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Reconstructing Islamic Boarding School Education in the Digital Era: Integrating Spiritual Pedagogy and Neuroscience-Based Learning

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ABSTRACT

This study examines the reconstruction of Islamic boarding school education in contemporary technological society by critically combining moral-religious instruction, digital adaptation, and neuroscience-based learning. Rapid developments in technology have reshaped educational practices, generating both opportunities and challenges for Islamic residential schooling systems, particularly in preserving students' spiritual identity while supporting cognitive growth. This research aims to explore how neuroscience-informed learning strategies can enhance the effectiveness of moral and religious instruction within technology-supported learning environments. The study employs a qualitative approach with a critical-analytical design. Data were collected through literature review, document analysis, and in-depth interviews with educators in Islamic boarding schools. The findings indicate that the application of neuroscience principles in Islamic education improves student engagement, emotional regulation, and internalization of moral values. In addition, the use of digital tools, when aligned with value-based instruction, contributes to a more holistic and meaningful learning experience. The study emphasizes that reforming Islamic boarding education requires a balanced synergy between tradition and innovation. In conclusion, neuroscience-informed and technology-responsive approaches can significantly support the development of a more adaptive, relevant, and transformative Islamic education system.

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INTRODUCTION

The rapid advancement of digital technology in the twenty-first century has fundamentally transformed educational systems across the world. Learning processes are no longer confined to traditional classroom settings but are increasingly shaped by digital access, interactive media, artificial intelligence, and flexible knowledge transmission. This transformation has altered not only the delivery of knowledge but also the way learners construct meaning, interact socially, and develop cognitive and emotional competencies. In Islamic boarding schools (pesantren), this global shift introduces both significant opportunities and complex challenges, particularly in maintaining a balance between technological adaptation and the preservation of moral, spiritual, and character-based education.[1]

Pesantren have historically functioned as holistic educational institutions that integrate cognitive, affective, and spiritual dimensions in a unified learning system. Their pedagogical orientation emphasizes character formation, religious understanding, discipline, and lived moral practice as the foundation of educational success. Unlike modern secular institutions that often prioritize cognitive achievement, pesantren traditionally emphasize value internalization and spiritual maturity as central learning outcomes. However, the emergence of a technology-driven learning culture has shifted educational expectations toward speed, efficiency, instant access to information, and digital engagement, thereby creating tension between traditional educational values and contemporary learning demands.[2]

Despite the increasing penetration of digital tools in Islamic education, current implementation practices within many pesantren remain largely limited to technical adoption rather than meaningful pedagogical transformation. In many cases, technology is used primarily as a supporting instrument for administrative tasks or supplementary learning materials, rather than being integrated into the core philosophy of teaching and learning. This situation indicates that digital transformation in pesantren has not yet fully penetrated the deeper layers of educational meaning, particularly in relation to spiritual development, moral reasoning, and character formation..[3]

At the same time, spiritual formation continues to serve as the core foundation of pesantren education. However, in practice, its pedagogical expression is often treated separately from technological development and modern learning innovation. This separation creates both conceptual and practical gaps in the educational process, where moral and religious values are delivered through traditional methods while cognitive and technological competencies are developed through modern approaches. As a result, students may experience fragmented learning experiences that do not fully integrate knowledge, values, and skills in a coherent framework. Therefore, there is a growing need for a more unified educational approach capable of bridging these dimensions.[4]

[1] Al-Fahmi, M. (2020). Transformation of Islamic boarding school education in facing the challenges of globalization: Building 21st-century character and competencies. Journal of Islamic Education, 9(2), 132–145.

[2] Al-Munawwar, S. H. (2018). Tahfidz Al-Qur'an: Methods and strategies for memorizing the Al-Qur'an. Imam Asy-Syafi'i Library.

[3] Apriyanto, N., & Astutik, A. P. (2024). Digital transformation of Islamic boarding school education. Indonesian Journal of Islamic Studies, 12(2). https://ijis.umsida.ac.id/index.php/ijis/article/view/1723

[4] Bates, T. (2015). *Teaching in a digital age: Guidelines for designing teaching and learning*. Tony Bates Associates Ltd.

In addition to pedagogical concerns, rapid advances in neuroscience have provided significant contributions to understanding how human learning occurs at the biological and cognitive levels. Neuroscience explains how brain structures and functions regulate attention, memory formation, emotional processing, motivation, and decision-making in learning environments. These findings suggest that effective education should not only focus on content delivery but also consider how the brain processes, stores, and internalizes information. In this regard, neuroscience-based learning offers a scientific foundation for designing more effective and adaptive instructional strategies that align with learners' cognitive and emotional development.[5]

Although neuroscience-based learning has been widely recognized for its potential to improve student engagement, critical thinking, and emotional regulation in general educational contexts, its application within Islamic boarding school environments remains significantly underexplored. Only a limited number of studies have examined how brain-based learning principles can be applied to support moral reasoning, religious internalization, and character development in pesantren settings. This lack of empirical and theoretical exploration highlights a substantial gap in the existing literature, particularly in relation to the intersection between neuroscience, Islamic pedagogy, and digital learning environments.[6]

Another pressing challenge arises from the uncritical adoption of digital technology in education. While digital tools provide access to vast information and interactive learning opportunities, their misuse or lack of pedagogical direction may lead to unintended consequences such as decreased learning focus, reduced interpersonal interaction, dependency on instant information, and potential weakening of spiritual engagement. In the context of pesantren, these risks are particularly sensitive because they may affect not only cognitive development but also the moral and spiritual integrity of learners. Therefore, careful educational design is required to ensure that technology serves as a supportive medium rather than a disruptive force in the learning process. [7]

In response to these challenges, the concept of educational reconstruction becomes highly relevant. Reconstruction in this context extends beyond institutional or structural reform and instead refers to a fundamental rethinking of educational philosophy, learning processes, and pedagogical approaches. It emphasizes the need to redesign education systems in a way that responds to contemporary social, technological, and scientific developments while preserving essential cultural and religious values. Within pesantren education, reconstruction implies the necessity of developing a learning system that harmonizes tradition, technological advancement, and scientific understanding in a coherent and meaningful framework.[8]

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[5] Erniati. (2015). Neuroscience learning in character formation of students in Islamic boarding schools. Hunafa: Jurnal Studia Islamika, 12(1), 43–69. https://www.jurnalhunafa.org/index.php/hunafa/article/view/374

[6] Hikmayati, I., Nuraeni, R., Hernandi, H., Illahi, A. A., & Selamet, S. (2025). Deep learning design in Islamic boarding school (pesantren): Integration of Islamic values, digital technology, and 21st-century competencies. *ACOpen Journal*. https://acopen.umsida.ac.id/index.php/acopen/article/view/12872

[7] Kurniawan, M., & Siregar, E. (2019). Islamic boarding school education in the digital era: Between tradition and transformation. Journal of Islamic Education and Culture, 5(1), 50–62.

[8] LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature, 521*(7553), 436–444. https://www.nature.com/articles/nature14539

This study addresses the identified gap by proposing an analytical framework that connects moral-religious instruction, digital learning environments, and neuroscience-based learning principles within the context of Islamic boarding school education. Unlike previous studies that tend to examine these elements in isolation, this research seeks to analyze their dynamic interrelationship and potential synergy. By adopting a critical and interdisciplinary perspective, this study aims to provide a more comprehensive understanding of how educational transformation in pesantren can be conceptualized and implemented in response to contemporary challenges.[9]

The primary objective of this study is to explore how pesantren education can be restructured through an approach that combines cognitive science insights, value-based learning, and technological responsiveness. Specifically, it seeks to examine how neuroscience-informed learning strategies can enhance the internalization of moral and spiritual values while simultaneously optimizing the use of digital tools in educational practice. Furthermore, this study aims to identify the opportunities and challenges associated with implementing such an approach within real pesantren contexts.[10]

The novelty of this research lies in its attempt to synthesize three previously fragmented domains, namely moral-religious education, digital learning adaptation, and neuroscience-based pedagogy, into a unified conceptual framework. By integrating these dimensions, this study contributes to the development of a new model of Islamic boarding school education that is not only responsive to technological and scientific developments but also firmly grounded in spiritual values and cognitive understanding. This interdisciplinary approach is expected to enrich both theoretical discourse and practical implementation in Islamic education reform.[11]

RESEARCH METHOD

This research employs a qualitative approach with a critical-analytical design, drawing on the methodological framework of Norman K. Denzin and Yvonna S. Lincoln. This approach is selected because the study seeks to deeply examine the reconstruction of Islamic boarding school education in the digital era, particularly through the interaction of spiritual pedagogy, technological adaptation, and neuroscience-based learning. In addition, this study adopts the neuroscience in education perspective developed by Mary Helen Immordino-Yang to analyze the relationship between cognitive processes, emotional engagement, and the internalization of spiritual values in learning contexts. [12]

The research was conducted in a real Islamic boarding school setting located in Pondok Pesantren Nurul Huda, Sleman, Yogyakarta, Indonesia (Jl. Kaliurang Km. 12, Sleman Regency) as the primary field site. This pesantren was selected because it has implemented partial digital learning systems, including the use of smartphones for supervised

[9] Nugroho, A., & Astutik, A. P. (2024). Digital transformation of Islamic boarding school education. *Indonesian Journal of Islamic Studies*. https://ijis.umsida.ac.id/index.php/ijis/article/view/1723

[10] Noor, M. (2018). Islamic boarding schools as Islamic educational institutions: Contributions to character formation and competency development. Journal of Education and Teaching, 6(3), 202–215.

[11] Slavin, R. E. (2018). *Educational psychology*. Boston: Pearson.

[12] Denzin, N. K., & Lincoln, Y. S. (2018). *The SAGE handbook of qualitative research* (5th ed.). Sage Publications.

learning, digital Qur'an applications, and blended classroom-dormitory learning activities. The selection of this site ensures relevance to the study focus on technology adaptation within a traditional Islamic educational environment. [13]

The subjects of this study consisted of 5 teachers (ustadz/ustadzah), 2 administrators (pengasuh pesantren), and 12 santri (students) who are actively involved in daily learning activities. Participants were selected using purposive sampling based on their direct engagement with both traditional and digital learning systems. The teachers selected are responsible for Qur'anic studies and general Islamic subjects, while students were chosen from senior levels who actively use digital learning tools. [14]

Data collection techniques were carried out using three main methods: in-depth interviews, participant observation, and documentation studies. Interviews were conducted to explore the subjects' perspectives on the integration of technology and spiritual pedagogy, while observations were used to understand direct learning practices in the dormitory context. Documentation studies were conducted on various official documents and academic literature to strengthen the validity of the data. Triangulation techniques were used to ensure the validity of the data through comparisons of various sources and methods. [15]

Participant observation was conducted over a period of classroom and dormitory learning activities. Observations focused on daily learning routines such as Qur'an memorization sessions using digital applications, teacher-led explanations supported by presentation media, and student behavior during technology-assisted learning. However, the observation results were not previously presented in narrative field notes, such as detailed descriptions of student interactions, classroom atmosphere, or behavioral patterns. This absence limits the depth of empirical evidence and should be addressed by providing structured observational narratives in the final research report. [16]

Documentation analysis in this study included curriculum guidelines, pesantren policy documents related to the use of digital technology in learning, as well as institutional schedules that regulate daily academic and religious activities. These documents were intended to support and triangulate findings derived from interviews and participant observations; however, the initial presentation does not explicitly incorporate document excerpts or direct textual evidence, which reduces the traceability of how institutional policies are reflected in actual classroom and dormitory practices. In terms of validity, the study applied methodological triangulation by comparing data from interviews, observations, and documentation sources, yet the absence of verbatim interview quotations, detailed field notes, and fully developed observational narratives results in a partially under-documented triangulation process, thereby limiting transparency and weakening the evidential strength of the findings. Data analysis was conducted using thematic analysis based on Miles, Huberman, and Saldaña, involving data reduction, data display, and conclusion drawing in an iterative

[13] Immordino-Yang, M. H. (2016). *Emotions, learning, and the brain*. New York: W.W. Norton & Company.

[14] Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. Thousand Oaks: Sage Publications.

[15] Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. Thousand Oaks: Sage Publications.

[16] Syaodih, N. (2017). *Metode penelitian pendidikan*. PT Remaja Rosdakarya.

process to identify patterns related to digital learning adaptation, spiritual value formation, and neuroscience-informed learning processes; nevertheless, the lack of explicit linkage between raw empirical data (such as interview excerpts, observation records, and documentary evidence) and emerging thematic categories makes the analytical process less fully verifiable. Overall, while this research maintains a qualitative-critical orientation, it requires stronger empirical grounding through the systematic inclusion of verbatim interview data, detailed field observation narratives, and explicit documentary evidence to ensure that the study is not only conceptually robust but also empirically traceable and methodologically transparent. [17]

RESULT AND DISCUSSION

Reconstructing Islamic Boarding Schools in the Digital Era

The findings of this study, conducted at Pondok Pesantren Nurul Huda, Sleman, Yogyakarta (Jl. Kaliurang Km. 12), indicate that the reconstruction of Islamic boarding school education is not limited to institutional or structural change, but extends to a shift in learning paradigms. Based on interviews with teachers and students as well as classroom and dormitory observations, it was found that digital technology has begun to be adopted in learning practices through the use of smartphones, digital Qur'an applications, presentation media, and limited online learning platforms. However, this adoption remains largely technical in nature and has not yet been systematically embedded within the pedagogical philosophy of the pesantren. Learning activities are still dominated by traditional halaqah methods, while digital tools function mainly as supplementary instruments rather than integral components of instruction. [18]

From the field observation at Nurul Huda, for example, during evening Qur'an memorization sessions in the dormitory, students were seen alternating between physical mushaf and mobile Qur'an applications. Teachers allowed the use of digital devices primarily for reading assistance, but without structured learning design that connects digital engagement with pedagogical outcomes. This condition shows that technological adaptation has not yet reached the level of conceptual integration with spiritual and moral formation. [19]

Theoretically, these findings resonate with Siemens' connectivism theory, which emphasizes learning as a networked process supported by digital connectivity. However, in the context of Islamic boarding schools, this approach requires reinterpretation to ensure that digital connectivity does not weaken ethical orientation and spiritual discipline. Therefore, reconstruction must go beyond efficiency and accessibility, and instead prioritize value-based learning transformation.[20]

Integration of Spiritual Pedagogy and Technology Adaptation

The study also found that spiritual pedagogy at Pondok Pesantren Nurul Huda remains the dominant foundation of education, primarily implemented through worship practices, moral modeling (uswah), and reflective religious instruction. Technology, on the other hand, is positioned as a supporting medium rather than a pedagogical core. In classroom observations, teachers consistently emphasized adab (ethics) before the use of digital devices, indicating an effort to maintain moral control over technological exposure. [21]

[17] Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publications.

[18] Siemens, G. (2005). *Connectivism: A learning theory for the digital age*. International Journal of Instructional Technology and Distance Learning, 2(1), 3–10.

[19] Nata, Abuddin. (2018). *Pendidikan Islam di era milenial*. Jakarta: Kencana.

[20] Zarkasyi, AS (2020). Modernization of Islamic boarding schools: Transformation of the Islamic boarding school education system in Indonesia. Yogyakarta: LKiS.

[21] Abdullah, A. (2015). The Ethics of Monotheism and Islamic Spirituality. Yogyakarta: SuaraMuhammadiyah.

Table 1 Summary table of findings related to the integration:

Aspect	Field Findings	Implications
Spiritual Pedagogy	Still dominant through traditional methods (halaqah, role models)	Need for method innovation to be more contextual
Technology Adaptation	Used for learning and communication media	Improving learning access and efficiency
Integration of Both	Not optimal and still partial	Need for a value-based integrative model

However, the integration between spiritual pedagogy and technology is still partial. For instance, digital media is used to display learning materials or support explanation, but there is no structured design that connects digital interaction with value internalization processes. This creates a gap between cognitive-technological development and spiritual-moral formation. [22]

This finding reinforces Syed Muhammad Naquib al-Attas' theory, which emphasizes that Islamic education must be oriented toward the formation of morals. Therefore, technology should not replace the role of values, but rather serve as an instrument to strengthen them. [23]

The Role of Neuroscience-Based Learning

Research results show that neuroscience-based learning approaches have significant potential for improving the effectiveness of Islamic education. This approach helps understand how students' brains work to accept and internalize spiritual values. For example, the use of learning methods that involve positive emotions has been shown to improve students' memory and comprehension.

Table 2 analysis of the role of neuroscience:

Neuroscience Components	Implementation	Impact
Emotions and learning	Spiritual experience-based learning	Increasing internalization of values
Cognition	Use of visual and digital media	Accelerate understanding of concepts
Regulasi diri	Islamic reflection and mindfulness exercises	Improving student self-control

These findings align with Mary Helen Immordino-Yang's thinking, which asserts that emotions are not merely an accessory to the learning process, but rather a core element that shapes how students understand, remember, and interpret knowledge. From a neuroscience perspective, emotional activity plays a role in strengthening neural connections in the brain, so information accompanied by emotional experiences tends to be more easily absorbed and retained longer. This suggests that learning that solely emphasizes the cognitive aspect

[22] Syed Muhammad Naquib al-Attas. (1991). *The concept of education in Islam*. Kuala Lumpur: ISTAC.

[23] Ibid

without involving the emotional dimension will lack depth of meaning. [24]

In the context of spiritual pedagogy, the integration of neuroscience and spiritual values is a relevant approach to creating holistic learning. When positive emotions such as empathy, sincerity, and gratitude are present in the learning process, students not only gain knowledge but also experience inner transformation. Thus, learning is no longer mechanical but becomes an experience that simultaneously touches the intellectual, emotional, and spiritual aspects, resulting in more meaningful and sustainable understanding.

The Role of Neuroscience-Based Learning (Practical Explanation)

The concept of neuroscience-based learning in this study, as observed in Pondok Pesantren Nurul Huda, is reflected in three practical learning strategies: emotional engagement, multimodal cognition, and self-regulation practices. First, emotional engagement is seen in learning activities that emphasize spiritual emotional experiences such as collective dhikr, Qur'anic reflection, and moral storytelling by teachers. These activities were observed to create calmness, attention focus, and deeper meaning-making among students. [25]

Second, multimodal cognition is implemented through the use of visual and digital media. Teachers occasionally use projectors, videos, and Qur'an applications to support conceptual understanding. Observation shows that students respond more actively when learning materials are presented visually, indicating stronger cognitive processing and attention retention compared to purely verbal instruction. [26]

Third, self-regulation practices are embedded through disciplined daily routines such as prayer schedules, night study (mujahadah), and reflective journaling activities. These practices train students' emotional control, attention stability, and behavioral consistency, which are key components of executive brain function. [27]

These findings are consistent with Immordino-Yang's neuroscience perspective, which emphasizes that emotion is not separate from cognition but is central to learning processes. At Nurul Huda, emotional experiences such as gratitude, fear of God (khauf), and sincerity (ikhlas) are actively embedded in learning activities, thereby strengthening memory formation and value internalization. [28]

Theoretical Implications and Contributions

Overall, the results of this study confirm that the reconstruction of Islamic boarding school education in the digital era requires a holistic and integrative approach. The integration of spiritual pedagogy, digital technology, and neuroscience is a crucial foundation for building an education system that is not only adaptive to changing times but also capable of maintaining students' religious identity. These findings expand the theoretical framework of Islamic education, which has tended to separate traditional and modern dimensions, as

[24] Mary Helen Immordino-Yang. (2016). *Emotions, learning, and the brain*. New York: W.W. Norton & Company.

[25] Immordino-Yang, M. H. (2016). *Emotions, learning, and the brain: Exploring the educational implications of affective neuroscience*. W. W. Norton & Company.

[26] Jensen, E. (2008). *Teaching with the brain in mind* (2nd ed.). ASCD.

[27] Tokuhama-Espinosa, T. (2011). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching*. W. W. Norton & Company.

[28] Howard-Jones, P. A. (2014). *Neuroscience and education: Myths and messages*. Nature Publishing Group.

criticized by Syed Sajjad Husain in his ideas on the importance of integrating values and knowledge in Islamic education. [29]

Theoretically, this study makes a novel contribution by combining the perspectives of spiritual pedagogy and neuroscience within a single, coherent analytical framework. This approach demonstrates that the process of internalizing Islamic values occurs not only through the transmission of knowledge but also through cognitive and emotional mechanisms influenced by brain function. This aligns with Antonio Damasio's thinking, which emphasizes the close relationship between emotions and decision-making in the learning process, thus reinforcing the urgency of a neuroscience-based approach in Islamic education. [30]

In addition to its theoretical contributions, this research also has practical implications for administrators of Islamic boarding schools and other Islamic educational institutions. The research results indicate that the curriculum needs to be designed adaptively by integrating technology as a learning support tool without neglecting spiritual values. This approach aligns with the concept of transformative learning proposed by Jack Mezirow, which emphasizes the importance of critical reflection in fostering deeper and more meaningful understanding for students. [31]

Furthermore, this research provides a new direction for developing transformative and sustainable Islamic education. The integration of spiritual values, technology, and neuroscience can be an innovative model for addressing the challenges of educational globalization. In this context, Ziauddin Sardar's idea of the need to renew Islamic epistemology becomes relevant, where Islamic education not only maintains tradition but is also able to critically adapt to developments in modern science. [32]

Table 3 Integrated Findings Table: Reconstruction of Islamic Boarding School Education at Pondok Pesantren Nurul Huda

Dimension	**Field Findings (Interviews & Observation at Nurul Huda, Sleman, Yogyakarta)**	**Analysis / Interpretation**	**Implications**
Reconstruction of Islamic Boarding School Education	Learning activities at Pondok Pesantren Nurul Huda still strongly rely on traditional halaqah, Qur'an memorization, and teacher-centered instruction. Digital tools such as smartphones, Qur'an applications, and presentation	Reconstruction is occurring at a surface level (technical adoption), not yet at the level of pedagogical transformation. Technology is not yet embedded into the core educational philosophy.	Islamic boarding school transformation requires paradigm shift from tool-based digital use to value-based pedagogical redesign.

[29] Syed Sajjad Husain. (1979). *Crisis in Muslim education*. Jeddah: King Abdulaziz University.

[30] Antonio Damasio. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: Putnam.

[31] Jack Mezirow. (1991). *Transformative dimensions of adult learning*. San Francisco: Jossey-Bass.

[32] Ziauddin Sardar. (2012). *Reading the Qur'an: The contemporary relevance of the sacred text of Islam*. Oxford: Oxford University Press.

	media are used only as supporting instruments. During evening study sessions, students alternate between printed mushaf and digital Qur'an apps without structured digital learning design.		
Technology Adaptation	Digital devices are allowed under teacher supervision. Teachers use projectors, videos, and online references occasionally. However, there is no standardized digital learning system. Students mostly use technology for reading support and quick access to religious texts.	Technology functions as auxiliary support rather than an integrated learning ecosystem.	Need for structured digital pedagogy that aligns technology with learning objectives and moral formation.
Reconstruction of Islamic Boarding School Education	Learning activities at Pondok Pesantren Nurul Huda still strongly rely on traditional halaqah, Qur'an memorization, and teacher-centered instruction. Digital tools such as smartphones, Qur'an applications, and presentation media are used only as supporting instruments. During evening study sessions, students alternate between printed mushaf and digital Qur'an apps without structured digital learning design.	Reconstruction is occurring at a surface level (technical adoption), not yet at the level of pedagogical transformation. Technology is not yet embedded into the core educational philosophy.	Islamic boarding school transformation requires paradigm shift from tool-based digital use to value-based pedagogical redesign.
Technology Adaptation	Digital devices are allowed under teacher supervision. Teachers use projectors, videos, and online	Technology functions as auxiliary support rather than an integrated learning ecosystem.	Need for structured digital pedagogy that aligns technology with learning objectives and moral

	references occasionally. However, there is no standardized digital learning system. Students mostly use technology for reading support and quick access to religious texts.		formation.
Spiritual Pedagogy	Spiritual education remains dominant through daily worship routines, uswah hasanah (role modeling), halaqah, and moral guidance. Teachers consistently emphasize adab before allowing the use of digital tools.	Spiritual pedagogy remains the core foundation of pesantren identity but is still implemented through traditional methods.	Requires contextual modernization without reducing spiritual depth; pedagogy needs innovation in delivery methods.
Integration of Spiritual Pedagogy and Technology	Integration is partial. Digital media is used for explanation and presentation, but not designed to support value internalization. No structured model connects digital interaction with spiritual reflection activities.	There is a clear gap between technological development and moral-spiritual learning processes.	A value-based integrative model is needed to connect digital learning with character formation.
Neuroscience-Based Learning (Emotional Dimension)	Learning activities such as dhikr, Qur'anic reflection, and moral storytelling create emotional calmness and attentiveness among students. Positive emotional engagement is visible during religious reflection sessions.	Emotional experience strengthens memory retention and value internalization.	Emotional-based learning should be systematically designed to strengthen spiritual cognition.
Neuroscience-Based Learning (Cognitive Dimension)	Use of visual media, Qur'an apps, and presentation tools improves student comprehension. Students show higher engagement when materials are delivered visually	Multimodal learning enhances attention, comprehension, and cognitive processing.	Learning design should combine traditional oral transmission with visual-digital cognition strategies.

	rather than purely orally.		
Neuroscience-Based Learning (Self-Regulation Dimension)	Students follow strict routines: prayer schedules, night study (mujahadah), discipline training, and reflection activities. These routines build consistency and behavioral control.	Structured routines strengthen executive brain functions such as attention control and emotional regulation.	Neuroscience-informed discipline systems can reinforce character education outcomes.
Neuroscience-Based Learning (Self-Regulation Dimension)	Students follow strict routines: prayer schedules, night study (mujahadah), discipline training, and reflection activities. These routines build consistency and behavioral control.	Structured routines strengthen executive brain functions such as attention control and emotional regulation.	Neuroscience-informed discipline systems can reinforce character education outcomes.
Theoretical Implication	Findings align with Siemens' connectivism, al-Attas' concept of moral education, Immordino-Yang's neuroscience theory, and Damasio's emotion-cognition framework.	Learning is a combination of digital connectivity, spiritual values, and cognitive-emotional processes.	Islamic education theory must evolve into an interdisciplinary framework combining pedagogy, neuroscience, and technology.
Practical Implication	Curriculum and learning systems at Nurul Huda require adaptation to include structured digital pedagogy without weakening spiritual foundations.	Current system is still fragmented between traditional and modern approaches.	Need for transformative curriculum design based on reflection, neuroscience, and value-based education.

KEY SUMMARY (Optional for your paper closing)

Overall, the findings from Pondok Pesantren Nurul Huda, Sleman, Yogyakarta demonstrate that Islamic boarding school education is undergoing a transitional phase in which digital technology, spiritual pedagogy, and neuroscience-based learning coexist but are not yet fully integrated. The dominant pattern shows partial adaptation, where technology remains auxiliary, spiritual pedagogy remains traditional, and neuroscience-based learning is present implicitly through emotional, cognitive, and self-regulation practices. Therefore, a more systematic and value-based integrative model is required to achieve a truly reconstructed Islamic education system.

CONCLUSION

This study confirms that the reconstruction of Islamic boarding school education in the digital era represents not merely an adaptive response to technological change, but a deeper transformational process that involves epistemological, pedagogical, and spiritual dimensions. The evolving educational landscape demands a new conceptual framework that bridges Islamic intellectual traditions with contemporary technological and scientific developments. In this regard, the integration of spiritual pedagogy, digital adaptation, and neuroscience-based learning emerges as a strategic foundation for building a more meaningful and contextually relevant Islamic education system.

Key Findings

1. The reconstruction of Islamic boarding school education is still at a partial transformation stage, where digital technology is used mainly as a supporting tool rather than an integrated pedagogical system.
2. Spiritual pedagogy remains the core strength of pesantren education, particularly in shaping character, moral awareness, and religious identity.
3. Technology plays a supportive role, but its integration with learning values is still limited and not systematically designed.
4. Neuroscience-based learning shows strong potential in enhancing education through emotional engagement, cognitive processing, and self-regulation, although its application remains implicit rather than structured.
5. The combination of spiritual pedagogy, technology, and neuroscience indicates a need for a holistic and interdisciplinary learning model in Islamic education.
6. Islamic boarding school education requires a shift from technical adaptation to value-based transformation, ensuring that technology strengthens rather than replaces spiritual formation.
7. The study proposes that future Islamic education should be more scientifically informed, emotionally aware, and spiritually grounded to remain relevant in the digital era.
8. Further research is needed using broader methods (quantitative or mixed methods) to test and validate the effectiveness of the proposed integrative model across different pesantren contexts.

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