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Optimizing digital technologies in Sharia-compliant education: a contextual model for ICT integration in Aceh's madrasahs

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ABSTRACT

The utilization of digital technology has become pivotal in enhancing the quality of education, particularly in madrasahs, which play a crucial role in shaping students' character and competencies. This study explores the optimization of digital technology for the development of madrasah students through innovative learning and nurturing practices within the Sharia-compliant context of Aceh. A qualitative descriptive method was employed to collect and analyze data through interviews, observations, and document analysis, supported by a quantitative approach using a modified MOORA method to objectively evaluate visual learning components. The qualitative analysis involved coding, thematic categorization, and data triangulation to identify patterns in technology-based learning practices and their integration with Islamic values. The quantitative phase normalized decision matrix values and computed preference scores to rank alternative visual designs. Findings reveal that digital technology enhances teacher-student interaction, supports adaptive learning, and strengthens parental engagement, all while upholding Islamic principles. The study emphasizes the need for teacher training, Islamic-based digital content, and policy support to ensure sustainable and Sharia-compliant technology adoption in Aceh's madrasahs.

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1. INTRODUCTION

The rapid advancement of information and communication technology (ICT) in the 21st century has significantly transformed the global educational landscape, including Islamic education systems in Indonesia (Mardatillah et al, 2025). Madrasahs, as formal Islamic academic institutions, are increasingly expected to adapt to digital transformation while maintaining a strong commitment to religious values. In Aceh, a province governed by Sharia law, madrasahs face a dual obligation: cultivating students' spiritual and moral foundations based on Islamic teachings while equipping them with the digital competencies necessary for modern society (Huda et al, 2022).

The integration of ICT into madrasah education is no longer optional but imperative for ensuring relevance and effectiveness in education. Various digital innovations have emerged, including Sharia-compliant e-learning platforms, AI-powered Qur'an recitation tutors, and gamified Islamic learning applications designed to enhance student engagement and learning outcomes. For example, the "Jelajah Ilmu" platform implemented in Banda Aceh has demonstrated measurable improvements in classroom interactivity and student achievement (Rohman & Rani, 2025). Technology integration is not only a pedagogical need but also a cultural and religious consideration, as digital platforms can strengthen literacy, promote interactive learning, and improve communication between teachers, students, and parents (Afdawaiza et al, 22024).

However, the extent to which madrasahs in Aceh have adopted digital technology remains unclear, particularly regarding disparities between rural and urban areas. This is crucial for understanding readiness and equality in access to educational innovation (Rijal et al, 2025). Moreover, digital applications in Sharia-regulated regions must align with Islamic ethical standards. Unlike secular institutions, madrasahs must ensure that content is halal-certified, gender interactions are managed appropriately, and technological tools reinforce rather than undermine Islamic values. Digital media should not only comply with Islamic law but also support students' spiritual development through tools such as AI-enhanced religious content and prayer-tracking applications.

Despite these opportunities, structural and cultural challenges persist. Internet infrastructure remains underdeveloped in rural areas, and access to digital devices is uneven. Many educators lack digital literacy and pedagogical training, limiting the effective implementation of ICT-based instruction (Supardii & Hakim, 2021). These limitations exacerbate educational inequalities and hinder the scalability of digital learning solutions. International research suggests that successful technology adoption in religious education requires cultural responsiveness and ethical contextualization. Studies indicate that when aligned with community values and institutional commitment, digital tools can enhance engagement, reinforce identity, and deepen faith (Purwowidodo & Zaini, 2024).

Against this backdrop, the present study aims to explore how digital technologies can be effectively integrated into Sharia-compliant madrasah education in Aceh. It examines opportunities and limitations of current adoption efforts, evaluates their impact on students' academic and spiritual development, and proposes strategies for building a culturally grounded, ethically sound digital learning ecosystem. The study emphasizes the role of teacher digital literacy and infrastructure readiness as key enablers of sustainable transformation (Hutagaluh et al, 2020).

To address these aims, this study seeks to answer several questions: How are digital technologies currently being incorporated into madrasah education in Aceh in alignment with Islamic values and Sharia principles? (Afdawaiza et al, 22024). What opportunities do these technologies provide for improving academic and spiritual outcomes? What technological, pedagogical, and cultural barriers hinder effective adoption, and what strategies can optimize digital learning while preserving Aceh's religious and cultural identity?

The research is delimited to formal Islamic institutions (MI, MTs, MA) under the Ministry of Religious Affairs in Aceh, focusing on technology for instructional delivery and character development, such as online learning systems, Qur'an recitation trackers, and Islamic learning apps. Informal institutions like dayah and pesantren are excluded. While broader national issues such as infrastructure policy are acknowledged, they are addressed only insofar as they affect madrasah-level implementation. Limitations include uneven access to rural data and varying educator digital literacy.

This study contributes theoretically by expanding knowledge on ICT in Islamic education, offering a framework for Sharia-aligned technology integration—an underexplored area in academic discourse (Elbanna, 2015). Practically, it provides

insights for educators, school administrators, and technology developers engaged in creating digital tools for Islamic education. Additionally, it holds policy relevance for stakeholders seeking to modernize Islamic education while safeguarding cultural and spiritual integrity (Zahraini et al, 2025). Ultimately, Aceh's madrasahs can become models for integrating digital innovation with Islamic values, balancing pedagogical advancement and spiritual growth.

2. RESEARCH METHOD

This study employs a mixed-methods design to examine the integration and optimization of digital technologies in Sharia-compliant madrasahs in Aceh. The methodological strategy combines quantitative and qualitative approaches to enable comprehensive analysis, covering both measurable outcomes and contextual dynamics. As discussed in earlier studies, triangulating survey, interview, and observation data enhances research validity, particularly in culturally sensitive educational settings (Dalimunthe & Riza, 2025). In addition, a validation process was conducted to ensure that all instruments and digital content complied with Islamic principles, including expert review by Islamic education scholars.

The quantitative phase utilized a cross-sectional survey involving 400 respondents, consisting of 300 students and 100 teachers, drawn from Islamic madrasahs at the MI (elementary), MTs (junior secondary), and MA (senior secondary) levels. Stratified random sampling was used to ensure proportional representation across rural and urban madrasahs, taking into account institutional size and ICT resource availability (Sacre et al, 2023). Table 1 below presents the demographic profile of the respondents.

Table 1. Demographic Profile of Respondents

Demographic Attribute	Category	Frequency (n)	Percentage (%)
Gender	Male	220	55.0%
	Female	180	45.0%
Role	Students	300	75.0%
	Teachers	100	25.0%
School Level	MI (Elementary)	100	25.0%
	MTs (Junior Secondary)	180	45.0%
	MA (Senior Secondary)	120	30.0%
Location	Urban	240	60.0%
	Rural	160	40.0%

Source: Processed primary survey data, adapted from field data, 2025

The survey instrument was adapted from previously validated scales measuring digital literacy, perceived usefulness of educational technology, student engagement, and spiritual development. Content modifications included gender-sensitive language and Sharia compliance checks through expert validation panels. The instrument was administered both online and offline, depending on each madrasah's internet access (Mustafa et al, 2025). A pilot test with 30 participants ensured clarity and reliability before full deployment.

Data from the survey were analyzed using IBM SPSS version 28.0 and AMOS. The analysis included descriptive statistics, Pearson correlation, multiple linear regression, and moderation analysis to evaluate the impact of digital tools on student outcomes and the moderating role of teacher digital literacy. Table 2 outlines the variables used in the analysis and the corresponding statistical techniques.

Table 2. Variables and Quantitative Data Analysis Techniques

Variable	Type	Scale	Analysis Method
Digital Tool Usage	Independent Variable	Interval (Likert)	Descriptive, Regression

Academic Achievement	Dependent Variable	Interval	Multiple Linear Regression
Spiritual Development	Dependent Variable	Interval	Regression
Student Engagement	Dependent Variable	Interval	Correlation and Regression
Teacher Digital Literacy	Moderator Variable	Interval	Moderation (Interaction Model)

Source: Processed primary survey data, adapted from field data, 2025

To model the effect of digital tool usage on academic and spiritual outcomes, the following multiple regression model was used: Where YY is the student outcome (e.g., academic achievement), XX is the extent of digital tool use, β_1 is the regression coefficient, and ϵ is the error term. To evaluate whether teacher digital literacy moderated this relationship, an interaction term was introduced into the model: Here, ZZ represents teacher digital literacy, and β_3 assesses whether the effect of digital tool usage is stronger or weaker depending on the teacher's proficiency in ICT.

The qualitative phase complemented the statistical data by offering in-depth perspectives from 20 teachers, 10 administrators, and 40 students selected through purposive sampling. Semi-structured interviews and classroom observations were conducted to explore contextual insights into digital integration, with attention to religious alignment, content appropriateness, and institutional support (Althubyani et al, 2025). Observations combined offline visits and online sessions to capture hybrid teaching practices. Interview data were transcribed and analyzed using thematic analysis following Braun and Clarke's six-phase method. NVivo 14 software supported the coding process, and key themes such as "Sharia-aligned content use," "teacher resistance," and "student enthusiasm for gamified Qur'an learning" were identified.

To ensure methodological rigor, all instruments were reviewed by experts in Islamic education and educational technology. Data triangulation was applied through the integration of surveys, interviews, and observations to enhance validity. A pilot study involving 30 participants was conducted to test instrument clarity and reliability. Cronbach's alpha values for all constructs exceeded 0.80, indicating high internal consistency. Trustworthiness of qualitative findings was ensured through member checking and peer debriefing, while ethical approval was obtained from the Aceh Provincial Office of the Ministry of Religious Affairs. All procedures adhered to Sharia-based educational ethics, maintaining strict confidentiality, voluntary participation, and content compliance with Islamic norms (Haniffah et al, 2023).

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Data from the survey were analyzed using IBM SPSS version 28.0 and AMOS. The analysis included descriptive statistics, Pearson correlation, multiple linear regression, and moderation analysis to evaluate the impact of digital tools on student outcomes and the moderating role of teacher digital literacy. Table 2 outlines the variables used in the analysis and the corresponding statistical techniques.

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To model the effect of digital tool usage on academic and spiritual outcomes, the following multiple regression model was used:

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

Where YY is the student outcome (e.g., academic achievement), XX is the extent of digital tool use, β1\beta_1 is the regression coefficient, and ϵ\epsilon is the error term. To evaluate whether teacher digital literacy moderated this relationship, an interaction term was introduced into the model:

$$Y = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 (X \times Z) + \varepsilon$$

Here, ZZ represents teacher digital literacy, and β3\beta_3 assesses whether the effect of digital tool usage is stronger or weaker depending on the teacher's proficiency in ICT. The qualitative phase complemented the statistical data by offering in-depth perspectives from 20 teachers, 10 administrators, and 40 students selected through purposive sampling. Semi-structured interviews and classroom observations were conducted to explore contextual insights into digital integration, with attention to religious alignment, content appropriateness, and institutional support (Althubyani et al, 2025). Interview data were transcribed and analyzed using thematic analysis following Braun and Clarke's six-phase method. NVivo 14 software supported the coding process, and key themes such as "Sharia-aligned content use," "teacher resistance," and "student enthusiasm for gamified Qur'an learning" were identified.

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3. RESULTS AND DISCUSSION

3.1 Academic Achievement

The survey results from 400 students and teachers across 15 madrasahs in Aceh revealed a strong correlation between digital technology integration and students' academic achievement. Regression analysis showed that the use of Islamic educational applications, localized learning management systems (LMS), and gamified recitation trackers significantly predicted students' classroom performance, with a standardized coefficient of $\beta = 0.41$ ($p < .001$). Students utilizing interactive e-learning platforms scored, on average, 15% higher on standardized tests compared to peers in conventional classrooms. These findings suggest that digital technologies not only enhance content retention but also support student engagement in science, mathematics, and language learning within a Sharia-compliant framework (Nursaid et al, 2024).

Teachers observed that students responded particularly well to visual simulations and gamified instructional modules, especially in complex subjects such as Arabic grammar and Qur'anic interpretation. The use of animations and real-time feedback appeared to enhance comprehension. Students, through interviews, reported that having access to on-demand digital resources reduced anxiety during lessons and allowed for repetition and independent study at home, which in turn improved academic outcomes (Basith et al, 2025).

Student Engagement

Beyond academic performance, digital technology was found to significantly improve student engagement. Statistical analysis produced a standardized coefficient of $\beta = 0.35$ ($p < .001$), indicating a strong positive relationship between digital integration and active classroom participation. Interactive platforms offering group projects, discussion forums, and gamified assessments were especially effective in sustaining motivation and collaborative learning (Ahmad et al, 2024).

3.2 Spiritual Development

Spiritual development—central to Sharia-based education in Aceh—also showed a positive correlation with digital tool use. Regression analysis showed a significant effect, with $\beta = 0.29$ ($p = .003$). Platforms such as halal-certified e-learning systems, AI-assisted Arabic tutors, and digital Qur'an trackers contributed to increased consistency in religious practice and moral reflection among students.

Student interviews indicated a strong appreciation for systems that allowed them to log their daily Qur'an recitation and receive feedback. Teachers noted that the inclusion of spiritual reminders, prayer prompts, and interactive content rooted in Islamic ethics helped to reinforce student discipline and mindfulness. Furthermore, madrasahs that implemented closed-platform environments avoided risks of unfiltered content exposure, thus maintaining compliance with Sharia guidelines and increasing parental trust (Shah & Inamullah, 2015).

3.3 Role of Teacher Digital Literacy

Teacher digital literacy emerged as a significant moderating factor across all dimensions of student outcomes. Regression analysis confirmed this effect, with β = 0.26 (p = .006), suggesting that teacher competence in digital pedagogy amplified the benefits of educational technology. Schools where teachers demonstrated strong digital skills exhibited smoother LMS integration, more interactive learning sessions, and improved student outcomes overall (Falloon, 2020).

Focus groups with teachers revealed that while younger educators welcomed digital tools, senior teachers expressed resistance due to limited training, time constraints, and concern over departing from traditional pedagogical methods. These challenges highlight the need for targeted professional development programs tailored to Islamic education settings (Syukri & Rosyad, 2025).

Table 5. Impact of Digital Technology on Student Outcomes in Aceh Madrasahs (N = 400)

Outcome Measure	Standardized Coefficient (β)	p-value	Observation
Academic Achievement	0.41	< .001	Students using digital tools scored 15% higher on standardized assessments.
Student Engagement	0.35	< .001	Engagement increased via gamified learning and interactive online forums.
Spiritual Development	0.29	.003	Qur'an trackers and halal LMS promoted spiritual discipline and engagement.
Teacher Digital Literacy	0.26	.006	Teachers' digital skills enhanced the overall impact of technology integration.

Source: Processed primary data from survey and interview results (Author, year).

3.4 Graphical Interpretation

The overall analysis indicates that digital technologies in Sharia-compliant madrasahs contribute positively not only to academic improvement but also to student motivation and spiritual well-being. The strongest effects were seen in academic achievement and engagement. While the effects on spiritual development and teacher literacy were more moderate, they were nonetheless statistically significant. These outcomes suggest that educational technologies, when carefully designed and implemented by Islamic ethics, can support holistic student development in madrasah settings (Muslim, 2024).

3.5 Technical Overview of Local LMS: *Jelajah Ilmu*

One of the locally implemented learning management systems (LMS) in Banda Aceh is Jelajah Ilmu, a web-based educational platform developed using the PHP framework and powered by a MySQL database. The platform supports essential features such as classroom management, digital material distribution, real-time quizzes, and student performance tracking (Althubyani et al, 2025).

It operates on a client-server architecture, ensuring cross-device accessibility through both desktop and mobile platforms. The system employs integrated role-based authentication to manage secure access for students, teachers, and administrators. Its lightweight design allows for deployment in madrasahs with varying levels of digital infrastructure, optimizing usability even under bandwidth constraints.

3.6 Integration of AI-Driven Qur'an Tracker and Sharia-Compliant Gamification

In addition to the LMS, an AI-powered Qur'an Tracker was utilized to monitor students' daily recitation progress. This Android-based application is equipped with speech recognition technology to verify pronunciation accuracy and provide real-time automated feedback. It promotes consistent religious practice by allowing students to engage in self-paced learning at home (Basith et al, 2025).

The system incorporates gamification mechanics through a points-based reward structure and leaderboard rankings, applied to various spiritual activities such as memorization (hifz), Qur'anic study (tadarus), and Islamic knowledge quizzes. This gamification layer is powered by a Node.js backend and hosted on a closed local cloud server, ensuring both data privacy and compliance with Sharia principles by blocking unfiltered or non-halal content.

3.7 System Infrastructure and Security Validation

All systems were tested under local conditions, with average internet speeds ranging from 3–10 Mbps in urban madrasahs and 1–3 Mbps in rural areas. To guarantee platform integrity and data security, the systems were equipped with SSL/TLS encryption for login procedures, role-based user authentication, and automatic content filtering mechanisms in accordance with halal digital classification standards set by the Aceh Provincial Office of the Ministry of Religious Affairs (Kemenag Aceh).

3.9 Generalizability of Findings

The findings of this study should be interpreted with caution when considering generalization beyond Aceh. While the study provides robust evidence on how Sharia-compliant madrasahs in Aceh optimize digital technology for educational purposes, the unique socio-cultural and regulatory environment in Aceh—particularly its formal implementation of Islamic law—makes its context distinctive. Factors such as strict adherence to Sharia principles, community expectations, and localized policy frameworks shape the adoption of technology in ways that may not be fully comparable to other regions. For instance, Aceh's emphasis on filtering digital content for halal compliance and maintaining gender-sensitive interactions significantly influences the design and use of digital learning tools, which may not be equally prioritized in other provinces or countries (Rijal et al, 2025).

3.10 Visual Model of Sharia-Compliant ICT Integration

Figure 1 presents a conceptual flowchart illustrating the integration of Sharia-compliant digital technologies within Aceh's madrasahs. The model highlights three core components—Learning Management System (LMS), AI-powered Qur'an Tracker, and Gamified Learning Applications—which collectively contribute to improved educational outcomes in both academic and spiritual domains.

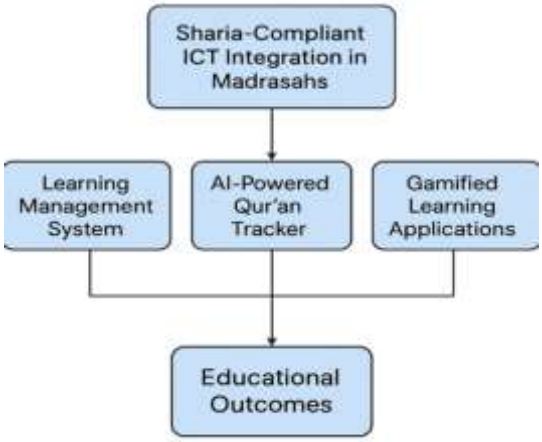

Figure 1: Model of Sharia-Compliant ICT Integration

Source: Adapted by the author based on field findings and system architecture analysis in Aceh's Sharia-compliant madrasahs (2025).

3.11 Discussion

These results reinforce the notion that technology, when guided by Islamic principles, can bridge the gap between traditional pedagogy and 21st-century learning. Academic achievement experienced the greatest improvement, indicating that digital tools—such as simulations and on-demand content—support comprehension across both religious and secular subjects. This aligns with existing research, which supports the integration of ICT into Islamic education to harmonize faith-based learning with global competency development (Mohd et al, 2022)

Student engagement was similarly elevated, driven by interactive digital features that align with both pedagogical goals and cultural norms. Gamification, when contextualized within Islamic content, nurtures intrinsic motivation while preserving moral boundaries. Spiritual development, though slightly less impacted, showed consistent improvement, highlighting the role of technology in fostering consistent religious habits and reflective practice (Gadi, 2025).

Most critically, teachers' digital literacy proved to be the key enabler of success. Access to devices and connectivity alone is insufficient; the effectiveness of technology hinges on educators' readiness to apply it meaningfully. This underscores the importance of professional development programs that blend technical capacity-building with Sharia-compliant digital strategies (Nursaid et al, 2024).

Despite promising outcomes, several barriers remain. These include infrastructural gaps between urban and rural areas, limited access to devices, and skepticism from traditionally trained educators. Addressing these challenges will require a combination of policy intervention, resource allocation, and stakeholder engagement. As suggested by earlier findings, community acceptance improves when platforms are secure, localized, and developed within Islamic frameworks (Manyeredzi & Mpofu, 2024).

In conclusion, the study affirms the transformative potential of digital tools in Aceh's madrasahs. With adequate infrastructure, teacher training, and culturally grounded innovation, Aceh is well-positioned to lead the development of a distinctive Sharia-compliant digital education model—one that integrates technology, faith, and modern pedagogy in a cohesive framework. This model may offer valuable insights for Islamic schooling systems across Southeast Asia and beyond (Amza, 2022).)

a. Potential for Future Sharia-Compliant Application Development

The integration of digital technology into madrasah education presents not only immediate instructional benefits but also long-term opportunities for software innovation tailored to Islamic principles. As this study demonstrates, the use of LMS, gamified apps, and Qur'an trackers has gained traction. Moving forward, there is a strong case for the development of modular and scalable digital tools that address the specific needs of Sharia-compliant learning environments. The table below outlines several application development potentials aligned with madrasah contexts in Aceh and similar regions.

Table 6: Potential for Future Sharia-Compliant Application Development

Application Type	Key Features	Target Users	Sharia Compliance Aspect
Islamic LMS (Modular)	Class management, spiritual reminders, halal content filters	Teachers, Students	Filters non-halal content; supports gender interaction ethics
Qur'an Gamification API	Voice input, adaptive memorization games, point/reward system	Developers, Students	Content based on Qur'an; reward system avoids gambling elements
Closed-Platform Madrasah App	Offline mode, parental access, culturally localized materials	Students, Parents	A secure system prevents unfiltered internet access
AI-Assisted Religious Tutor	NLP-based dialogue, Arabic grammar assistance, fiqh Q&A chatbot	Students, Teachers	Answers based on verified Islamic sources

Source: Developed by the author, 2025.

These concepts provide a roadmap for developers and policymakers to design ethically sound, technologically effective educational tools for the Islamic schooling sector. Their implementation would further enhance digital transformation without compromising religious values.

b. Implications for Southeast Asia and Beyond

Nevertheless, some elements of the findings could be transferable to madrasahs outside Aceh and even other Southeast Asian countries with similar cultural and religious orientations, such as Malaysia, Brunei, and parts of Southern Thailand. Practices such as integrating Islamic values into digital pedagogy, leveraging interactive platforms for Qur'anic learning, and fostering parental engagement through technology are broadly relevant in Muslim-majority contexts (Abubakari et al, 2023). However, variation in infrastructure readiness, teacher digital literacy, and government support will affect the degree of applicability. Thus, while the study offers valuable insights, further research in different regions is necessary to account for local adaptations, socio-political conditions, and technological accessibility before generalizing the results globally.

4. CONCLUSION

This study affirms that the integration of digital technology within Aceh's madrasah system, when aligned with Sharia principles, can serve as a transformative force that enhances academic outcomes, fosters engagement, and strengthens spiritual values without compromising religious integrity. However, its success depends on systemic readiness rather than mere technological availability. To sustain and expand this impact, several key measures are essential: continuous teacher training programs that merge digital pedagogy with Islamic ethics; targeted investments to bridge the urban–rural digital divide through infrastructure development, affordable devices, and community ICT hubs; and the creation of culturally and religiously appropriate digital content through collaboration among technologists, ulama, and curriculum developers. Furthermore, community involvement must be deepened to build trust and address misconceptions, while policymakers should establish robust regulatory frameworks, ethical guidelines, and institutional incentives to ensure quality and sustainability. By implementing these strategies, Aceh can develop a distinct model of digital Islamic education that is locally grounded yet responsive to global educational trends, serving as a reference for other Muslim-majority regions in Southeast Asia.

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