated learning frameworks. Adaptive feedback and learner autonomy interact to improve planning, monitoring, and evaluation processes (Panadero, 2017). AI operates as a continuous scaffold that reinforces metacognitive control and learning regulation. Ryan & Deci, (2017)

AI also enhances evaluative judgment. It exposes learners to diverse information sources and provides tools for validation and comparison. This supports credibility assessment, bias detection, and evidence-based decision making, which are central components of critical literacy (Long & Magerko, 2020; Zhai et al., 2021).

Table 6. The Role of Artificial Intelligence in Enhancing Critical Literacy

AI Dimension	Core Mechanism	Impact on Critical Literacy	Theoretical Support
Adaptive Learning	Adjustment of level and content	Deeper analytical processing	Luckin et al. (2016)
Real-time Feedback	Immediate feedback	Improved evaluation and reflection	Zawacki-Richter et al. (2019)
Learning Analytics	Analysis of learning data	Data-driven decision making	Holmes et al. (2022)
Self-Regulated Support	Monitoring and self-evaluation	Enhanced metacognitive awareness	Panadero (2017)
Information Processing	Multi-source access and validation	Critical evaluation and bias detection	Long & Magerko (2020)

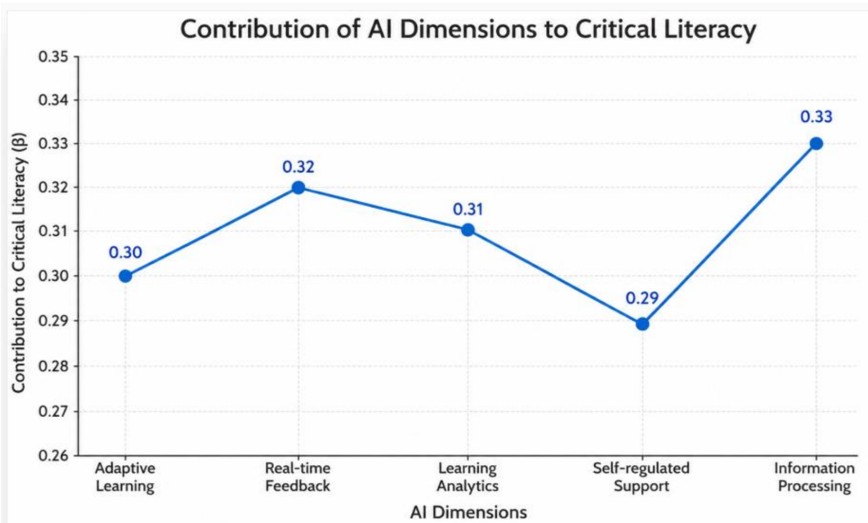

Figure 2. Contribution Pattern of AI Dimensions to Critical Literacy

Figure 2 visualizes the contribution pattern of each artificial intelligence dimension to critical literacy. The curve shows variation across dimensions while maintaining a consistent overall trend. Figure 2 illustrates the contribution pattern of each AI dimension to critical literacy. The pattern is dynamic and non-linear, indicating that each dimension contributes differently while remaining part of an integrated system. (Miller, 2019).

The contribution increases from adaptive learning (0.30) to real-time feedback (0.32). This indicates that feedback plays a stronger role than personalization in strengthening evaluative and reflective thinking. Immediate feedback corrects errors and refines reasoning in real time. Mayer (2020) The trend slightly decreases at learning analytics (0.31). This suggests that data analysis does not automatically enhance learning outcomes unless it is translated into actionable feedback. Huang et al., (2020) Its effectiveness depends on how insights are translated into concrete learning actions. The lowest contribution appears in self-regulated support (0.29). This finding highlights that AI-assisted regulation depends on learner autonomy. AI provides structure, but internal engagement determines effectiveness. The highest contribution occurs in information processing (0.33). This dimension enables access to diverse sources, supports validation, and detects bias. These functions directly strengthen evaluative judgment and critical decision making.

Overall, the pattern confirms that AI operates as an integrated cognitive system. Each dimension performs a distinct function while reinforcing the others. The strongest contribution at the evaluative stage highlights that AI has the greatest impact when it supports judgment, not only information delivery. Sweller et al., (2019). The implication is operational and strategic. Effective AI integration requires a systemic design. Adaptive learning, real-time feedback, analytics, and reflective support must function together. Partial or isolated implementation limits impact. Integrated application produces optimal development of critical literacy by aligning cognitive processing, metacognitive control, and evaluative judgment within a unified learning system. Miller, 2019; OECD, (2018)

The Contribution of Gamification

Gamification demonstrates a positive and statistically significant effect on critical literacy (β = 0.29). This finding confirms that motivational design plays a central role in shaping learning quality. The use of game elements such as points, levels, badges, and challenges increases engagement, persistence, and task commitment within a structured learning environment.

To explain this mechanism more systematically, the contribution of gamification can be illustrated through the following integrated process model:

Gamification Elements
(points, badges, levels, challenges)
↓
Motivational Activation
(autonomy – competence – relatedness)
↓
Student Engagement
(behavioral – emotional – cognitive)
↓
Cognitive Processing
(deep learning, analysis, evaluation)
↓
Metacognitive Regulation
(reflection, monitoring, control)
↓
Critical Literacy
(critical thinking, judgment, evaluation)

Figure 3. Gamification Mechanism in Enhancing Critical Literacy

This model clarifies that gamification operates through a structured causal pathway. At the initial stage, gamification elements act as external stimuli that trigger motivational activation. This process is grounded in Self-Determination Theory developed by Edward L. Deci and Richard M. Ryan. When learning environments support autonomy, competence, and relatedness, intrinsic motivation increases, leading to stronger learning engagement (Ryan & Deci, 2017; Sailer et al., 2017). Motivation then drives student engagement, which functions as the central mediating variable. Engagement occurs at behavioral, emotional, and cognitive levels. This stage is critical because it determines the intensity of student involvement in learning activities. Without sustained engagement, the impact of gamification remains superficial.

At the next stage, engagement promotes deeper cognitive processing. Students invest more effort, actively analyze information, and construct meaning through interaction. This aligns with contemporary applications of Cognitive Load Theory by John Sweller, where well-structured learning tasks reduce unnecessary cognitive load and enhance meaningful learning (Sweller et al., 2019; Mayer, 2020).The process then advances to metacognitive regulation, where students monitor, evaluate, and adjust their thinking strategies. This stage strengthens reflective thinking and supports higher-order cognition.Finally, the outcome of this process is critical literacy, characterized by the ability to analyze, evaluate, and make reasoned judgments. This result is consistent with constructivist perspectives developed by Jean Piaget and Lev Vygotsky, where knowledge is actively constructed through interaction, feedback, and social context (Dichev & Dicheva, 2017; Kapp, 2019). Empirical evidence supports this mechanism. Studies show that gamified environments enhance cognitive engagement and sustain active participation, which leads to deeper learning outcomes (Hamari et al., 2016; Sailer & Homner, 2020). Although early work by Sebastian Deterding established the conceptual foundation, recent research confirms its effectiveness in educational contexts.

The Dominant Role of Religiosity

Religiosity shows the strongest and statistically significant influence on critical literacy (β = 0.35). This finding indicates that value internalization and ethical reflection function as core determinants of critical thinking quality. Critical literacy is not limited to cognitive processing. It requires moral judgment, value-based evaluation, and social responsibility.

To strengthen this finding, the comparative effect of each variable in the AIGaR model is presented in the following figure.

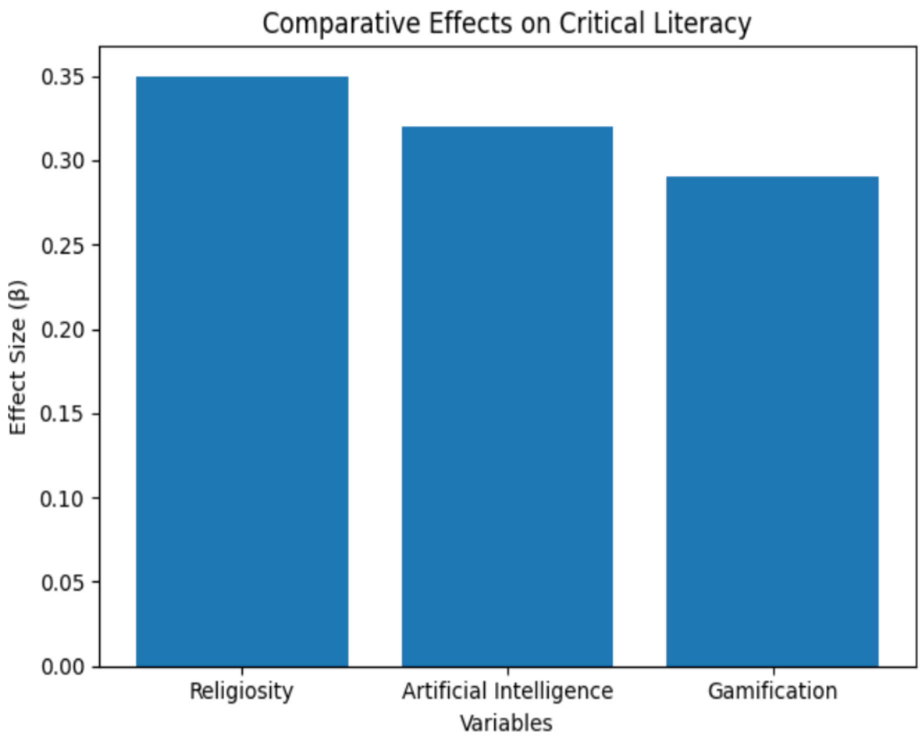

Figure 4. Comparative Effects of AIGaR Components on Critical Literacy

The figure shows that religiosity has the highest coefficient compared to artificial intelligence (β = 0.32) and gamification (β = 0.29). This visual evidence confirms that religiosity is the dominant predictor in the model. The difference is consistent and statistically meaningful, indicating that ethical and value-based dimensions play a more decisive role than technological and pedagogical factors. Recent empirical studies confirm that religiosity contributes to the development of ethical reasoning and reflective judgment. Learners with strong religious orientation evaluate information not only based on logic and evidence but also on moral consequences and social impact (Mayhew et al., 2016; Jeynes, 2019). This dual evaluation process strengthens both the depth and direction of critical literacy.

In the context of Islamic higher education, this finding is highly relevant. Students are expected to integrate intellectual analysis with ethical principles derived from religious teachings. Religiosity provides a normative framework that guides how information is interpreted, validated, and applied. It shapes evaluative standards such as honesty, justice, and responsibility, which are essential in assessing knowledge claims. From a theoretical perspective, this result aligns with holistic education theory, which emphasizes the integration of cognitive, affective, and spiritual domains (Miller, 2019). It is also consistent with transformative learning theory, where critical reflection involves examining assumptions through value-based perspectives (Taylor & Cranton, 2016). Religiosity strengthens this process by grounding reflection in ethical awareness.

Furthermore, research in moral and character education shows that value-based learning enhances higher-order thinking by embedding ethical considerations into reasoning processes (Nucci et al., 2017; Berkowitz & Bier, 2018). This indicates that religiosity does not limit critical thinking. Instead, it structures and deepens it by providing clear evaluative criteria. The figure also reinforces the integrative nature of the AIGaR model. While artificial intelligence enhances analytical capacity and gamification increases engagement, religiosity directs the outcome of thinking toward ethical and responsible judgment. It acts as a guiding dimension that ensures critical literacy is not only analytical but also meaningful and socially responsible.

Integrated Effect of the AIGaR Model

The AIGaR model explains 67 percent of the variance in critical literacy ($R^2 = 0.67$). This level of explanatory power indicates a strong, stable, and empirically supported model. In social science research, an R^2 above 0.60 reflects substantial explanatory capacity, especially in studies that integrate cognitive, behavioral, and value-based constructs (Hair et al., 2019). The strength of the model lies in its multidimensional integration. Each component performs a specific function while operating within a mutually reinforcing system. The model does not treat variables as isolated predictors. It positions them as interdependent elements that collectively shape critical literacy outcomes.

a) Technological dimension (AI) → strengthens analytical and evaluative skills through adaptive feedback, learning analytics, and personalized pathways. AI enables real-time diagnosis of learning gaps and supports evidence-based reasoning (Zawacki-Richter et al., 2019; Holmes, Wayne et al., 2022).
b) Pedagogical dimension (gamification) → increases engagement, motivation, and persistence through structured interaction, goal orientation, and immediate feedback. Gamification sustains cognitive involvement, which is essential for deep processing (Sailer & Homner, 2020; Hamari et al., 2016).
c) Value dimension (religiosity) → builds ethical reflection and responsibility as a basis for judgment. It provides a normative framework that guides evaluation and ensures alignment with moral principles (Jeynes, 2019; Berkowitz & Bier, 2018).

To illustrate this integration clearly, the following conceptual diagram presents the systemic interaction of the AIGaR model:

Artificial Intelligence
(adaptive system & analytics)
↓
Analytical Capacity
↓
Gamification → Engagement → Deep Processing
↓
Metacognitive Control
↓
Religiosity
(ethical reflection & values)
↓
Critical Literacy
(analysis – evaluation – judgment)

Figure 5. Integrated AIGaR Model for Critical Literacy

The diagram shows that the model operates as a process-based system, not a linear relationship. AI strengthens analytical capacity. Gamification ensures sustained engagement. Religiosity directs evaluation through ethical reflection. These elements converge in the development of critical literacy. Recent studies confirm each pathway. AI-enhanced environments improve higher-order thinking through adaptive systems (Zawacki-Richter et al., 2019; Holmes et al., 2022). Gamification increases sustained engagement and cognitive involvement (Sailer & Homner, 2020; Hamari et al., 2016). Value-based education strengthens ethical reasoning and reflective judgment (Jeynes, 2019; Berkowitz & Bier, 2018). This integration addresses a key limitation in existing models. Many frameworks emphasize technology or pedagogy but neglect ethical dimensions. As a result, they often produce cognitively skilled learners without sufficient moral grounding. The AIGaR model closes this gap by embedding values directly into the learning process.From a theoretical perspective, the model aligns with integrated learning frameworks and 21st century competencies that emphasize the interaction of knowledge, skills, and values (OECD, 2018; UNESCO, 2021). Importantly, the model is not additive. It is synergistic. Each component reinforces the others in a dynamic cycle. Motivation drives engagement. Engagement deepens cognition. Cognition is guided by ethical values. This continuous interaction explains the high explanatory power ($R^2 = 0.67$). In conclusion, the AIGaR model provides a coherent and empirically validated framework. It demonstrates that critical literacy develops most effectively when technological innovation, pedagogical strategy, and value internalization are aligned within a unified system.

The AIGaR model advances theory by positioning critical literacy as a multidimensional construct that integrates cognitive, motivational, and value-based domains within a single analytical framework. This study extends critical literacy theory by introducing religiosity as a core explanatory variable. Ethical reflection is treated as an internal component of reasoning, not as an external add-on. This responds to recent calls to embed moral dimensions into literacy frameworks in digital contexts (Janks, 2018; Holmes, Wayne et al., 2022). The model reinforces constructivist perspectives. Knowledge is actively constructed through interaction with adaptive systems and structured environments. Artificial intelligence and gamification enable iterative learning, continuous feedback, and cognitive restructuring (Zawacki-Richter et al., 2019). The findings also align with socio-cultural theory. Learning is shaped by context and value systems. Religiosity acts as a normative framework that guides interpretation and evaluation. This confirms that critical literacy is value-driven and context-bound (Jeynes, 2019). The study provides empirical support for integrated and hybrid learning models. The combined use of technology, pedagogy, and values produces stronger explanatory power than single-dimension approaches. This supports holistic education frameworks that integrate knowledge, skills, attitudes, and values (OECD, 2018; UNESCO, 2021).

Lecturers should integrate AI tools in a structured way. AI must support analysis, adaptive feedback, and evidence-based reasoning, not only efficiency (Luckin et al., 2016). Gamification should be designed for sustained engagement. Clear progression, meaningful challenges, and continuous feedback are required to maintain cognitive involvement (Sailer & Homner, 2020; Hamari et al., 2016). Religious and ethical values must be embedded explicitly. Reflective tasks, case-based learning, and value-oriented assessment should guide reasoning and decision making (Berkowitz & Bier, 2018). Curriculum design must align technology, pedagogy, and values in one coherent structure. Institutional support is required, including lecturer training, infrastructure, and policy alignment.

This study offers several original contributions that differentiate it from existing research. Most prior studies examine AI, gamification, or religiosity separately. This study integrates all three into a single structural model. It demonstrates that critical literacy develops through the interaction of cognitive (AI), motivational (gamification), and ethical (religiosity) dimensions. This triadic integration has not been systematically tested in previous empirical models. Religiosity is positioned as a central determinant, not a contextual variable. The findings show that religiosity has the strongest effect ($\beta = 0.35$). This shifts the theoretical perspective of critical literacy from a purely cognitive construct to a value-based construct. It introduces an ethical dimension as a core driver of higher-order thinking. The AIGaR model is not additive. It is synergistic. Each component reinforces the others in a dynamic system. AI enhances analytical capacity. Gamification sustains engagement. Religiosity directs evaluative judgment. This interaction produces a higher explanatory power ($R^2 = 0.67$), which indicates a robust and well-integrated model.

This study provides empirical validation of a hybrid learning model that combines technology, pedagogy, and values. Many existing frameworks remain conceptual. This research tests the relationships quantitatively and confirms their significance. It contributes methodological rigor to the field of educational technology and critical literacy research. The study is grounded in the context of Islamic higher education. It demonstrates how religiosity functions as an epistemological and ethical foundation in learning. This context-specific contribution enriches global literature by introducing a non-Western perspective in critical literacy research. The model provides a clear structure for implementation. It does not only explain relationships but also guides practice. It offers a framework for designing learning environments that integrate AI tools, gamified strategies, and value-based education in a coherent system.

The key novelty of this study lies in its integrative paradigm. It moves beyond fragmented approaches and proposes a unified model of learning. Critical literacy is conceptualized as the outcome of a system where thinking, motivation, and values interact continuously. This study redefines critical literacy. It is not only the ability to analyze and evaluate information. It is the ability to do so with ethical awareness, social responsibility, and reflective judgment. The AIGaR model therefore offers a new direction for research and practice. It provides a scientifically grounded and contextually relevant framework for developing learners who are not only critical thinkers but also ethically responsible individuals.

CONCLUSION

This study produces generalized findings aligned with the research problem on how artificial intelligence, gamification, and religiosity influence students' critical literacy through the AIGaR model. First, the study confirms that critical literacy is significantly shaped by the integration of technological, pedagogical, and value-based dimensions. The structural model shows strong explanatory power (R^2 = 0.67), which indicates that the combined variables explain a substantial portion of variance in critical literacy. This finding supports the view that higher-order thinking develops through a multidimensional process rather than a single-factor approach. Second, all variables have positive and significant effects. Artificial intelligence strengthens analytical and adaptive learning processes. Gamification increases engagement and sustains cognitive involvement. Religiosity emerges as the most dominant factor, indicating that ethical reflection and value internalization play a decisive role in shaping critical literacy. These results confirm that critical literacy is not only cognitive but also value-driven. Third, the AIGaR model proves to be an effective integrative framework. The model connects AI-based learning, gamified pedagogy, and religiosity into a coherent system. This integration produces a balanced learning process that develops analytical skills, maintains motivation, and ensures ethical direction. The model is particularly relevant for higher education contexts that emphasize the alignment between knowledge and values.

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AUTHOR CONTRIBUTIONS

Hadi Widodo served as the principal investigator and lead author. He initiated the research idea, formulated the conceptual framework, and developed the integrated AIGaR model. He designed the study using the Design-Based Research (DBR) approach, developed and refined the research instruments, and conducted advanced data analysis using PLS-SEM. He interpreted the results within a theoretical and empirical context and took primary responsibility for drafting, structuring, revising, and finalizing the manuscript. Samsul Bahri contributed to strengthening the theoretical and methodological foundation of the study. He conducted a comprehensive literature review, supported the operationalization of variables, and validated the research instruments. He was actively involved in the data collection process and provided critical feedback on the conceptual framework, research design, and alignment between theory and methodology. Tumiyem was responsible for the practical implementation of the study in the field. She conducted classroom implementation of the AIGaR model, managed data collection procedures, and ensured data quality and organization. She performed preliminary data analysis and contributed to interpreting field-based findings. She also assisted in reviewing, editing, and refining the manuscript to improve clarity and consistency. All authors contributed to the discussion of results and the refinement of the final manuscript. All authors have read and approved the final version and agree to be accountable for all aspects of the work, including the accuracy, integrity, and reliability of the research.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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