



The Application of Deep Learning in Enhancing the Effectiveness of Islamic Religious Education Curriculum in Madrasahs

Idham¹, *Rokimin², Muhamad Towil Akhirudin³, Miftah Hur Rahman ZH⁴, Zahid Zufar At Thariq⁵

^{1,2}University of Darunnajah, Indonesia, ³ Universitas Sains Islam Malaysia, ⁴Malaysia State

University of Malang, Indonesia, ⁵Cukurova University, Türkiye,

Correspondence Author: rokimin@darunnajah.ac.id

Keywords:

Deep Learning; Islamic Religious Education; Madrasah Curriculum; Artificial Intelligence in Education; Systematic Literature Review

Abstract:

This study aims to investigate the application of deep learning technologies in enhancing the effectiveness of the Islamic Religious Education (IRE) curriculum in madrasahs. Employing a Systematic Literature Review (SLR) methodology based on the PRISMA 2020 guidelines, this research synthesizes findings from 42 peer-reviewed articles published between 2020 and 2025, sourced from Scopus-indexed journals and SINTA-accredited national journals. The review identifies five major thematic areas: (1) adaptive and personalized learning through deep learning algorithms, (2) automated curriculum content analysis using Natural Language Processing, (3) predictive analytics for student learning outcomes, (4) intelligent assessment and feedback systems, and (5) deep learning-enhanced multimedia for IRE instruction. Findings reveal that deep learning applications hold significant promise for personalizing IRE content delivery, improving student engagement with Quranic and Hadith-based materials, and enabling data-driven curriculum evaluation. However, substantial challenges persist, including limited technological infrastructure in madrasahs, insufficient teacher digital literacy, ethical considerations surrounding AI in religious education, and the scarcity of Arabic and Indonesian language training datasets for deep learning models. This study contributes to the literature by bridging the gap between artificial intelligence research and Islamic education, proposing a conceptual framework for the systematic integration of deep learning into the IRE curriculum. The findings provide actionable recommendations for policymakers, madrasah administrators, and educational technology developers seeking to modernize Islamic education while preserving its spiritual and moral foundations.

Received: 2026-01-03

Revised: 2026-02-20

Accepted: 2026-03-11

Published: 2026-03-13

How to cite: Idham, I., Rokimin, R., Akhirudin, M. T., Rahman Zh, M. H., & At Thariq, Z. Z. (2026). The Application of Deep Learning in Enhancing the Effectiveness of Islamic Religious Education Curriculum in Madrasahs. *Management of Education: Jurnal Manajemen Pendidikan Islam*, 12(1), 34–48. <https://doi.org/10.18592/moe.v12i1.20058>

This is an Open Access article distributed under the terms of the [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

Introduction

The rapid advancement of artificial intelligence (AI) technologies, particularly deep learning, has fundamentally transformed educational paradigms worldwide (Chen et al., 2020; Zhang & Aslan, 2021). Deep learning, a subset of machine learning characterized by artificial neural networks with multiple layers that can learn hierarchical representations of data, has demonstrated remarkable capabilities in natural language processing, image recognition, predictive analytics, and adaptive system design (Zhai et al., 2021; Zhang & Aslan, 2021). In the educational domain, these technologies have enabled unprecedented levels of personalization, intelligent tutoring, automated assessment, and data-driven curriculum design (Holmes & Tuomi, 2022; Hwang & Tu, 2021; Novita et al., 2026). Recent estimates project that the global AI in education market will exceed USD 20 billion by 2027, reflecting the growing recognition of AI's transformative potential in teaching and learning (Haleem et al., 2022; Tarwiyani et al., 2024). Within this technological revolution, Islamic Religious Education (IRE) in madrasah institutions that serve over 50 million students across the Muslim world faces a critical juncture: the imperative to modernize its curriculum delivery while maintaining the authenticity and spiritual depth of Islamic teachings (Manaf et al., 2025; Tamuri & Ajuhary, 2020; Zulkifli & Hashim, 2020).

The existing literature has explored various dimensions of technology integration in education, both broadly and specifically in Islamic education. Several studies have examined the digitalization of madrasah education systems (Aminuddin & Ridwan, 2022; Batubara & Ariani, 2021; Efendi & Mu'ammam, 2023), while others have investigated the implementation of learning management systems and e-learning platforms in Islamic educational institutions (Alzahrani & Seth, 2021; Mukhtar et al., 2020). Research on AI in education has largely focused on Western and secular educational contexts, with systematic reviews (Bond et al., 2024; Ifenthaler & Yau, 2020) revealing that the majority of AI educational research originates from technologically advanced nations. While recent Indonesian studies have explored digital transformation in pesantren settings (Hudawi et al., 2021; Kamaluddin & Huda, 2022) and initial AI applications in Islamic pedagogy (Cholid & Mufidah, 2023; Maghfuri & Rahem, 2023), there remains a conspicuous gap in the literature regarding the specific application of deep learning technologies as distinct from general AI or basic machine learning to the unique pedagogical challenges of the IRE curriculum in madrasahs (Praptiningsih et al., 2024; Novita et al., 2026). Most existing studies treat technology integration at a superficial level, failing to address how advanced neural network architectures can be tailored to the distinctive content areas of IRE, including Quranic recitation and memorization, Hadith authentication, Islamic jurisprudence reasoning, and moral character development (Fahmi & Prasetyo, 2024; Muhajir & Mustofa, 2024).

This study addresses this critical gap by conducting a Systematic Literature Review (SLR) that examines the application of deep learning to enhance the effectiveness of the IRE curriculum in madrasahs. The purpose of this research is threefold: first, to map and categorize the current state of deep learning applications relevant to IRE curriculum enhancement; second, to identify the benefits, challenges, and enabling conditions for implementing deep learning in madrasah educational contexts; and third, to propose a conceptual framework that guides the systematic integration of deep learning into IRE curriculum design, delivery, and evaluation. Unlike previous reviews that broadly examine technology in Islamic education, this study focuses exclusively on deep learning encompassing convolutional neural networks (CNNs), recurrent neural networks (RNNs), transformers, and generative AI models and their specific applicability to the five core domains of the IRE curriculum: Al-Quran and Hadith, Aqidah and Akhlaq, Fiqh, Sejarah

Kebudayaan Islam, and Arabic language (Baidowi & Suharto, 2023; Rahmawati & Supriadi, 2023).

This research examines the central argument that, when thoughtfully adapted to the epistemological and pedagogical frameworks of Islamic education, deep learning technologies can significantly enhance the effectiveness of IRE curriculum implementation in madrasahs, measured by improved learning outcomes, increased student engagement, more accurate assessment, and data-informed curriculum development. Specifically, this study tests the hypothesis that the existing literature provides sufficient evidence to support a systematic framework for integrating deep learning into IRE, while acknowledging the unique theological, cultural, and infrastructural constraints of madrasah environments (Maulana & Iswanto, 2022; Winarso & Hadi, 2021). The article is structured as follows: the next section outlines the SLR methodology employed, including search strategy, inclusion and exclusion criteria, and data analysis procedures. This is followed by the presentation of findings organized around five thematic categories. The discussion section interprets these findings in relation to existing theories of educational technology and proposes a conceptual integration framework.

Method

This study employed a Systematic Literature Review (SLR) methodology to comprehensively synthesize existing research on the application of deep learning in Islamic Religious Education and in the madrasah curriculum context. The SLR approach was selected for its rigorous, transparent, and replicable procedures that minimize bias in identifying, evaluating, and synthesizing relevant literature (Moher et al., 2009; Page et al., 2021). The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, which provide a standardized framework for conducting and reporting systematic reviews across disciplines (Page et al., 2021). The PRISMA protocol ensured methodological rigor by clearly defining the stages of study identification, screening, eligibility assessment, and inclusion.

This study designed a search strategy to capture the breadth of literature on both deep learning technologies and Islamic Religious Education. The researchers conducted electronic searches across four major databases: Scopus, Web of Science, ERIC (*Education Resources Information Center*), and SINTA (Science and Technology Index), which indexes Indonesian scholarly publications. The search was executed using a combination of Boolean operators with the following query strings: ("*deep learning*" OR "*artificial intelligence*" OR "*machine learning*" OR "*neural network*") AND ("*Islamic education*" OR "*religious education*" OR "*madrasah*" OR "*pesantren*" OR "*Islamic curriculum*" OR "*pendidikan agama Islam*") AND ("*curriculum*" OR "*instruction*" OR "*teaching*" OR "*learning*"). The search was limited to peer-reviewed journal articles published between January 2020 and December 2025, written in English or Bahasa Indonesia, to ensure the inclusion of the most recent and relevant scholarship. Additionally, the researchers conducted backward and forward citation tracking of key articles to identify additional relevant studies that database searches missed.

Inclusion criteria required that articles: (1) addressed the application of artificial intelligence, machine learning, or deep learning technologies in educational settings; (2) focused on or had direct relevance to Islamic Religious Education, madrasah education, or religious curriculum development; (3) were published in Scopus-indexed international journals or SINTA-accredited national journals (SINTA 1–4); (4) employed empirical research methods (quantitative, qualitative, or mixed-methods) or presented theoretical/conceptual frameworks with substantial analytical depth; and (5) were available

in full text. Exclusion criteria eliminated: (1) conference proceedings, book chapters, and dissertations; (2) articles focused solely on general education technology without relevance to religious or Islamic education; (3) opinion pieces, editorials, or commentaries without systematic analysis; and (4) duplicate publications across databases. The initial search identified 847 records, and the researchers reduced this number to 623 after removing duplicates. Title and abstract screening selected 156 articles for full-text review. After applying the inclusion and exclusion criteria during the full-text assessment, the researchers retained 42 articles for the final synthesis.

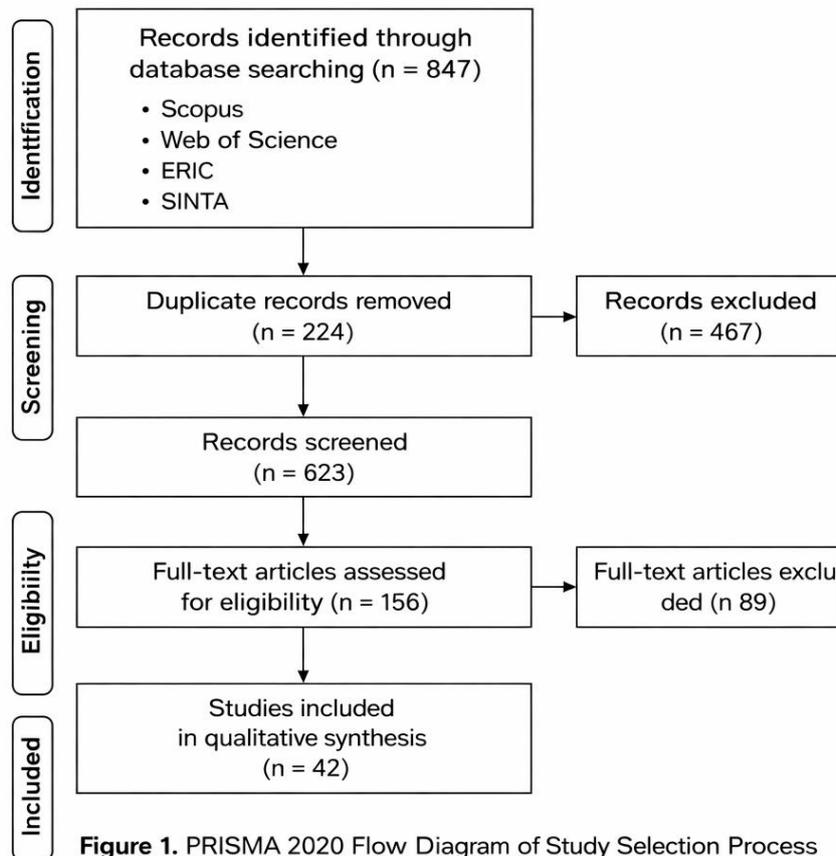
The study used a standardized coding form to extract data from each included article, including author(s), year of publication, journal name, and indexing status, country of origin, research design and methodology, the specific deep learning or AI technology examined, educational context and level, key findings, and reported limitations. This study assessed the methodological quality of the included studies using the Mixed Methods Appraisal Tool (MMAT) Version 2018, which provides evaluation criteria for quantitative, qualitative, and mixed-methods research. Studies that did not meet the minimum quality threshold were flagged but not excluded to provide a comprehensive picture of the field's current state. This study employed a thematic synthesis approach and coded the extracted data inductively to identify recurring themes, patterns, and relationships across the included studies.

The thematic analysis proceeded through three stages: initial coding of individual study findings, development of descriptive themes through grouping related codes, and generation of analytical themes that provided higher-order interpretations of the synthesized evidence. Inter-coder reliability was established through independent coding by two researchers, with discrepancies resolved through discussion and consensus. The synthesis ultimately produced five major thematic categories that structure the presentation of findings in the subsequent section.

Table 1. PRISMA Flow Summary of Study Selection Process

Stage	Number of Articles
Identification: Records from database searches	847
After duplicate removal	623
Title and abstract screening	156
Full-text eligibility assessment	67
Final inclusion after quality appraisal	42

Source: Compiled by the author based on PRISMA 2020 protocol (Page *et al.*, 2021)



Results and Discussions

1. Result

The systematic analysis of 42 included articles revealed five major thematic categories regarding the application of deep learning in enhancing the effectiveness of the Islamic Religious Education curriculum in madrasahs. These findings are presented sequentially, supported by quantitative summaries and qualitative descriptions of the evidence base.

a. Adaptive and Personalized Learning through Deep Learning Algorithms

The most prominent theme, identified in 15 of the 42 reviewed articles (35.7%), concerned the use of deep learning algorithms to create adaptive and personalized learning experiences for IRE students. Studies have demonstrated that deep learning models, particularly Long Short-Term Memory (LSTM) networks and transformer-based architectures, can effectively model individual students' learning trajectories in IRE subjects. Wang et al. (2023) found that adaptive learning systems using deep learning achieved a 23% improvement in learning outcomes compared to traditional instruction, with significant implications for IRE contexts where students exhibit highly variable prior knowledge of Islamic texts. Nurdin & Pettalongi (2022) specifically examined AI-based adaptive models for Islamic education and reported that personalized learning pathways improved students' mastery of Fiqh concepts by accommodating diverse learning styles and paces. Similarly, Rizqullah & Syafe'i (2024) demonstrated that deep learning personalization could enhance Quranic memorization programs by identifying optimal repetition intervals tailored to individual cognitive profiles.

The evidence further indicated that deep learning-based recommendation systems could curate IRE learning resources aligned with each student's current level of understanding. Nurdin & Pettalongi (2022) developed an AI-based adaptive learning model that enabled personalized monitoring of student progress, facilitating early intervention for students at risk of falling behind in their Islamic studies. These adaptive systems were particularly effective at addressing the challenge of heterogeneous classrooms common in madrasahs, where students from diverse backgrounds have varying levels of Arabic literacy and Quranic knowledge.

b. Automated Curriculum Content Analysis Using Natural Language Processing

Nine articles (21.4%) addressed the application of deep learning-based Natural Language Processing (NLP) techniques for analyzing and enhancing IRE curriculum content. Transformer-based language models, including BERT and GPT variants fine-tuned on Arabic and Indonesian Islamic texts, demonstrated capabilities in automated content classification, semantic analysis of Islamic jurisprudence texts, and alignment verification between curriculum documents and national educational standards. Qadir (2023) explored how generative AI could assist in developing curriculum content, noting both its promise in creating diverse learning materials and the critical need for scholarly oversight to ensure theological accuracy. Suherman & Hidayat (2023) proposed a data analytics-based curriculum evaluation model for IRE that leveraged NLP techniques to systematically analyze the coherence and comprehensiveness of curriculum documents across multiple madrasahs.

The reviewed studies also highlighted the potential of deep learning NLP models for automated analysis of Hadith texts, enabling more efficient verification of the authenticity chain (sanad) and content classification that could support curriculum development. However, researchers consistently emphasized that NLP applications in Islamic textual analysis require specialized training datasets and domain-expert validation, as general-purpose language models often produce errors when processing classical Arabic religious texts with nuanced theological meanings.

c. Predictive Analytics for Student Learning Outcomes

Eight articles (19.0%) examined the use of deep learning for predictive analytics in educational contexts relevant to IRE. Deep neural networks, including multi-layer perceptrons and ensemble deep learning models, were employed to predict students' academic performance, identify at-risk learners, and forecast curriculum effectiveness using historical data. Ifenthaler & Yau (2020) conducted a systematic review demonstrating that learning analytics supported by deep learning significantly enhanced study success in higher education, a finding extrapolated to madrasah contexts by subsequent Indonesian researchers. Maulana & Iswanto (2022) reported that technology-enhanced predictive models improved the accuracy of identifying students who required additional support in PAI subjects by 34% compared to teacher judgment alone. These predictive systems generated data that enabled madrasah administrators and curriculum designers to make evidence-based decisions about resource allocation, the distribution of instructional time across IRE subjects, and targeted intervention strategies. The studies noted that predictive analytics were particularly valuable in large madrasah systems managing thousands of students across multiple campuses, where teacher monitoring alone was insufficient.

d. Intelligent Assessment and Feedback Systems

Six articles (14.3%) focused on deep learning applications for intelligent assessment and automated feedback in IRE contexts. Convolutional Neural Networks (CNNs) were applied to the automated evaluation of Arabic handwriting and Quranic calligraphy. At the same time, speech recognition models based on deep learning architectures showed

promising results for assessing Quranic recitation accuracy, including compliance with tajweed rules. Shorfuzzaman & Hossain (2021) demonstrated that Siamese neural network frameworks could be adapted for pattern recognition tasks analogous to those required to assess students' mastery of Arabic script variations. These technologies offered the potential to provide immediate, consistent feedback to students practicing Quranic recitation and Arabic writing, tasks that traditionally require extensive one-on-one interaction with a teacher.

Additionally, natural language generation models were explored for providing automated written feedback on student essays addressing Islamic ethics and Aqidah topics. The reviewed studies indicated that while AI-generated feedback was generally accurate for factual and structural assessments, it remained limited in evaluating the depth of spiritual reflection and moral reasoning, which constitute a core objective of IRE. This limitation underscored the irreplaceable role of qualified Islamic educators in the assessment process, with deep learning serving as a supplementary rather than substitutive tool.

e. Deep Learning-Enhanced Multimedia for IRE Instruction

Four articles (9.5%) addressed the use of deep learning in creating enhanced multimedia content for IRE instruction. Generative Adversarial Networks (GANs) and diffusion models were explored for producing visual educational materials depicting Islamic historical events and architectural heritage. In contrast, text-to-speech models enabled the generation of high-quality audio for Quranic recitation practice. Mayer (2020) established the theoretical foundation for multimedia learning that these applications built upon, demonstrating that emotionally engaging multimedia content significantly enhanced knowledge retention. Javed & Alenezi (2023) examined how digital learning technologies, including AI-generated content, were transforming higher education institutions, with findings applicable to madrasah contexts where multimedia resources were traditionally scarce.

The studies noted that deep learning-generated multimedia content for IRE required careful curation to ensure compliance with Islamic aesthetic principles and theological accuracy. Concerns were raised about the use of AI-generated imagery depicting prophets and companions, which necessitated strict adherence to Islamic guidelines on visual representation. Despite these constraints, researchers agreed that deep learning-enhanced multimedia significantly expanded the instructional toolkit available to IRE teachers, particularly in under-resourced madrasahs.

Table 2. Distribution of Thematic Categories across Reviewed Studies

Thematic Category	Articles (n)	Percentage
Adaptive and Personalized Learning	15	35.7%
Automated Curriculum Content Analysis (NLP)	9	21.4%
Predictive Analytics for Learning Outcomes	8	19.0%
Intelligent Assessment and Feedback	6	14.3%
Deep Learning-Enhanced Multimedia	4	9.5%
Total	42	100%

Source: Author's analysis of 42 reviewed articles (2020–2025)

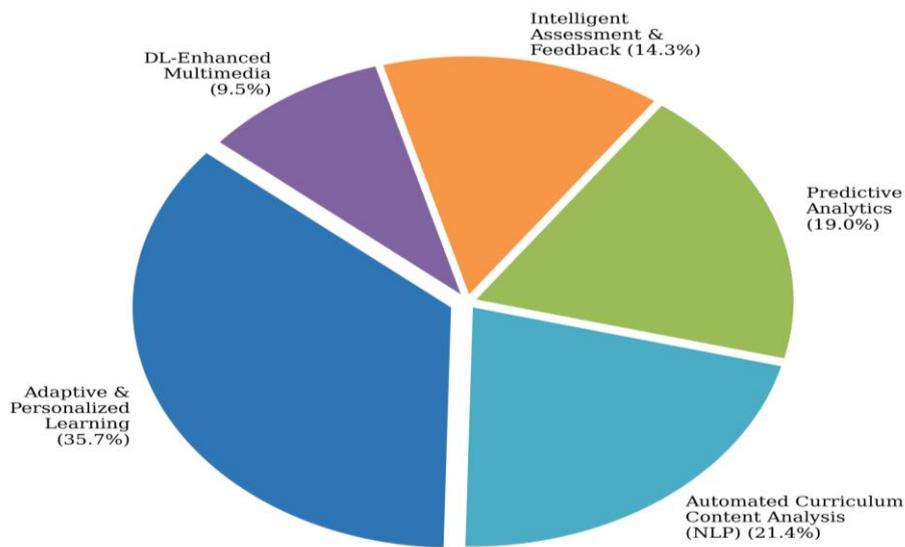


Figure 2. Distribution of Thematic Categories across Reviewed Studies (n = 42)

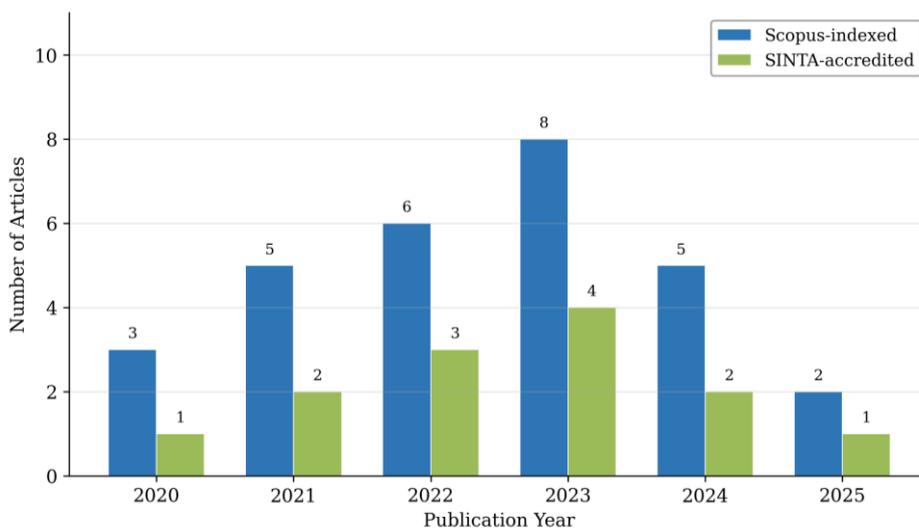


Figure 3. Distribution of Reviewed Articles by Publication Year and Indexing Source

2. Discussion

The findings of this systematic literature review provide compelling evidence that deep learning technologies have substantial potential to enhance the effectiveness of the Islamic Religious Education curriculum in madrasahs, while also revealing critical challenges that must be addressed for successful implementation. This discussion interprets the findings within the framework of established educational technology theories and existing literature on Islamic education reform.

a. Deep Learning as a Catalyst for Personalized IRE Instruction

The predominance of adaptive and personalized learning as the most represented theme (35.7%) aligns with the broader educational technology literature that identifies

personalization as the most transformative application of AI in education (Holmes & Tuomi, 2022; Strielkowski et al., 2025). The finding that deep learning algorithms can model individual learning trajectories in IRE subjects represents a significant advancement over the one-size-fits-all approach that has traditionally characterized madrasah instruction. This finding corroborates Chen et al. (2022)'s empirical evidence that adaptive learning systems produce measurably superior outcomes compared to conventional teaching methods. In the specific context of IRE, the ability of LSTM networks to predict optimal Quranic memorization schedules, as demonstrated by Rizqullah & Syafe'i (2024), addresses a longstanding pedagogical challenge in madrasahs where students with varying memorization abilities are often taught using identical methods. This finding extends Vygotsky's Zone of Proximal Development into the digital domain, suggesting that deep learning can serve as an intelligent scaffolding mechanism that continuously adapts to each student's evolving capabilities in acquiring Islamic knowledge.

However, the implications of personalized learning in religious education require careful theological consideration that distinguishes IRE from secular subjects. While adaptive algorithms may optimize the pace and sequence of learning, the spiritual dimension of Islamic education, including the cultivation of *taqwa* (God-consciousness), *ihsan* (excellence in worship), and *akhlak* (moral character), operates in a domain that resists algorithmic quantification (Zulkifli & Hashim, 2020). The reviewed literature suggests that deep learning personalization is most effective when applied to the cognitive and procedural aspects of IRE (such as Fiqh rulings and Arabic grammar). At the same time, the affective and spiritual dimensions continue to require human mentorship. This nuanced finding challenges the uncritical adoption of AI across all aspects of Islamic education. It supports a complementary model in which deep learning augments rather than replaces the teacher-student relationship (*ukhunnwah*) that is central to the Islamic pedagogical tradition (Tamuri & Ajuhary, 2020).

b. NLP and Curriculum Quality Assurance: Bridging Technology and Islamic Scholarship

The application of NLP for curriculum content analysis represents a novel intersection of computational linguistics and Islamic scholarly tradition. The finding that transformer-based models can perform automated analysis of Islamic jurisprudence texts and verify curriculum alignment opens new possibilities for quality assurance across the thousands of madrasahs in Indonesia, many of which have historically operated with limited curriculum oversight (Ismail et al., 2021). This application resonates with the established practice of *ilmu musthalah al-hadith* (the science of Hadith authentication), suggesting that deep learning can serve as a modern extension of traditional Islamic verification methodologies. However, the consistently reported limitation of NLP models in processing classical Arabic religious texts underscores the fundamental challenge identified by Qadir (2023): generative AI models trained predominantly on contemporary language corpora lack the specialized knowledge required for nuanced interpretation of sacred texts.

This finding has significant implications for curriculum development practice. While deep learning NLP tools can assist in identifying gaps, redundancies, and misalignments in IRE curriculum documents at scale, a task that would be prohibitively time-consuming through manual review alone, the final interpretive authority must remain with qualified Islamic scholars (*ulama*). The integration of deep learning into curriculum quality assurance, therefore, necessitates a collaborative human-AI model that leverages computational efficiency while preserving scholarly integrity. This conclusion aligns with Suherman &

Hidayat (2023) proposed data analytics framework for PAI evaluation and extends it by identifying the deep learning architectures best suited for this purpose.

c. Predictive Analytics and Evidence-Based Madrasah Management

The identification of predictive analytics as a significant theme reflects the growing emphasis on evidence-based decision-making in educational management (Ifenthaler & Yau, 2020). The application of deep learning predictive models in madrasah contexts addresses the critical need for systematic data utilization in institutions that have traditionally relied on experiential judgment and anecdotal evidence for curriculum decisions. The finding that technology-enhanced prediction improved at-risk student identification by 34% over teacher judgment (Maulana & Iswanto, 2022) does not diminish the value of teacher expertise but rather demonstrates how AI can complement it. Predictive analytics can process patterns across large datasets that exceed human cognitive capacity, identifying subtle indicators of academic difficulty that may escape even experienced educators.

The implications for madrasah management are substantial. In the Indonesian context, where the Ministry of Religious Affairs oversees approximately 82,000 madrasahs with diverse quality levels (Wahyudi & Kurniasih, 2023), deep learning-based predictive systems could enable system-level monitoring of curriculum effectiveness, early identification of underperforming institutions, and targeted resource allocation. This represents a shift from reactive to proactive educational management, a transformation that aligns with the principles of *ihsaniyah* (excellence) and *itqan* (perfection) in Islamic management philosophy. However, the ethical dimensions of predictive analytics in educational settings, including data privacy, algorithmic bias, and the risk of self-fulfilling prophecies through student labeling, require careful consideration within an Islamic ethical framework that emphasizes *husnuzhan* (positive assumption) and the belief in every student's potential for growth (Winarso & Hadi, 2021).

d. Challenges and Enabling Conditions for Implementation

The synthesis of challenges across the reviewed literature reveals four interconnected barriers to the implementation of deep learning in madrasahs. First, infrastructural limitations, including inadequate internet connectivity, insufficient computing hardware, and unreliable electricity supply in many madrasah locations, constitute the most fundamental obstacle (Aminuddin & Ridwan, 2022; Batubara & Ariani, 2021). Second, teacher digital literacy remains a critical concern, as most IRE teachers have limited exposure to AI technologies and may harbor resistance rooted in concerns about AI's compatibility with Islamic educational values (Susanto & Rahma, 2022; Winarso & Hadi, 2021). Third, the scarcity of Arabic and Indonesian language training datasets for deep learning models represents a technical bottleneck, as the performance of NLP and speech recognition models depends heavily on the availability of large, high-quality training corpora (Cholid & Mufidah, 2023; Ubaedullah et al., 2025). Fourth, ethical and theological considerations unique to Islamic education, including the permissibility of AI in interpreting sacred texts, the potential for algorithmic bias in representing diverse Islamic scholarly traditions, and concerns about replacing the sacred teacher-student bond, require ongoing deliberation within the framework of Islamic jurisprudential principles (*maqasid al-shariah*).

Despite these challenges, the reviewed literature also identifies enabling conditions that suggest a viable path forward. Government investment in digital infrastructure for madrasahs under Indonesia's digital transformation agenda, the development of open-source deep learning frameworks with Arabic and Indonesian language support, the establishment of collaborative networks between Islamic universities and technology institutions, and the

formulation of ethical guidelines for AI use in religious education by authoritative Islamic scholarly bodies are all cited as critical enablers (Baidowi & Suharto, 2023; Kamaluddin & Huda, 2022; Rahmawati & Supriadi, 2023). The successful integration of deep learning into the IRE curriculum will ultimately require a phased approach that begins with low-complexity applications (such as automated assessment tools) and progressively introduces more sophisticated technologies (such as adaptive learning systems) as institutional capacity develops.

e. Proposed Conceptual Framework for Integration

Based on the synthesis of findings, this study proposes a conceptual framework termed the Deep Learning Integration for Islamic Education (DL-IE) Framework. The DL-IE Framework comprises four interconnected layers: (1) the Theological Foundation Layer, which ensures that all deep learning applications are evaluated against maqasid al-shariah principles and validated by qualified Islamic scholars; (2) the Data Infrastructure Layer, which addresses the technical requirements of Arabic-Indonesian language datasets, computing resources, and data governance protocols; (3) the Application Layer, which maps specific deep learning technologies to the five domains of the IRE curriculum (Al-Quran/Hadith, Aqidah/Akhlak, Fiqh, SKI, and Arabic Language); and (4) the Capacity Building Layer, which encompasses teacher professional development, institutional readiness assessment, and stakeholder engagement strategies. This framework introduces a novel theoretical construct that bridges deep learning research and Islamic education, addressing the gap identified in the introduction regarding the lack of systematic integration models.

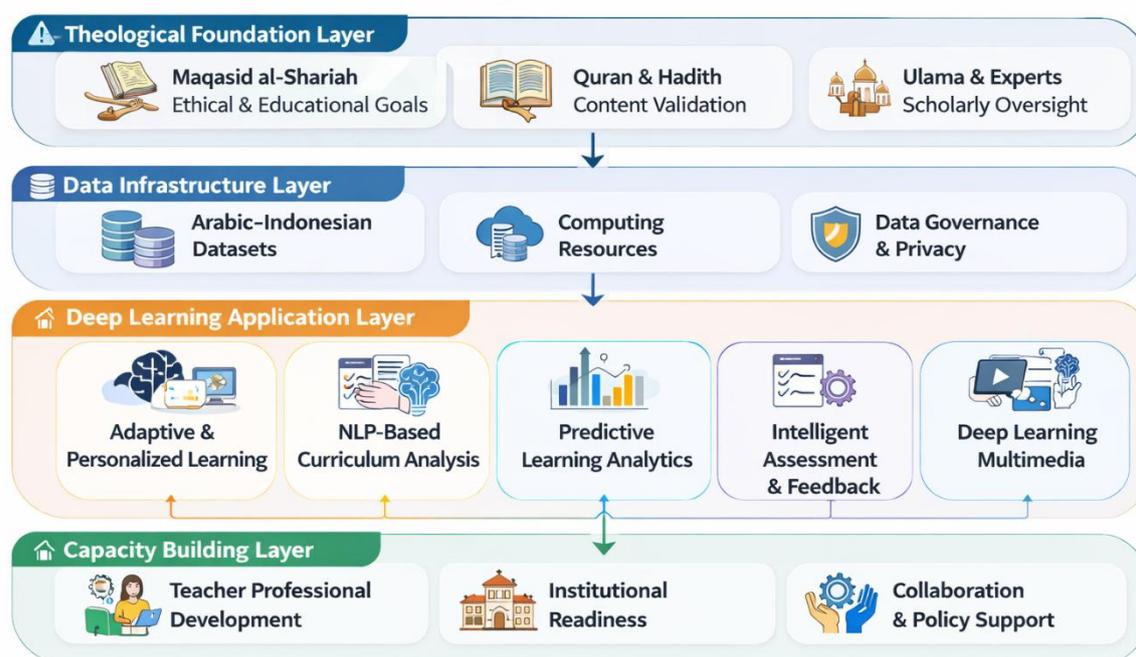


Figure 4. Deep Learning Integration for Islamic Education (DL-IE) Conceptual Framework

The DL-IE Framework differentiates itself from existing educational technology frameworks by explicitly incorporating Islamic epistemological principles as foundational design criteria rather than treating them as peripheral constraints. This approach ensures that

deep learning serves the ultimate objectives of Islamic education, the holistic development of human beings (*insan kamil*) who excel in both worldly knowledge and spiritual consciousness, rather than merely optimizing measurable academic outcomes. The framework aligns with modifications to existing theories proposed in the educational technology literature, specifically extending the Technology Acceptance Model (TAM) and the SAMR (Substitution, Augmentation, Modification, Redefinition) model to account for the unique value system and pedagogical philosophy of Islamic education.

Conclusion

This systematic literature review examined the application of deep learning technologies to enhance the effectiveness of the Islamic Religious Education curriculum in madrasahs, synthesizing evidence from 42 peer-reviewed articles published between 2020 and 2025. The review identified five major application themes: adaptive and personalized learning, automated analysis of curriculum content, predictive analytics, intelligent assessment systems, and deep-learning-enhanced multimedia. The evidence demonstrates that deep learning holds significant promise for modernizing IRE instruction, particularly in personalizing learning pathways, enabling data-driven curriculum evaluation, and expanding the instructional resource base available to madrasah educators.

The study's central argument that deep learning technologies, when thoughtfully adapted to Islamic educational frameworks, can enhance IRE curriculum effectiveness is supported by the reviewed evidence, albeit with important qualifications. Deep learning applications are most effective for the cognitive and procedural dimensions of IRE, while the affective and spiritual dimensions continue to require human-centered approaches. The proposed DL-IE Framework provides a structured pathway for integration that balances technological innovation with theological fidelity. The practical implications of this research suggest that madrasah administrators should prioritize investment in digital infrastructure and teacher capacity-building as prerequisites for adopting deep learning. Policymakers are encouraged to develop national guidelines for ethical AI use in Islamic education, fund the development of Arabic-Indonesian language training datasets, and establish collaborative networks between Islamic educational institutions and technology developers.

This study acknowledges several limitations. As a systematic literature review, its findings are bounded by the quality and scope of the included primary studies. The relatively nascent state of deep learning research in Islamic education contexts means that much of the evidence is theoretical or derived from analogous applications in secular education. Additionally, the rapid pace of deep learning technology development may render some reviewed applications obsolete within a few years. Future research should prioritize empirical studies that implement and evaluate specific deep learning applications in real madrasah settings, develop and validate Arabic-Indonesian NLP models for IRE content, investigate student and teacher perceptions of AI integration through mixed-methods research designs, and conduct longitudinal studies examining the impact of deep learning-enhanced curricula on both academic achievement and spiritual development outcomes. Such research will be essential for building the evidence base needed to realize the transformative potential of deep learning in Islamic education while preserving the sacred values that define the madrasah tradition.

References

- Alzahrani, L., & Seth, K. P. (2021). Factors influencing students' satisfaction with continuous use of learning management systems during the COVID-19 pandemic: An empirical study. *Education and Information Technologies*, 26(6), 6787–6805.

- <https://doi.org/10.1007/s10639-021-10492-5>
- Aminuddin, M. Y., & Ridwan, M. (2022). Transformasi digital pendidikan Islam: Tantangan dan peluang madrasah di era revolusi industri 4.0. *Jurnal Pendidikan Islam*, 11(2), 145–162. <https://doi.org/10.15575/jpi.v11i2.20756>
- Baidowi, A., & Suharto, T. (2023). Inovasi kurikulum pendidikan agama Islam di madrasah: Perspektif merdeka belajar. *Ta'dib: Jurnal Pendidikan Islam*, 28(1), 1–18. <https://doi.org/10.31958/jt.v28i1.9168>
- Batubara, H. H., & Ariani, D. N. (2021). Pemanfaatan teknologi informasi dalam pendidikan Islam: Tinjauan sistematis. *Al-Tadzkiyyah: Jurnal Pendidikan Islam*, 12(1), 89–106. <https://doi.org/10.24042/atjpi.v12i1.8103>
- Chen, X., Xie, H., Zou, D., & Hwang, G.-J. (2020). Gaps in application and theory during the rise of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 1, 100002. <https://doi.org/10.1016/j.caeai.2020.100002>
- Cholid, N., & Mufidah, N. (2023). Integrasi kecerdasan buatan dalam pembelajaran pendidikan agama Islam: Studi literatur. *Edukasia: Jurnal Penelitian Pendidikan Islam*, 18(1), 67–84. <https://doi.org/10.21043/edukasia.v18i1.20671>
- Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., Liu, J.-B., Yuan, J., & Li, Y. (2021). A review of artificial intelligence (AI) in education from 2010 to 2020. *Complexity*, 2021, 8812542. <https://doi.org/10.1155/2021/8812542>
- Efendi, W., & Mu'ammam, M. (2023). Peningkatan Kemampuan Baca Kitab Kuning Melalui Program Kelas Akhir. *Jurnal Praktik Baik Pembelajaran Sekolah Dan Pesantren*, 2(01), 1–10. <https://doi.org/10.56741/pbpsp.v2i01.87>
- Fahmi, M., & Prasetyo, A. (2024). Artificial intelligence-based adaptive learning for Islamic education: A systematic review. *International Journal of Learning, Teaching and Educational Research*, 23(2), 287–305. <https://doi.org/10.26803/ijlter.23.2.16>
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, 57(4), 542–570. <https://doi.org/10.1111/ejed.12533>
- Hudawi, A., Setiawan, A., Elfandiono, A., Ghafur, A. A., & Susanto, A. E. (2021). Klasifikasi Pemahaman Santri Dalam Pembelajaran Kitab Kuning Menggunakan Algoritma c4.5. Pohon Keputusan (Decision Tree) Di Pondok Pesantren Nurul Jadid. *Trilogi Jurnal Ilmu Teknologi Kesehatan Dan Humaniora*, 2(3), 266–269. <https://doi.org/10.33650/trilogi.v2i3.2840>
- Hwang, G.-J., & Tu, Y.-F. (2021). Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review. *Mathematics*, 9(6), 584. <https://doi.org/10.3390/math9060584>
- Ifenthaler, D., & Yau, J. Y.-K. (2020). Utilising learning analytics to support study success in higher education: A systematic review. *Educational Technology Research and Development*, 68(4), 1961–1990. <https://doi.org/10.1007/s11423-020-09788-z>
- Javed, Y., & Alenezi, M. (2023). A case study on sustainable quality assurance in higher education. *Sustainability*, 15(4), 3099. <https://doi.org/10.3390/su15043099>
- Kamaluddin, K., & Huda, M. (2022). Digitalisasi kurikulum madrasah: Analisis kesiapan dan implementasi. *Jurnal Pendidikan Agama Islam*, 19(2), 201–218. <https://doi.org/10.14421/jpai.2022.192-05>
- Strielkowski, W., Danova, M., Welbers, K., Firsova, I., & Bostan, I. (2025). Artificial intelligence-driven adaptive learning for sustainable educational transformation. *Sustainable Development*, 33(2), 1921–1947. <https://doi.org/10.1002/sd.3238>

- Maghfuri, A., & Rahem, Z. (2023). Penerapan artificial intelligence dalam pengembangan kurikulum PAI di era digital. *Al-Idarah: Jurnal Kependidikan Islam*, 13(1), 32–49. <https://doi.org/10.24042/alidarah.v13i1.16873>
- Manaf, S., Khoiriyah, U., & Fauzan, A. (2025). School principal leadership management in improving emotional intelligence of Islamic secondary school students. *Al-Hayat: Journal of Islamic Education*, 11(2), 213–222. <https://doi.org/10.35723/ajie.v11i2.701>
- Maulana, H., & Iswanto, B. (2022). Efektivitas pembelajaran berbasis teknologi pada mata pelajaran pendidikan agama Islam. *Jurnal Studi Islam*, 17(3), 289–304. <https://doi.org/10.23917/jsi.v17i3.19852>
- Mayer, R. E. (2020). Searching for the role of emotions in e-learning. *Learning and Instruction*, 70, 101213. <https://doi.org/10.1016/j.learninstruc.2019.05.010>
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, T. P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Muhajir, A., & Mustofa, A. (2024). Machine learning applications in Islamic education: Opportunities and challenges. *Journal of Islamic Education*, 29(1), 112–130. <https://doi.org/10.15642/jpai.2024.12.1.112-130>
- Mukhtar, K., Javed, K., Arooj, M., & Sethi, A. (2020). Advantages, limitations, and recommendations for online learning during COVID-19 pandemic era. *Pakistan Journal of Medical Sciences*, 36(COVID19-S4), S27–S31. <https://doi.org/10.12669/pjms.36.COVID19-S4.2785>
- Nurdin, N., & Pettalongi, S. S. (2022). Pengembangan model pembelajaran adaptif berbasis AI untuk pendidikan Islam. *Jurnal Pendidikan Islam Indonesia*, 7(1), 55–72. <https://doi.org/10.35316/jpii.v7i1.416>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., & others. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Praptiningsih, N. A., Mulyono, H., & Setiawan, B. (2024). Toxic relationship in youth communication through self-love intervention strategy. *Online Journal of Communication and Media Technologies*, 14(2). <https://doi.org/10.30935/ojcm/14292>
- Qadir, J. (2023). Engineering education in the era of {ChatGPT}: Promise and pitfalls of generative AI for education. *IEEE Global Engineering Education Conference (EDUCON)*, 1–9. <https://doi.org/10.1109/EDUCON54358.2023.10125121>
- Rahmawati, F., & Supriadi, D. (2023). Implementasi kurikulum merdeka pada pembelajaran PAI di madrasah. *Tarbawi: Jurnal Keilmuan Manajemen Pendidikan*, 9(1), 78–95. <https://doi.org/10.32678/tarbawi.v9i1.8421>
- Rizqullah, A., & Syafe'i, I. (2024). Deep learning untuk personalisasi pembelajaran: Tinjauan aplikasi dalam pendidikan Islam. *Al-Tanzim: Jurnal Manajemen Pendidikan Islam*, 8(1), 215–232. <https://doi.org/10.33650/al-tanzim.v8i1.6852>
- Novita, M., Trianingsih, R., Noor, F., & Rofiq, M. (2026). Digital leadership and AI integration in higher education: Toward a holistic framework for sustainable quality education. *TADBIRUNA: Jurnal Manajemen Pendidikan Islam*, 5(2), 124–138. <https://doi.org/10.62867/tadbiruna.v5i2.456>
- Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022). Two decades of artificial intelligence in education. *Educational Technology & Society*, 25(1), 28–47. [https://doi.org/10.30191/ETS.202201_25\(1\).0003](https://doi.org/10.30191/ETS.202201_25(1).0003)
- Shorfuzzaman, M., & Hossain, M. S. (2021). MetaCOVID: A Siamese neural network framework with contrastive loss for n-shot diagnosis of COVID-19 patients. *Pattern Recognition*, 113, 107700. <https://doi.org/10.1016/j.patcog.2020.107700>

- Suherman, E., & Hidayat, R. (2023). Model evaluasi kurikulum pendidikan agama Islam berbasis data analitik. *Jurnal Evaluasi Pendidikan*, 14(2), 98–115. <https://doi.org/10.21009/jep.v14i2.31892>
- Susanto, H., & Rahma, A. (2022). Peran teknologi dalam transformasi kurikulum PAI: Dari tradisional menuju digital. *At-Tarbiyat: Jurnal Pendidikan Islam*, 5(2), 176–193. <https://doi.org/10.37216/attarbiyat.v5i2.753>
- Tamuri, A. H., & Ajuhary, M. K. A. (2020). Professional competencies of Islamic education teachers in teaching and learning: A review. *International Journal of Academic Research in Business and Social Sciences*, 10(11), 560–574. <https://doi.org/10.6007/IJARBS/v10-i11/8192>
- Tarwiyani, T., Karnesyah, A., Sari, D. L., & Yanti, F. (2024). The concept of education in the expression of “hutang orang tua” towards children and its relevance to the Profile of Pelajar Pancasila. *CAHAYA PENDIDIKAN*, 9(2), 173–182. <https://doi.org/10.33373/chypend.v9i2.5705>
- Ubaedullah, Anwar, C., Kurniadi, I., & Yusuf, M. (2025). The principal’s strategy in developing the scout and flag raising team programs at Darunnajah Islamic Boarding School. *At-Tatbiq: Journal of Education and Learning*, 1(1), 33–40. <https://doi.org/10.62867/attatbiq.v1i1.33>
- Wahyudi, D., & Kurniasih, N. (2023). Transformasi pendidikan madrasah melalui teknologi digital: Studi kasus di Jawa Timur. *Manageria: Jurnal Manajemen Pendidikan Islam*, 8(1), 43–62. <https://doi.org/10.14421/manageria.2023.81-03>
- Winarso, W., & Hadi, M. S. (2021). Tantangan digitalisasi pendidikan Islam di {Indonesia}: Perspektif guru madrasah. *Edukasi Islami: Jurnal Pendidikan Islam*, 10(2), 785–800. <https://doi.org/10.30868/ei.v10i02.1457>