https://research.adra.ac.id/index.php/islamicstudies
P - ISSN: 3048-3980
E - ISSN: 3048-4146

Navigating Disruption: E-Learning Adoption and Digital Pedagogy Challenges in Traditional Islamic Boarding Schools

Mohammed Al-Hamadi[1], Rasha Al-Ansari[2], Ahmed Al-Khalil[3]
[1] American University of Sharjah, UAE
[2] American University in Dubai, UAE
[3] Abu Dhabi University, UAE

ABSTRACT

Digital transformation in education has accelerated rapidly, presenting both opportunities and disruptions for traditional Islamic boarding schools (pesantren) that have long relied on face-to-face, text-centered, and teacher-led instructional traditions. The shift toward e-learning environments challenges established pedagogical norms, teacher authority, and communal learning structures that are central to pesantren identity. The growing pressure to integrate digital tools highlights the need to understand how pesantren negotiate pedagogical, technological, and cultural tensions during this transition. This study aims to analyze the extent of e-learning adoption, identify the key challenges faced by teachers and students, and examine how digital pedagogy aligns—or conflicts—with traditional Islamic educational practices. A mixed-methods design was employed, combining surveys from 220 teachers and students in selected pesantren with in-depth interviews involving kyai, ustadz, and senior students. Descriptive and inferential analyses were conducted to assess levels of digital readiness, perceived usefulness of e-learning tools, and barriers encountered during implementation, while thematic analysis captured cultural and pedagogical insights. The findings reveal low-to-moderate levels of digital adoption, constrained primarily by limited infrastructure, low digital literacy, and concerns about maintaining adab and discipline in online environments. Teachers reported significant challenges in designing digital instructional materials, while students experienced decreased engagement and difficulty adapting to self-directed learning. Despite these obstacles, some pesantren demonstrated innovative hybrid models that preserved traditional learning values while incorporating digital platforms. The study concludes that successful e-learning transformation requires culturally responsive digital pedagogy, targeted training for educators, and institutional strategies that harmonize technology with pesantren's spiritual-communal ethos.

KEYWORDS

Digital Pedagogy, Educational Disruption, Islamic Boarding Schools, Pesantren

Citation: Al-Hamadi, M., Al-Ansari, R., & Al-Khalil, A. (2025). Navigating Disruption: E-Learning Adoption and Digital Pedagogy Challenges in Traditional Islamic Boarding Schools. *Islamic Studies in the World*, *2*(5), 13–25.
https://doi.org/10.17323/islamicstudies.v2i5.2941

Correspondence:
Mohammed Al-Hamadi,
mohammedalhamadi@gmail.com

Received: April 05, 2025
Accepted: July 17, 2025
Published: October 07, 2025

INTRODUCTION

Traditional Islamic boarding schools, or pesantren, represent one of the oldest and most resilient educational institutions in Southeast Asia, maintaining deeply rooted pedagogical traditions centered on kitab kuning, face-to-face mentoring, and the authority of the kyai (Zaman & Fajriana, 2025). These institutions emphasize discipline, communal learning, and religious immersion, forming a

holistic environment that shapes both intellectual and moral development (Rey-Becerra dkk., 2026). Their continuity across centuries illustrates remarkable adaptability despite broader societal changes.

Recent advances in information and communication technologies have reshaped global education systems, accelerating the shift toward digital learning and remote instruction (Rodolico dkk., 2025). E-learning platforms, virtual classrooms, and digital learning resources have become integral components of contemporary pedagogy, particularly following global disruptions such as pandemics and rapid digital expansion (Amin dkk., 2025). Educational systems worldwide increasingly rely on digital competencies as essential components of 21st-century learning.

Pesantren have not been exempt from these changes, as external pressures from government policy, societal expectations, and technological advancement continue to push for modernization in teaching and learning (Suresman dkk., 2025). Administrators and teachers face growing demands to integrate digital tools to improve accessibility, instructional quality, and academic competitiveness (Juhary, 2011). These pressures illustrate the increasing relevance of technology literacy even within traditional religious institutions.

Existing studies highlight that digital adoption in Islamic schools varies widely, influenced by infrastructure availability, leadership support, and teacher readiness (Mahmud dkk., 2022). Some pesantren have begun experimenting with hybrid learning models that combine online platforms with traditional recitation methods, while others maintain minimal engagement with technology due to concerns about cultural preservation (Utomo & Martini, 2025). Variability across institutions demonstrates the complexity of integrating technology in religious learning settings.

Scholars agree that digital pedagogy introduces both opportunities and challenges within traditional Islamic education. Opportunities arise through enhanced access to resources, individualized learning, and more efficient administrative processes (Sharifkhani dkk., 2023). Challenges emerge involving disruptions to established norms, reduced authority of human teachers, and concerns about preserving adab, discipline, and spiritual concentration in online environments. These tensions reflect broader global debates about technology's role in shaping educational values.

Current discourse acknowledges that the digitalization of learning environments requires rethinking pedagogical frameworks, training programs, and learning culture. Pesantren leaders increasingly recognize that technology adoption must align with institutional identity and religious mission. Effective integration depends not only on technological readiness but also on cultural compatibility, teacher beliefs, and organizational willingness to adapt (Dayal, 2023). This dynamic underscores the need for deeper analysis of how pesantren navigate digital transformation.

Limited research explains how traditional pesantren negotiate tensions between digital innovation and deeply established pedagogical-pietistic traditions (Jonathan, 2025). The internal decision-making processes, cultural negotiations, and practical adaptations occurring during digital adoption remain insufficiently explored. This knowledge gap restricts a full understanding of how technology interacts with the religious learning ecosystem.

Little is known about the specific digital pedagogical challenges experienced by teachers and students within pesantren environments. Existing studies often generalize e-learning adoption in Islamic schools without differentiating the unique structural, cultural, and epistemological characteristics of pesantren learning (Huangfu dkk., 2025). The absence of context-specific insights reduces the effectiveness of policy and training recommendations.

Evidence remains scarce regarding how pesantren communities perceive the impact of digital tools on religious discipline, memorization practices, and interpersonal spiritual guidance (Maita

dkk., 2024). The cultural sensitivity embedded in pesantren education suggests that digital transformation carries implications beyond academic performance, affecting ethical formation and communal cohesion (Barkoczi & Roman, 2025). These dimensions require deeper empirical examination.

Current literature provides minimal comparative data on varying adaptation strategies across different pesantren types—salaf, khalaf, urban-based, and rural-based (Kovalchuk dkk., 2025). Diverse institutional identities suggest that each pesantren may respond uniquely to technological disruption (Semerikov dkk., 2025). Understanding these differences is essential for developing scalable and culturally responsive digital education frameworks.

Investigating e-learning adoption in pesantren is essential for informing educational policy and supporting institutions in transitioning toward sustainable, culturally aligned digital ecosystems (Aborisade, 2009). A clearer understanding of the pedagogical and cultural challenges will allow policymakers, educators, and Islamic organizations to design solutions that respect the unique identity of pesantren while improving instructional quality.

Identifying specific obstacles—such as digital literacy gaps, infrastructural limitations, or resistance due to cultural concerns—enables the development of targeted interventions, training modules, and hybrid learning models that preserve religious values while leveraging technological strengths (Mavrikis dkk., 2019). Such insights ensure that digital transformation enhances, rather than disrupts, the spiritual and academic missions of pesantren.

This study hypothesizes that the success of e-learning adoption in pesantren depends not only on technological access but also on cultural negotiation, teacher readiness, and institutional leadership (Suresh Babu dkk., 2025). Filling this gap provides a conceptual and empirical foundation for designing digital pedagogy frameworks that integrate tradition with innovation, supporting pesantren in navigating educational disruption in a rapidly digitalizing world.

RESEARCH METHODOLOGY

The study employed a mixed-methods research design to capture both the measurable patterns of e-learning adoption and the deeper cultural-pedagogical dynamics occurring within traditional Islamic boarding schools (Muthmainnah dkk., 2025). The quantitative component utilized a descriptive–inferential survey to assess levels of digital readiness, perceived usefulness of e-learning tools, and specific obstacles encountered by teachers and students. The qualitative component incorporated interviews, focus groups, and document analysis to explore the cultural negotiations, pedagogical concerns, and institutional responses shaping technology integration within pesantren (Unsriana dkk., 2025). The combined design ensured a holistic understanding of the disruptions, enabling triangulation of numerical trends and rich contextual insights.

The population consisted of teachers, administrators, and students from selected traditional Islamic boarding schools representing both salaf and khalaf pesantren in Indonesia. The sample included 220 respondents for the survey phase, selected through stratified sampling to ensure representation across institutional roles, gender groups, and pesantren typologies. A smaller qualitative subsample of 24 participants—comprising kyai, senior ustadz, and student leaders—was purposively selected to obtain varied perspectives on digital transformation and pedagogical adaptation. The sampling strategy ensured that the dataset reflected instructional, administrative, and learner experiences within diverse pesantren environments.

The quantitative data were collected using a structured questionnaire consisting of Likert-scale items measuring digital competency, perceived challenges, infrastructure readiness, and acceptance of e-learning tools (Liu dkk., 2025). The instrument also included items adapted from

established technology acceptance frameworks such as the Technology Acceptance Model (TAM) and the Digital Readiness Index to enhance validity (Aboderin dkk., 2025). Qualitative data were obtained through semi-structured interview guides designed to elicit narratives about cultural tensions, pedagogical adjustments, and institutional strategies for managing disruption. Additional supporting instruments included observation sheets and school document review protocols focusing on digital policies, teaching schedules, and learning materials.

Data collection proceeded in two sequential phases, beginning with the administration of online and paper-based surveys in participating pesantren. Respondents completed the instruments during scheduled academic sessions under the supervision of trained research assistants to ensure clarity and reduce response bias (Yong dkk., 2019). Interview sessions were conducted in person within pesantren settings, allowing researchers to observe learning environments, teacher–student interactions, and existing technological facilities. Data from all sources were transcribed, coded, and analyzed using both statistical software—employing descriptive and inferential techniques—and qualitative thematic analysis (McIntyre, 2012). Integration of the findings occurred during the interpretation stage to generate a comprehensive understanding of e-learning adoption and digital pedagogy challenges within traditional Islamic boarding schools.

RESULT AND DISCUSSION

The descriptive statistics indicate that overall e-learning adoption in traditional Islamic boarding schools remains at a low-to-moderate level. Survey results show that 62% of teachers reported limited confidence in using digital tools, while 58% of students indicated difficulties in navigating online learning platforms. Infrastructure readiness was also constrained, with only 41% of pesantren reporting stable internet connectivity and adequate device availability. These results highlight a foundational technological gap that restricts smooth implementation of digital learning environments.

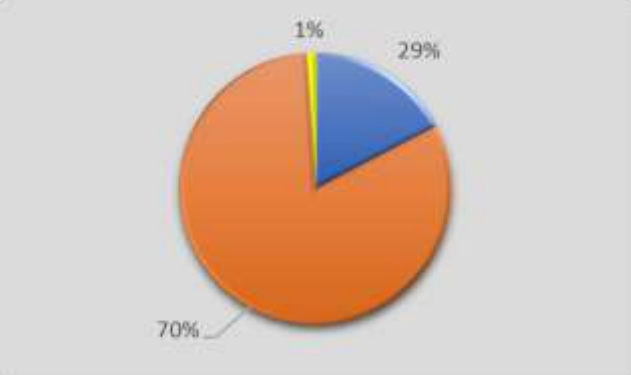

Figure 1. The Digital Divide in Traditional Islamic Education: Adoption and Infrastructure

The descriptive data also reveal significant variations across pesantren types. Khalaf (modern) pesantren reported higher digital readiness scores compared to salaf (traditional) institutions, particularly in the areas of learning management system (LMS) usage and digital resource access. Students in modern pesantren demonstrated greater familiarity with multimedia learning, whereas students in traditional pesantren relied heavily on face-to-face recitation and kitab kuning methodologies. These descriptive trends point toward structural disparities in technological integration.

Table 1. Descriptive Statistics of E-Learning Readiness in Pesantren

Category	Percentage (%)	Description
Teacher digital confidence	38% high, 62% low	Majority report limited skill

Category	Percentage (%)	Description
Student platform proficiency	42% high, 58% low	More than half struggle using LMS
Internet stability	41% adequate, 59% poor	Limited infrastructure
Device availability	45% adequate, 55% inadequate	Many rely on shared devices
Institutional support	50% supportive, 50% weak	Leadership varies significantly

The descriptive patterns suggest that technological constraints shape the overall trajectory of e-learning adoption in pesantren. Limited connectivity, insufficient devices, and low digital competence result in uneven integration across subjects and grade levels. Institutions with stronger administrative support showed better readiness, indicating the central role of leadership in digital transformation. Teachers in these environments were more willing to experiment with digital methods and reported fewer pedagogical disruptions. The explanatory analysis further reveals that cultural perceptions also play a significant role. Many teachers expressed concerns about maintaining discipline, spiritual focus, and adab during online learning sessions. Students reported reduced feelings of communal learning, which traditionally forms the core of pesantren pedagogy. These cultural and pedagogical concerns help explain the cautious approach to digital adoption, reflecting the need to balance innovation with preservation of religious educational values.

The qualitative data indicate that teachers experience difficulty redesigning instructional activities to suit online platforms. Several ustadz noted that kitab kuning learning—traditionally dependent on oral commentary and direct teacher presence—is challenging to translate into asynchronous digital formats. Students echoed these sentiments, explaining that virtual sessions reduce opportunities for clarification and immediate feedback, resulting in decreased comprehension and engagement. The interview data also highlight that pesantren with preexisting exposure to digital tools adapted more quickly. These institutions employed multimedia lectures, recorded recitations, and online discussion groups to complement face-to-face learning. Administrators reported improved efficiency in communication and resource sharing, suggesting that digital tools, when used appropriately, enhance instructional management without undermining traditional practices.

The inferential results from the independent samples t-test reveal significant differences in digital readiness between salaf and khalaf pesantren ($p < 0.01$). The mean digital readiness score for khalaf pesantren ($M = 3.78$) exceeded that of salaf pesantren ($M = 2.91$), indicating that institutional modernization correlates with higher acceptance of e-learning tools. Regression analysis further showed that teacher digital literacy significantly predicts perceived e-learning effectiveness ($\beta = .46$, $p < .001$). The inferential results also show that infrastructure quality significantly predicts student engagement in online learning environments ($\beta = .39$, $p < .01$). Pesantren with stable internet and adequate devices reported higher student attendance and more consistent participation in digital tasks. These findings confirm the structural determinants of digital adoption, illustrating how technological capacity shapes educational outcomes.

Table 2. Inferential Statistics of Digital Readiness Factors

Variable	Coefficient (β)	Significance (p)
Teacher digital literacy → E-learningeffectiveness	.46	< .001
Infrastructure → Student engagement	.39	< .01
Leadership support → Digital adoption	.33	< .05
Pesantren type (salaf vs khalaf) → Readiness	—	< .01

Variable	Coefficient (β)	Significance (p)
score		
Student digital habit → Participation	.28	< .05

The relationship between digital literacy and adoption demonstrates that teachers' readiness directly influences the pace of pedagogical transformation. Higher digital competence correlates with greater enthusiasm for digital tools, more experimentation with e-learning features, and better student outcomes. This relational pattern underscores the centrality of teacher capacity building in any digital integration effort. Leadership support also strengthens these relationships by creating an environment conducive to innovation. The relational analysis between infrastructure and student engagement reveals a clear structural dependency. Students in pesantren with stable digital facilities participated more actively in synchronous sessions, submitted assignments more consistently, and interacted more frequently with instructors. These relational patterns confirm the interplay between technological and pedagogical factors, each reinforcing the other to shape learning experiences.

The case study of a rural salaf pesantren highlights significant challenges in transitioning to e-learning. Teachers reported difficulty conducting online recitations due to weak internet connectivity and lack of devices among students. Several students joined sessions using shared smartphones, resulting in reduced audio quality and fragmented learning experiences. Administrators acknowledged that digital learning disrupted traditional study routines and weakened the sense of communal learning central to pesantren identity. The contrasting case study of an urban khalaf pesantren demonstrates a more successful digital transition. The institution utilized a structured LMS, provided digital training for teachers, and incorporated multimedia Qur'anic recitation tools. Students described a smoother learning experience, citing improved access to materials and better flexibility in completing assignments. The teachers noted that digital platforms enabled them to monitor student progress more effectively.

The contrasting case studies illustrate the diversity of adaptation experiences among pesantren. Rural institutions face deeper structural and cultural barriers that amplify disruptions during digital adoption. Limited resources, strong adherence to traditional learning styles, and minimal technological exposure hinder the establishment of digital routines. These factors collectively explain the low engagement levels observed in the descriptive data. The urban pesantren case underscores how institutional investment and openness to innovation enable smoother transitions. Teachers who received digital training reported greater confidence, while students benefitted from integrated hybrid learning models. This synthesis explains the significant statistical differences between pesantren types and highlights the influence of institutional culture on digital adaptability.

The results collectively indicate that digital pedagogy adoption in traditional Islamic boarding schools is shaped by a combination of technological capacity, cultural values, and teacher readiness. Integration efforts succeed when supported by adequate infrastructure, leadership endorsement, and pedagogical training. Institutions lacking these conditions experience deeper disruptions and reduced student engagement. The overall interpretation suggests that e-learning implementation in pesantren is not simply a technological challenge but a cultural-pedagogical negotiation. Digital tools must be aligned with the spiritual, communal, and disciplinary traditions of pesantren to be effective. These findings reinforce the need for culturally responsive approaches to digital transformation within Islamic educational contexts.

The findings demonstrate that e-learning adoption in traditional Islamic boarding schools remains uneven, with overall readiness levels categorized as low to moderate. Teachers and

students reported significant challenges related to digital literacy, infrastructure limitations, and difficulty adapting pesantren's oral and communal learning model to online platforms (Qumbisa & Awuzie, 2025). Quantitative data highlighted structural constraints, while qualitative insights revealed deep cultural concerns related to maintaining discipline, adab, and spiritual immersion during digital learning. The results show clear disparities between salaf and khalaf pesantren, with modern institutions displaying higher digital readiness and better integration of online tools. Statistical analyses confirmed significant differences in digital adoption based on institutional type, leadership support, and technological access (Ursachi dkk., 2025). Case study findings further illustrated contrasting experiences, where urban pesantren demonstrated smoother transitions while rural pesantren faced persistent barriers.

The findings also indicate that teacher capacity plays a central role in digital transformation. Institutions with systematic digital training programs showed stronger adoption rates and more innovative instructional practices. Students in these environments reported higher engagement and greater satisfaction with blended learning models, suggesting that pedagogical readiness is as critical as technological readiness (Adi Badiozaman dkk., 2022). The combined results portray digital adoption as a complex interaction between technology, culture, and pedagogy. Pesantren do not reject technology categorically but engage in selective, negotiated adoption shaped by religious values, institutional identity, and perceived threats to traditional learning. The findings thus reflect a nuanced form of disruption management rather than outright acceptance or resistance.

Existing literature on digital adoption in Islamic schools identifies digital literacy and infrastructure as dominant barriers, and the present study aligns with these findings. The patterns observed in this research confirm global trends indicating that traditional educational institutions experience greater resistance and slower adoption than modern schools (Sadasivan dkk., 2025). The similarity suggests that pesantren are influenced by the universal structural constraints facing low-resource educational communities. Comparative studies on religious education emphasize the importance of cultural compatibility for successful ICT integration, and the current results reinforce this claim. The insistence on maintaining adab and teacher authority mirrors concerns raised in previous studies from Middle Eastern madrasas and South Asian Islamic seminaries. The consistency across different cultural contexts points to a shared pedagogical ethos within Islamic education.

The findings diverge from research that assumes technology inherently improves learning effectiveness regardless of context. The results here show that digital tools can weaken pedagogical foundations when implemented without cultural alignment or teacher readiness. This contrast highlights the limitations of techno-centric approaches that overlook the socio-religious dynamics shaping learning environments. The study contributes new perspectives by demonstrating that pesantren engage in adaptive, hybrid strategies rather than binary acceptance or rejection. Previous research tends to categorize Islamic institutions as resistant to modernization, but the present study reveals a more flexible and contextually informed form of negotiation (Borazon dkk., 2025). This difference enriches the discourse by portraying pesantren as active agents in shaping their digital futures.

The findings indicate that digital disruption is not solely a technological event but a cultural-pedagogical negotiation within pesantren. The tensions observed between maintaining traditional learning values and adopting modern platforms reflect the institution's effort to preserve its identity in the digital era (Yan, 2025). This negotiation signifies that pesantren value continuity of tradition while acknowledging the educational demands of contemporary society. The results highlight that digital learning challenges deeply held assumptions about authority, community, and discipline in

Islamic education. E-learning shifts certain forms of control from teachers to students and technologies, signaling a transformation in how religious knowledge is transmitted. This shift marks a critical stage in the evolution of pesantren pedagogy, where sacred traditions encounter digital autonomy.

The variability across pesantren indicates that institutional culture plays a decisive role in shaping responses to digital disruption. Institutions with a modern orientation showed adaptability, whereas traditional pesantren exercised caution rooted in concerns about spiritual integrity. This pattern suggests that digital transformation mirrors broader debates on modernization within Islamic communities (Ali dkk., 2025). The findings also signal the emergence of new hybrid pedagogical models that integrate technology without abandoning tradition. Examples include digital recitation tools, online kitab kuning forums, and structured LMS-based discussion groups. These innovations point toward a future where pesantren develop culturally grounded digital ecosystems capable of strengthening their educational missions.

The results hold significant implications for policymakers, educational designers, and pesantren leaders. Digital transformation cannot be approached as a purely technical initiative; it requires cultural sensitivity, teacher preparation, and long-term institutional support. Policies must reflect the unique spiritual and communal functions of pesantren to avoid misalignment between digital expectations and traditional values (Nikolopoulou, 2023). The findings imply that investment in digital infrastructure alone is insufficient to ensure successful e-learning adoption. Teacher training and pedagogical redesign emerge as essential components of digital readiness. Institutions that focus on these aspects are more likely to integrate digital tools effectively and sustain learning quality during disruptions.

The study suggests that e-learning can expand access to educational resources in pesantren, particularly for students who require differentiated learning support. Digital platforms provide opportunities for personalized feedback and flexible learning pathways, indicating potential benefits for academic performance when appropriately contextualized (Bose dkk., 2025). These implications encourage the development of pesantren-specific digital learning frameworks. The broader implication concerns the role of digital literacy in maintaining institutional resilience. Pesantren capable of integrating technology in culturally coherent ways may enhance their relevance and sustainability in the modern educational landscape. This perspective positions digital adoption not as a threat but as an opportunity for institutional strengthening.

The disparities in digital adoption stem from differences in institutional culture, leadership orientations, and historical teaching traditions. Pesantren with strong modernist leanings tend to embrace innovation more readily, while traditional institutions maintain cautious approaches based on theological and pedagogical considerations. This cultural differentiation explains the statistical differences between salaf and khalaf pesantren (Linda, 2024). The challenges reported by teachers and students arise from longstanding pedagogical norms that emphasize oral transmission, direct mentorship, and communal study. E-learning disrupts these norms by decentralizing authority and shifting learning responsibilities toward students. These structural changes create friction, which is reflected in the slow adoption patterns observed in the study.

The limited digital literacy among teachers contributes significantly to the difficulties experienced during digital transitions. Many educators lack formal training in instructional technology design, making them hesitant to adopt new tools (Wong dkk., 2020). This skill gap explains the reliance on traditional methods despite the availability of digital platforms. The uneven infrastructure across pesantren contributes to inconsistent adoption outcomes. Rural institutions face greater logistical challenges, resulting in poor connectivity and device shortages that undermine

digital learning efforts. These constraints explain why even willing pesantren struggle to implement e-learning effectively.

The results call for the development of culturally responsive digital pedagogy frameworks tailored specifically for pesantren. Training programs must address both technological skills and methods for harmonizing digital practices with Islamic educational values. Institutional leaders need to play an active role in guiding these transformations to ensure continuity of tradition (Hamzaoui dkk., 2024). The findings highlight the need for long-term capacity-building initiatives focused on teacher digital competence. Continuous professional development, mentorship, and peer learning networks can help teachers adapt to digital demands without feeling overwhelmed. Strengthening teacher agency will improve the sustainability of e-learning integration.

The study points toward the importance of designing hybrid models that preserve communal learning while leveraging digital efficiency. Blended approaches such as digital recitation assistance, online discussion forums, and LMS-based assignments can enhance learning without replacing the central role of the kyai and ustadz (Ali Abegaz & Ngassam, 2019). These models offer a balanced pathway forward. The next phase of research should expand the scope to multiple regions and pesantren affiliations, enabling comparative analyses that capture broader trends. Future studies may also explore long-term impacts on student spiritual development and the role of digital tools in shaping contemporary pesantren identity (Hargis dkk., 2014). These directions will deepen understanding of how Islamic education evolves amid digital transformation.

CONCLUSION

The most significant finding of this study lies in the identification of digital disruption as both a pedagogical and cultural challenge within traditional Islamic boarding schools, revealing that e-learning adoption is shaped not only by technological readiness but also by the preservation of pesantren identity, communal learning norms, and the central authority of the kyai. This study differs by demonstrating that digital integration in pesantren is not a simple progression from traditional to modern methods, but rather a negotiated process characterized by selective adaptation, hybridization, and cultural filtering. The dual influence of structural constraints and theological–pedagogical values emerged as the defining feature that distinguishes pesantren from other educational institutions undergoing digital transformation.

The primary contribution of this research lies in its conceptual advancement of a culturally responsive digital pedagogy framework tailored specifically for Islamic boarding schools, integrating technological, cultural, and religious dimensions into a single analytical model. The study enriches the literature by combining mixed-methods analysis with ethnographically informed insights, producing a holistic understanding of how digital tools interact with pesantren traditions. The methodological integration of quantitative digital readiness metrics with qualitative cultural narratives provides a replicable and context-sensitive approach for examining technology adoption in religious education systems, offering a new lens through which policymakers and educators can design interventions aligned with Islamic educational values.

The study's limitations stem from its focus on a limited sample of pesantren and the relatively short time frame of data collection, which may not fully capture long-term adaptation patterns or regional variations in digital adoption. The reliance on self-reported data introduces potential biases related to social desirability and institutional reputation, while infrastructural differences across schools constrain the generalizability of the findings. Future research should extend to longitudinal studies examining sustained behavioural, cultural, and pedagogical transformations; cross-regional comparisons to map national adoption trends; and deeper investigations into the spiritual, ethical,

and identity-related implications of digital learning within pesantren communities, enabling a more comprehensive understanding of how traditional Islamic education evolves under conditions of technological disruption.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

REFERENCES

Aboderin, O. S., Pietersen, D., & Langeveldt, D. (2025). Exploring the Promotion of Skills Development in an Odel Space Vis-À-Vis 4IR Technologies in Sub-Saharan Africa. *International Journal of Learning, Teaching and Educational Research*, *24*(9), 584–600. Scopus. https://doi.org/10.26803/ijlter.24.9.29

Aborisade, P. (2009). Investigating a Nigerian XXL-Cohort WIKI-learning experience: Observation, feedback and reflection. Dalam F. Salajan (Ed.), *Proc. Int. Conf. E-Lear., ICEL* (Vol. 2009-January, hlm. 1–9). Academic Conferences Limited info@academic-conferences.org; Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84938683270&partnerID=40&md5=3a5778f0e31507b82fdd972e49b10a4a

Adi Badiozaman, I. F., Leong, H. J., & Wong, W. (2022). Embracing educational disruption: A case study in making the shift to a remote learning environment. *Journal of Applied Research in Higher Education*, *14*(1), 1–15. Scopus. https://doi.org/10.1108/JARHE-08-2020-0256

Ali Abegaz, Z., & Ngassam, E. (2019). A Generic Framework for eLearning Adoption. Dalam P. Cunningham & M. Cunningham (Ed.), *IST-Africa Week Conf., IST-Africa*. Institute of Electrical and Electronics Engineers Inc.; Scopus. https://doi.org/10.23919/ISTAFRICA.2019.8764857

Ali, S. R., Memon, M. I., Hussain, J., Mohatram, M., & Faraz, M. (2025). Digital Learning Platforms and Blockchain for Entrepreneurial Skill Development: Bridging Gaps in Education and Practice. *IEEE Access*, *13*, 180877–180890. Scopus. https://doi.org/10.1109/ACCESS.2025.3622194

Amin, S. M., Hanafiah, M., Sabirin, M. I., Zalikha, S., & Hadi, M. (2025). Strengthening Muslim Family Faith and the Importance of Da'wah in the Digital Age: Insights from Scholars of Al-Aziziyah Samalanga Islamic Boarding School through the Lens of Islamic Philosophy. *El-Usrah*, *8*(1), 406–427. Scopus. https://doi.org/10.22373/q48epp30

Barkoczi, N., & Roman, A. F. (2025). Pedagogical Implications of the Adoption of Educational Technologies in Initial Teacher Training. Dalam *Innov. Approaches to contemp. Trends in educ.* (hlm. 239–252). Peter Lang AG; Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105024933153&partnerID=40&md5=8f106553d302b0321bf3dab535a97583

Borazon, E. Q., Marques, S., & Saycon, D. R. (2025). E-learning adoption: A comparative analysis of public sentiments during COVID-19. *Information Technology for Development*, *31*(4), 792–820. Scopus. https://doi.org/10.1080/02681102.2024.2423286

Bose, A., Chatterjee, S., & Gangopadhyay, S. (2025). Developing a digital learning platform to improve educational institution management through pedagogy and risk management. *Technology, Pedagogy and Education*. Scopus. https://doi.org/10.1080/1475939X.2025.2569506

Dayal, S. (2023). Roadblocks in education amidst global crisis- A study based in India. *PLOS ONE*, *18*(10 October). Scopus. https://doi.org/10.1371/journal.pone.0292465

Hamzaoui, R., Bachiri, Y. A., Ouassam, E., Mouncif, H., & Bouikhalene, B. (2024). A HYBRID APPROACH FOR ASSESSING DISTANCE LEARNING INSTRUCTIONAL VIDEOS USING ARTIFICIAL INTELLIGENCE. *International Journal on Technical and Physical Problems of Engineering*, *16*(3), 234–243. Scopus.

Hargis, J., Cavanaugh, C., Kamali, T., & Soto, M. (2014). A Federal Higher Education iPad Mobile Learning Initiative: Triangulation of Data to Determine Early Effectiveness. *Innovative Higher Education*, *39*(1), 45–57. Scopus. https://doi.org/10.1007/s10755-013-9259-y

Huangfu, Q., Wang, H., & Zhu, L. (2025). Examining the influences of peer and teacher support on chemistry learning satisfaction: An analysis of a serial mediation model. *Chemistry Education Research and Practice*, *26*(3), 734–747. Scopus. https://doi.org/10.1039/d5rp00074b

Jonathan, G. M. (2025). Rebooting Information Systems Pedagogy with Interactive Online Learning. *Am. Conf. Inf. Syst., AMCIS*, *4*, 2213–2222. Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105025421670&partnerID=40&md5=db22828aaebb8ee4de4aaeddae12c814

Juhary, J. B. (2011). The importance of e-pedagogy for a successful e-learning implementation. *Social Sciences*, *6*(4), 291–298. Scopus. https://doi.org/10.3923/sscience.2011.291.298

Kovalchuk, V., Kovalchuk, A., Vovk, B., Derevyanchuk, O., & Rozhkov, O. (2025). Model of Digitalization Professional Training of Future Vocational Education Teachers. *Environ. Technol. Resour. - Proc. Int. Sci. Pract. Conf.*, *3*, 195–201. Scopus. https://doi.org/10.17770/etr2025vol3.8560

Linda, N. (2024). Challenges to eLearning and Teaching During COVID-19 in South Africa. Dalam *Redefining Education and Development: Innovative Approaches in the Era of the Sustainable Development Goals* (hlm. 77–92). Springer Nature; Scopus. https://doi.org/10.1007/978-3-031-69954-2_6

Liu, Q., Wang, Z., & Yang, Q. (2025). From Barriers to Bridges: A TPACK-XL Framework for Knowledge Graph Integration in Higher Education. *Proc. Guangdong-Hong Kong-Macao Greater Bay Area Educ. Digit. Comput. Sci. Int. Conf. EDCS*, 767–773. Scopus. https://doi.org/10.1145/3746469.3746588

Mahmud, M. M., Freeman, B., & Abu Bakar, M. S. (2022). Technology in education: Efficacies and outcomes of different delivery methods. *Interactive Technology and Smart Education*, *19*(1), 20–38. Scopus. https://doi.org/10.1108/ITSE-01-2021-0021

Maita, I., Saide, S., Putri, A. M., & Muwardi, D. (2024). Pros and Cons of Artificial Intelligence-ChatGPT Adoption in Education Settings: A Literature Review and Future Research Agendas. *IEEE Engineering Management Review*, *52*(3), 27–42. Scopus. https://doi.org/10.1109/EMR.2024.3394540

Mavrikis, M., Geraniou, E., Gutiérrez-Santos, S., & Poulovassilis, A. (2019). Intelligent analysis and data visualisation for teacher assistance tools: The case of exploratory learning. *British Journal of Educational Technology*, *50*(6), 2920–2942. Scopus. https://doi.org/10.1111/bjet.12876

McIntyre, S. (2012). Exploring a rhizomic model for the design and dissemination of professional development in online teaching. *Proc. European Conf. on e-Gov., ECEG*, 492–501. Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84870859913&partnerID=40&md5=df82219a3e80497bcd0d7a91d21cc0aa

Muthmainnah, M., Cardoso, L., Kaur, D., Al Yakin, A., Marzuki, A. G., & Apriani, E. (2025). Informatization on Developing E-Learning Materials for IoT-Assisted Education to Enhance EFL in Higher Education. Dalam A. Swaroop, B. Virdee, S. D. Correia, & Z. Polkowski (Ed.), *Lect. Notes Networks Syst.* (Vol. 1302, hlm. 529–552). Springer Science and Business Media Deutschland GmbH; Scopus. https://doi.org/10.1007/978-981-96-3381-4_42

Nikolopoulou, K. (2023). Digital Education in the Post-Covid Era: Challenges and Opportunities to Explore. Dalam T. Keane, C. Lewin, T. Brinda, & R. Bottino (Ed.), *IFIP Advances in Information and Communication Technology: Vol. 685 AICT* (hlm. 3–14). Springer Science and Business Media Deutschland GmbH; Scopus. https://doi.org/10.1007/978-3-031-43393-1_1

Qumbisa, N., & Awuzie, B. (2025). Enhancing Student Engagement with Disruptive Pedagogy Through Peer-to-Peer Learning: A Preliminary Quantitative Analysis. Dalam M. Sutrisna, M. B. Jelodar, R. Potangaroa, C. Atapattu, & D. A. S. Samarasinghe (Ed.), *Lect. Notes Civ. Eng.* (Vol. 562, hlm. 159–169). Springer Science and Business Media Deutschland GmbH; Scopus. https://doi.org/10.1007/978-981-96-1181-2_13

Rey-Becerra, E., Barrero, L. H., Ellegast, R., & Kluge, A. (2026). VR- or lecture-based training? The role of culture in safety training outcomes. *Applied Ergonomics*, *130*. Scopus. https://doi.org/10.1016/j.apergo.2025.104626

Rodolico, G., Breslin, M., Brown, R., Lewis-Cole, A., Abodunrin, A., Dashaputre, N., Mariani, A. M., & Dinger, C. (2025). Unpacking the Impact of Collaborative Online International Learning on Educators and Students: A Reflective Case Study. Dalam *The Emerald Handb. On Int. High. Educ.: Navig. Workforce and Leadersh. Chang. In a Digit. Age* (hlm. 453–468). Emerald Publishing; Scopus. https://doi.org/10.1108/978-1-83549-788-320251028

Sadasivan, A., Dosaya, D., & Athira, M. (2025). Educators in the Post-COVID Digital Era: An Enquiry Through the Transformational Leadership Lens. Dalam *The Emerald Handb. On Int. High. Educ.: Navig. Workforce and Leadersh. Chang. In a Digit. Age* (hlm. 339–348). Emerald Publishing; Scopus. https://doi.org/10.1108/978-1-83549-788-320251021

Semerikov, S. O., Striuk, A. M., Pinchuk, O. P., Vakaliuk, T. A., Kanevska, O. B., & Ostroushko, O. A. (2025). Learning under pressure: Game-based, AI-driven, and crisis-responsive pedagogies in focus of the 12th Workshop on Cloud Technologies in Education. Dalam S. O. Semerikov, A. M. Striuk, O. P. Pinchuk, & T. A. Vakaliuk (Ed.), *CEUR Workshop Proc.* (Vol. 4043, hlm. 1–14). CEUR-WS; Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105018470433&partnerID=40&md5=7700c3e0e336b6b0adf00584dc3d180d

Sharifkhani, M., Davidson, J., MacCallum, K., Evans-Freeman, J., Brown, C., Bullsmith, C., & Richards, B. (2023). Sustainable Practices in Education: Virtual Labs. Dalam T. Cochrane, V. Narayan, C. Brown, K. MacCallum, E. Bone, C. Deneen, R. Vanderburg, & B. Hurren (Ed.), *ASCILITE - Conf. Proc.: Int. Conf. Innov., Pract. Res. Use Educ. Technol. Tert. Educ.* (hlm. 205–214). Australasian Society for Computers in Learning in Tertiary Education (ASCILITE); Scopus. https://doi.org/10.14742/apubs.2023.539

Suresh Babu, C. V., William, M. P., & Rohith, M. (2025). Innovative Pedagogy in the Digital Era: Empowering Learning Through Digital Leadership and Technology Integration. Dalam *Digital Leadersh. For Sustainable Higher Education* (hlm. 255–290). IGI Global; Scopus. https://doi.org/10.4018/979-8-3693-9989-7.ch008

Suresman, E., Faqihuddin, A., & Abdullah, M. (2025). From sorogan to digital learning: A systematic literature network analysis of pesantren learning models. *Cogent Education*, *12*(1). Scopus. https://doi.org/10.1080/2331186X.2025.2580776

Unsriana, L., Perdana, B., Ariana, S., Saputra, D. R., Supyaningsih, F., & Peeter, A. (2025). Gamified and AI-Powered Learning Systems in Japanese Literature Education in the Digital Age. *Proceeding - Int. Conf. Creat. Commun. Innov. Technol.: Empower. Transform. MATURE LEADERSH.: Harnessing Technol. Adv. Glob. Sustain., ICCIT*. Scopus. https://doi.org/10.1109/ICCIT65724.2025.11167003

Ursachi, T.-M., Brezoaie, R.-E., & Dascəlu, M.-I. (2025). Emerging Technologies in Immersive Learning: A Systematic Review of Trends, Challenges, and Opportunities. *IEEE Int. Conf. Blockchain, Smart Healthc. Emerg. Technol., SmartBlock4Health*. Scopus. https://doi.org/10.1109/SmartBlock4Health64843.2025.11189574

Utomo, D. T. P., & Martini, D. E. (2025). DEVELOPING TPACK OF EFL TEACHERS IN ISLAMIC BOARDING SCHOOLS THROUGH A TPACK-BASED COURSE. *Teflin Journal*, *36*(1), 172–187. Scopus. https://doi.org/10.15639/teflinjournal.v36i1/172-186

Wong, W. Y., Sam, T. H., & Yu, S. W. (2020). An Innovative, Practical-based and Commercial-based Approach: Techno-Commerce Entrepreneurship Shaping the Outcome-based Learning. *Proceeding - IEEE Conf. Syst., Process Control, ICSPC*, 140–145. Scopus. https://doi.org/10.1109/ICSPC50992.2020.9305778

Yan, W. (2025). Digital Transformation in Music Education: A Machine Learning-Based Analysis of Public Awareness and Adoption. *Proc. Int. Conf. Gener. AI Digit. Media Arts, GAIDMA*, 258–263. Scopus. https://doi.org/10.1145/3770445.3770490

Yong, S.-T., Gates, P., Chan, A., Chien-Sing, C.-S., Matthews, R., & Tiong, K.-M. (2019). Exploring the Feasibility of Computer Games in Mathematics Education. *HAVE - IEEE Int. Symp. Haptic, Audio-Vis. Environ. Games, Proc.* Scopus. https://doi.org/10.1109/HAVE.2019.8921018

Zaman, Q., & Fajriana, F. (2025). Supporting Application Fast Learning of Kitab Kuning for Santri' Ula Using Natural Language Processing Methods. *International Journal of Engineering, Science and Information Technology*, *5*(1), 278–289. Scopus. https://doi.org/10.52088/ijesty.v5i1.713