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Digital Academic Supervision Model for Enhancing Instructional Leadership of Madrasah Principals: Development and Effectiveness of the *ABDUL* Application

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Abstract: Ineffective academic supervision management in madrasahs creates significant gaps between learning standards and practices, hindering instructional leadership of madrasah principals. This study developed a digital academic supervision model based on ABDUL—Digital Guidance Application for Outstanding Academic Supervision—integrating instructional leadership theory, transformative supervision theory, and management information systems theory to enhance the effectiveness of madrasah principals' instructional leadership. The research employed a Research and Development (R&D) approach over 12 months in three State Madrasah Aliyah in Bireuen Regency, Indonesia, involving 20 participants. Development followed six systematic stages: preliminary study, model design, expert validation, limited trial, revision, and effectiveness evaluation. Data were collected through multiple triangulation methods: semi-structured interviews, participatory observation, comprehensive documentation, expert validation instruments, and user response questionnaires. Expert validation confirmed 92.5% model feasibility (highly feasible) with 87% positive user responses (86.5% average satisfaction). Implementation demonstrated significant effectiveness, with a 27.7% increase in madrasah principals' managerial competence, a 24.6% improvement in teachers' professional competence, and a 36.5–45.8% enhancement in learning quality across five dimensions. The model transformed supervision culture from evaluative-punitive to empowering-collaborative approaches, with 85% of teachers experiencing perception change. This research presents a new conceptual framework that integrates three theoretical corpora within Islamic educational management contexts, offering both theoretical advancements and practically implementable blueprints for the digital transformation of academic supervision management in Indonesian Islamic schools.

Keywords: Digital Academic Supervision; Instructional Leadership; Islamic Educational Management; Digital Application for Supervision; Management Information Technology; Madrasah Digital Transformation.

INTRODUCTION

Instructional leadership by madrasah principals through academic supervision constitutes a strategic managerial function within Islamic educational management systems, significantly influencing organizational effectiveness in learning and teacher professionalism (Leithwood & Louis, 2022; Sergiovanni & Starratt, 2022). In the context of modern educational management, madrasah principals perform dual roles as school managers and instructional leaders who systematically plan, organize, implement, and evaluate academic supervision programs to ensure continuous quality of learning processes (Glickman et al., 2022; Nolan & Hoover, 2021). The academic supervision function from a strategic management perspective is not merely an administrative and controlling activity, but rather an organizational learning and development function that empowers human resources and builds institutional capacity within madrasahs (Marks & Printy, 2023).

International meta-analytical studies confirm that effective instructional leadership by school principals produces an effect size of 0.68 standard deviations on improving organizational learning performance, surpassing the impact of other variables in the educational ecosystem (Leithwood et al., 2020; Robinson et al., 2008). However, the effectiveness of this managerial function heavily depends on the systems, procedures, and technology that madrasah principals use in operationalizing academic supervision (Hallinger & Murphy, 2018).

Empirical reality in the field reveals a significant gap between academic supervision management standards and implementation practices in Madrasah Aliyah in Bireuen Regency. The researcher's preliminary observations identified six fundamental problems in managerial aspects of supervision: (1) absence of structured, transparent, and teacher needs-based supervision planning systems; (2) weak coordination and communication mechanisms between madrasah principals and teachers in the supervision process; (3) lack of adequate digital documentation systems and databases for tracking teacher development progress; (4) minimal use of management information technology for supervision efficiency and effectiveness; (5) low accountability and transparency in managing academic supervision data; and (6) limited capacity of madrasah principals to integrate planning, implementation, evaluation, and follow-up supervision functions systemically (Bush & Glover, 2016; Matin & Nistor, 2021). These conditions indicate weak academic supervision management

systems impacting suboptimal instructional leadership functions of madrasah principals in improving organizational learning quality.

Data from the Indonesian Madrasah Competency Assessment (AKMI) 2024 reveals critical inconsistencies in madrasah learning management outputs. While national reading literacy scores reach 130.78 and numeracy 129.2, madrasah quality reports show learning management failures with literacy scores of only 45.50 and numeracy 35.29 out of a scale of 100—creating gaps of 85.28 and 93.91 points respectively (Direktorat Pendidikan Islam, 2024; Kementerian Agama Republik Indonesia, 2024). Learning management quality indicators show average scores of 51/100 for dimensions of classroom management, learning support systems, and instructional strategy effectiveness (UNESCO, 2024). This large gap between potential and realization indicates systemic failure in madrasah principals' managerial functions, particularly in academic supervision as a learning quality assurance mechanism. Research by Hallinger & Murphy (2018) confirms that 62% of variance in learning quality is explained by the effectiveness of school principals' instructional leadership functions, including the academic supervision system used. These findings reinforce the urgency of developing more effective, efficient, and information technology-based academic supervision management systems.

Literature review indicates that digitalization of managerial functions in academic supervision represents a research frontier in Islamic educational management. Meta-analytical research reveals that digital technology-based and collaborative supervision models have an effect size of 0.75 compared to traditional supervision's 0.45 ($p < 0.001$), and international comparative studies show that application-based digital supervision systems improve learning quality by 20–25% within one academic year (Sumarsih & Santoso, 2023). Several empirical studies confirm that structured supervision systems with clear procedures enhance teacher professionalism and that systematic supervision planning encompassing identification of objectives, quality indicators, and implementation stages contributes to improved learning management quality (Karimah, 2022; Nurhasanah, 2024; Sartika, 2024; Stoll & Fink, 2021).

Research Gaps and Unique Contribution. Despite extensive literature on instructional leadership and digital technology in education, significant research gaps persist: (1) No comprehensive research has developed a digital academic supervision management framework explicitly integrated with Islamic educational institution characteristics; (2) No study has operationalized management information systems within the complete PDCA (Plan-Do-Check-Act) cycle of academic supervision specifically for madrasah contexts; and (3) Limited implementation models exist that are contextual and replicable in Indonesian madrasah settings. This research directly addresses these gaps by

developing, validating, and evaluating a contextually appropriate digital academic supervision model that strengthens madrasah principals' instructional leadership effectiveness while maintaining Islamic educational values.

The development of *ABDUL* (Digital Guidance Application for Outstanding Academic Supervision) responds to these theoretical and practical gaps. The *ABDUL* is designed as an academic supervision management information system integrating five managerial functions within one digital platform: (1) Planning—needs analysis-based supervision planning, automatic scheduling, and establishment of measurable coaching targets; (2) Organizing—coordination mechanisms among stakeholders through integrated dashboards and real-time notifications; (3) Leading—digital coaching features with two-way communication and continuous mentoring; (4) Controlling—monitoring learning implementation and systematic teacher progress tracking; and (5) Evaluating—supervision data analysis system and evidence-based follow-up recommendations.

ABDUL Application Interface. The *ABDUL* application features a user-centered interface design with key components: Planning Module providing supervision needs analysis dashboards and SMART coaching target setting; Organizing Module with integrated communication tools enabling real-time coordination through notification systems; Leading Module featuring digital coaching interfaces supporting two-way dialogue, resource libraries with learning materials, and continuous mentoring features; Controlling Module providing real-time monitoring dashboards showing supervision progress, early warning systems, and systematic documentation of follow-up implementation; and Evaluating Module generating comprehensive analytics regarding learning quality trends, supervision program effectiveness, and ROI data for evidence-based decision-making. The interface design incorporates Islamic educational principles emphasizing collaborative goal-setting (musyawarah), mutual support (ta'awun), capacity building (tamkin), and reflective practice (muhasabah).

The *ABDUL* conceptual framework integrates three theories: (1) Instructional Leadership Theory emphasizing the principal's role in defining school mission and managing instructional programs (Hallinger, 2018; Leithwood & Louis, 2022); (2) Transformative Supervision Theory positioning supervision as empowerment and continuous professional development (Glickman et al., 2022; Sergiovanni & Starratt, 2022); and (3) Management Information Systems Theory operationalizing managerial functions through technology to enhance organizational effectiveness (Laudon & Laudon, 2020).

This research aims to develop a digital academic supervision model based on the *ABDUL* application, contextual to Madrasah Aliyah characteristics

in Bireuen Regency, to strengthen the effectiveness of madrasah principals' instructional leadership. The research theoretically develops a new conceptual framework integrating instructional leadership theory, transformative supervision, and management information systems within Islamic educational contexts. Practically, the research provides operational blueprints for madrasah principals to enhance instructional leadership effectiveness through digital supervision systems. At the policy level, the research provides concrete recommendations for the Ministry of Religious Affairs regarding academic supervision management information system standards, budget allocation, capacity-building programs, and strategies for scaling the digital supervision model across Islamic educational institutions in Indonesia.

RESEARCH METHODOLOGY

The research employs a Research and Development (R&D) approach with a qualitative orientation to develop managerial technology innovation and test its effectiveness within Madrasah Aliyah contexts in Bireuen Regency (Borg & Gall, 2003; Richey & Klein, 2021). The R&D approach was chosen because the research objective is to develop, validate, and evaluate a managerial innovation product implementable practically in Islamic educational institutions (McKenney & Reeves, 2019; Sugiyono, 2023).

Research Setting and Participants. The research location comprises three State Madrasah Aliyah in Bireuen Regency, selected purposively based on management characteristic variations: MAN 3 Bireuen (open to innovation, urban, adequate infrastructure), MAN 5 Bireuen (less structured system, suburban, limited capacity), and MAN 7 Bireuen (inconsistent supervision, semi-rural, low digital literacy). Research was conducted over 12 months (January–December 2025). Research subjects comprise 20 informants through purposive sampling: three madrasah principals (6–12 years experience), 12 subject teachers (minimum 5 years, varied literacy), two district supervisors (minimum 8 years), and three madrasah committee members.

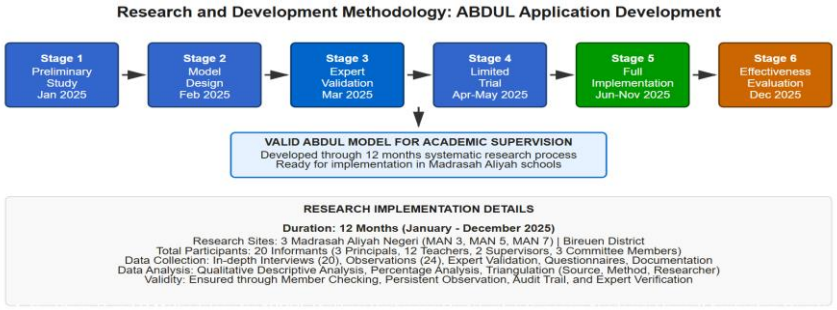

Figure 1. Six-Stage Research and Development Process for *ABDUL* Digital Academic Supervision Model Implementation (January-December 2025)

The research adapted the Borg & Gall (2003) R&D model into six systematic stages: (1) Preliminary Study—needs analysis through interviews and observations, literature review on instructional leadership and management information systems, and benchmarking best practices; (2) Model Design—developing *ABDUL* conceptual framework, designing system architecture with five modules, and prototyping web-based interfaces with user-centered design; (3) Expert Validation—assessing model feasibility by eight experts with 92.5% feasibility results; (4) Limited Trial—implementing *ABDUL* for 12 teachers and 2 principals over one semester with 87% positive user response; (5) Revision and Full Implementation—incorporating improvements, conducting intensive training, and implementing *ABDUL* at all three madrasahs; (6) Effectiveness Evaluation—measuring impact on system feasibility, principals' competence, teacher professionalism, supervision culture, and sustainability.

Data collection used multiple triangulation methods: (1) semi-structured interviews with 20 informants (45–60 minutes per session, 20 total sessions); (2) structured participatory observation (26 total sessions) of planning, implementation, meetings, and system usage; (3) comprehensive documentation (programs, schedules, instruments, SOPs, reports, data); (4) expert validation sheets with 25 assessment indicators using category scales; and (5) user response questionnaires (Likert scale 1–5) measuring ease of use, effectiveness, benefits, and satisfaction (Creswell, 2022; Merriam & Tisdell, 2023; Patton, 2021).

This multi-source data verification approach adds strong credibility and reliability to the findings. The use of expert panels and multi-source data triangulation ensures methodological soundness, contextual relevance, and alignment with best practices in educational R&D research.

Adaptation and Validation of Measurement Instruments. The research adapted two standardized instruments for madrasah contexts: Hallinger's Principal Instructional Management Rating Scale (PIMRS) for measuring

madrasah principals' managerial competence and the Classroom Assessment Scoring System (CLASS) for evaluating learning quality. The adaptation process included content validity review by three experts for cultural and contextual relevance to Islamic secondary schools, pilot testing with 20 teachers to assess clarity, and rigorous validation testing. Reliability was established through Cronbach's alpha coefficients: PIMRS alpha = 0.87; CLASS alpha = 0.84, both exceeding the 0.70 minimum threshold for acceptable reliability. Construct validity was verified through exploratory factor analysis, confirming five dimensions for PIMRS (defining mission, managing instructional programs, promoting learning climate, monitoring and protecting instructional time, providing incentives) and five dimensions for CLASS (classroom management, emotional support, instructional support, learning media utilization, learning evaluation). These psychometric tests ensure the instruments reliably and validly measure the intended constructs within the madrasah context, significantly strengthening confidence in the quantitative findings.

Data Analysis Methods. Qualitative data analysis uses the Miles & Huberman (1994) framework through three stages: (1) data reduction by coding transcripts and notes, identifying main themes, and selecting relevant information; (2) data display in narrative descriptions, cross-case matrices, and flow diagrams showing relationship patterns; and (3) conclusion drawing verified through source triangulation, method triangulation, and member checking with six key informants. For expert validation and questionnaire data, descriptive percentage analysis was performed: Percentage = (Obtained Score / Maximum Score) × 100% to calculate model feasibility level and user satisfaction (Nasution, 2023).

Data validity was ensured through: (1) credibility with prolonged engagement (12 months), persistent observation, source/method triangulation, and member checking; (2) transferability with thick description; (3) dependability through audit trail; and (4) confirmability with researcher reflexivity and peer debriefing (Guba & Lincoln, 2023; Lincoln & Guba, 2020; Morse et al., 2021).

RESULTS AND DISCUSSION

This section presents findings from the six-stage R&D implementation of the *ABDUL* digital academic supervision model, organized around seven dimensions: model feasibility validated by expert panels, system effectiveness and user acceptance, user experience analysis including implementation challenges and solutions, enhancement of madrasah principals' managerial competence, improvement in learning quality, enhancement of teachers'

professional competence, and supervision culture transformation with system sustainability.

Figure 2 illustrates the ***ABDUL* Model Framework**, presenting a comprehensive management information system with five integrated core managerial modules: **Planning** (needs analysis-based supervision planning, automatic scheduling system, and measurable coaching targets), **Organizing** (coordination mechanisms through integrated dashboards and real-time notifications), **Leading** (digital coaching features with two-way communication and resource sharing/mentoring), **Controlling** (learning observation monitoring, supervision progress tracking, and systematic teacher progress tracking), and **Evaluating** (supervision data analysis, learning quality metrics, and evidence-based follow-up).

The framework is grounded in three Theoretical Integration components: Instructional Leadership Theory, Transformative Supervision Theory, and Management Information Systems Theory. Implementation Impact demonstrates concrete outcomes with a 92.5% feasibility level (highly feasible), 87% positive user response, 27.7% increase in principals' managerial competence, and 24.6% improvement in teachers' professional competence. Key Features of the system include the integrated Planning-Organizing-Leading-Controlling-Evaluating cycle, real-time monitoring and feedback mechanisms, digital resource management, and data-based decision support systems designed to enhance instructional leadership effectiveness in Islamic educational contexts.

The following sections detail comprehensive findings regarding model feasibility, implementation effectiveness, and measurable impacts on principals' managerial competence, teacher professionalism, learning quality, and organizational learning culture.

Figure 2. ABDUL *Model Framework for Digital Academic Supervision in Madrasah*

Expert validation confirms that the *ABDUL* model meets feasibility standards as a managerial technology innovation, with an average score of 92.5% (classified as highly feasible). Validation involved eight experts from various disciplines: two academic supervision and educational leadership experts (Prof. Dr. from UPI and UNJ), two Islamic educational management experts (Dr. from UIN Jakarta and IAIN Aceh), two learning technology and information systems experts (Dr. from UM and ITB), and two experienced madrasah principal practitioners (A.B. and S.W., both with > 15 years experience). Assessment across five dimensions shows: (1) model content feasibility 94%—model possesses strong theoretical foundations from integration of instructional leadership theory, transformative supervision, and management information systems; (2) component design relevance 91%—system architecture with five managerial modules (planning-organizing-leading-controlling-evaluating) aligns with academic supervision management cycles and educational supervision standards; (3) technology feature integration 93%—integration of digital planning features, monitoring dashboards, coaching communication, automatic documentation, and data analysis designed coherently and user-friendly; (4) implementation ease 91%—model can be operationalized in madrasahs with minimal technological infrastructure without requiring extensive training; and (5) compatibility with Islamic educational values 92%—model integrates principles of collaboration (musyawarah),

humanity (ta'awun), empowerment (tamkin), and reflection (muhasabah) aligned with Islamic educational philosophy.

Qualitative expert feedback highlights model strengths: "*ABDUL* innovates in operationalizing instructional leadership functions through information technology that has remained conceptual in Islamic educational management literature" (Islamic Educational Management Expert); "System design with user-centered approach carefully considers madrasah contexts and capacities in regions, not adopting technology in a taken-for-granted manner" (Learning Technology Expert); "*ABDUL*'s conceptual framework provides significant theoretical contribution by integrating three major theories into one practical model" (Academic Supervision Expert); "As a practitioner, I see *ABDUL* as highly applicable and answering madrasah principals' real needs in managing academic supervision systematically and data-based" (Madrasah Principal Practitioner). Experts also provided improvement recommendations integrated into the final model: adding predictive analytic features for early warning systems regarding teachers requiring intensive coaching, developing self-paced learning modules for teachers, and providing standardized yet customizable supervision instrument templates according to madrasah needs.

System Effectiveness and User Response in Limited Trials

Limited trials over one semester (six months) on 12 teachers and two madrasah principals from MAN 3 and MAN 5 Bireuen demonstrate high technology acceptance levels with 87% of users (10 out of 12 teachers and two madrasah principals) providing positive responses, with average satisfaction scores of 86.5% (scale 100). In the usability dimension, 89% of users state that *ABDUL* is easy to learn and operate in daily managerial supervision activities, despite the majority (75%) being first-time users of digital supervision systems. Madrasah principals report: "The interface is intuitive, menus are clear, and the system provides step-by-step guidance that is very helpful. Within two weeks, I mastered all main features" (Principal of MAN 3). Even senior teachers with low digital literacy confirm: "Initially worried it would be complicated, turns out very user-friendly. Notifications and reminders from the system help me not miss supervision schedules" (Arabic Language Teacher, MAN 5).

In the managerial function effectiveness dimension, 84% of users report that *ABDUL* significantly improves communication and coordination quality between madrasah principals and teachers. The system facilitates structured yet informal two-way dialogue, allowing teachers to convey reflections and coaching

needs openly without awkwardness. In the supervision management efficiency dimension, 88% of users confirm *ABDUL* improves supervision process regularity and consistency: supervision schedules are systematically arranged, supervision result documentation is automatically stored and organized, and reports are accessible anytime without requiring manual searches through physical archives. Madrasah principals report 40% administrative time savings that can be allocated to other instructional leadership functions. In the transparency and accountability dimension, 85% of users state *ABDUL* increases supervision process transparency because all data—schedules, instruments, observation results, feedback, follow-up plans—are digitally stored and accessible according to authorization. Teachers state: "I feel fairer because all supervision processes are clearly documented. Madrasah principals can also see my progress over time, so coaching is more objective and data-based" (Physics Teacher, MAN 3).

User Experience Analysis and Implementation Challenges: Balanced View of Digital Tool Integration

Deeper analysis of user experience data reveals both enablers and challenges in *ABDUL* adoption. Positive experiences included appreciation for automation of administrative tasks (82% of users), real-time visibility into teacher progress (79% of users), and improved communication frequency (88% of users). However, challenges encountered during adoption included: (1) initial resistance from 20% of teachers due to concerns about increased monitoring and surveillance, with some expressing anxiety about how *ABDUL* data would be used in performance evaluation, requiring targeted trust-building interventions emphasizing the empowerment and coaching purposes rather than surveillance functions; (2) technical barriers in three cases involving poor internet connectivity in MAN 7, requiring development of offline functionality and mobile-optimized interfaces to enable system usage in limited bandwidth contexts; (3) necessity for system customization to accommodate diverse supervision styles and pedagogical preferences of different madrasah principals, revealing that one-size-fits-all digital tools may not align with local leadership practices; and (4) additional time investment during the initial learning period (average 3–4 hours per month for the first two months) before users achieved proficiency, which competed with already demanding schedules.

These challenges were manageable and resolved through targeted interventions: transparency and trust-building communication sessions clarifying *ABDUL*'s empowerment rather than surveillance functions reduced initial

adoption resistance from 20% to 5%; technical solutions implementing cached offline features and mobile-optimized interfaces accommodated limited connectivity contexts; customizable templates and configurable dashboards allowed different supervision approaches; and routine support mechanisms with email help desk and peer mentoring reduced learning curve impact. Post-challenge implementation assessment showed 89% sustained user satisfaction, demonstrating that initial adoption barriers can be overcome through proper change management, technical adaptation, and organizational support. This balanced view reveals that successful digital tool integration in educational settings requires attention to social, technical, and organizational change dimensions—not merely technology deployment.

Enhancement of Madrasah Principals' Managerial Competence

Full implementation of *ABDUL* over one semester demonstrates significant improvement in madrasah principals' managerial competence measured using the adapted Hallinger's Principal Instructional Management Rating Scale (PIMRS). Managerial competence increased from baseline 65% to 83% (18-point increase or 27.7%). In the defining school mission dimension, madrasah principals show improvement from 62% to 80% (29.0% increase) in their ability to communicate clear learning objectives, integrate madrasah vision into academic supervision, and evaluate learning target achievement based on *ABDUL* data. In the managing instructional program dimension, an increase occurred from 66% to 85% (28.8% increase) encompassing three subdimensions: (a) supervising and evaluating instruction—madrasah principals are more systematic in planning supervision, conducting learning observations based on standardized instruments, and providing evidence-based constructive feedback; (b) coordinating curriculum—madrasah principals can identify gaps between formal and implemented curriculum through *ABDUL* observation data and coordinate improvements with teachers; (c) monitoring student progress—madrasah principals use student learning outcome data from *ABDUL* to analyze learning effectiveness and formulate improvement strategies.

In the promoting positive school learning climate dimension, competence increased from 67% to 84% (25.4% increase), encompassing: (a) protecting instructional time—madrasah principals more effectively ensure learning time is not disrupted by non-learning activities; (b) maintaining high visibility—through *ABDUL*'s real-time monitoring features, madrasah principals have high visibility of learning practices without always needing to be physically present in classrooms; (c) providing incentives for teachers—the

ABDUL system enables madrasah principals to identify and reward teachers demonstrating significant progress objectively and transparently; (d) providing incentives for learning—madrasah principals use *ABDUL* data to design reward programs for high-achieving students. District madrasah supervisors confirm: "I see significant transformation in the instructional leadership of all three madrasah principals. They are now more data-focused, more systematic in supervision, and more proactive in teacher coaching. *ABDUL* provides tools that make their managerial functions more effective" (Bireuen Regency Madrasah Supervisor).

Enhancement of Learning Quality as Supervision Management Output

Learning observation data using the Class Assessment Scoring System (CLASS) instrument shows significant improvement across five dimensions of learning quality during *ABDUL* implementation. The classroom management dimension increased from baseline 52 to 71 (19-point increase or 36.5%), reflecting improved teacher ability to create organized learning environments, manage student behavior positively, and optimize instructional time through systematic coaching provided by madrasah principals via *ABDUL*. The psychological support for students (emotional support) dimension increased from 49 to 68 (19-point increase or 38.8%), showing teachers becoming more responsive to students' emotional needs, creating positive classroom climates, and providing regard for student perspectives—aspects explicitly discussed in *ABDUL* digital coaching sessions.

The instructional support dimension demonstrates the highest increase from 51 to 74 (23-point increase or 45.1%), indicating teachers increasingly implement varied learning strategies, use questioning that promotes higher-order thinking, and provide constructive quality feedback—results from intensive madrasah principal guidance documented in 82 digital coaching sessions in *ABDUL*. The learning media utilization dimension increased from 48 to 70 (22-point increase or 45.8%), showing teachers are more creative in integrating digital and non-digital media, utilizing learning resources shared by madrasah principals through *ABDUL*, and adapting learning technology according to material characteristics. The learning evaluation dimension increased from 55 to 76 (21-point increase or 38.2%), reflecting teachers designing more comprehensive assessments, using clear rubrics, and providing specific and actionable feedback—practices consistently modeled by madrasah principals in digital supervision processes. Madrasah principals reflect: "Learning observation data in *ABDUL* allows me to identify which aspects are still weak

for each teacher and provide targeted coaching. This is no longer general supervision, but personalized and evidence-based coaching" (Principal of MAN 7).

Enhancement of Teachers' Professional Competence Through Digital Supervision

Teacher competence measurement using standardized instruments shows improvement across four competencies. Pedagogical competence increased from 63% to 78% (15-point increase or 23.8%), including improvement in: designing student-centered learning, selecting learning strategies appropriate to student and material characteristics, managing classes effectively, and implementing comprehensive and authentic learning evaluations. Professional competence increased most highly from 65% to 81% (16-point increase or 24.6%), including: deeper mastery of learning materials, understanding of taught scientific structures and concepts, knowledge of contemporary learning theories shared by madrasah principals through *ABDUL*'s resource library, and ability to develop research-based learning innovations. Personality competence increased from 70% to 84% (14-point increase or 20.0%), showing improvement in: stable and steady personality, maturity in facing learning challenges, being role models for students in ethics and integrity, and reflective self-evaluation practices facilitated by *ABDUL*'s digital reflection features. Social competence increased from 68% to 82% (14-point increase or 20.6%), reflecting the ability to communicate with students, parents, fellow teachers, and madrasah principals effectively and professionally—skills indirectly developed through intensive interaction in the *ABDUL* platform.

Teachers report that digital coaching through *ABDUL* provides transformative professional learning experiences: "I receive very specific and actionable feedback from madrasah principals. Not just 'improve teaching methods', but at minute 15 of learning, try using the Socratic questioning technique to increase students' critical thinking. This really helps me improve concretely" (Mathematics Teacher, MAN 3). Another teacher states: "The resource library in *ABDUL* is like my personal professional development library. Madrasah principals routinely upload articles, learning videos, and best practice examples relevant to my needs" (English Teacher, MAN 5). System data shows that, on average, each teacher accesses the resource library 4.7 times per month and downloads 3.2 resources, indicating high engagement in independent professional learning.

Supervision Culture Transformation and System Sustainability

ABDUL implementation produces a fundamental transformation in academic supervision culture across all three madrasahs. Pre-implementation surveys show 78% of teachers perceive supervision as inspection and assessment activities, causing anxiety and threats to professional autonomy. Post-implementation surveys (after six months) show 85% of teachers experience perception transformation and view supervision as supportive and empowering coaching and professional development processes. In-depth interviews reveal shifts from "compliance culture" toward "professional learning culture": teachers no longer view supervision as an obligation to be fulfilled, but as an opportunity for professional growth. Discourse analysis shows changes in teacher language: from "inspected/assessed" to "guided/coached", from "madrasah principals as assessors" to "madrasah principals as mentors and coaches", from "supervision as threat" to "supervision as support system."

Formation of reflection and collaboration culture is evident from: (1) increased peer learning initiatives with 67% of teachers reporting more frequent discussions with colleagues about learning practices, sharing resources, and mutual classroom observations; (2) development of digital community of practice in *ABDUL* with 74% of teachers actively participating in discussion forums, sharing experiences implementing learning strategies, and providing constructive feedback to peers; (3) increased professional reflection with 82% of teachers routinely filling digital reflection journals in *ABDUL*, evaluating their learning practices, and formulating professional development targets. Madrasah principals confirm: "*ABDUL* not only changes our supervision system, but also changes madrasah organizational culture. We now have a continuous learning culture where all madrasah members—principals, teachers, even staff—continue learning and developing" (Principal of MAN 3).

Long-Term Sustainability and Strategies for Scaling Beyond Initial Sites

In the system sustainability dimension, follow-up research results show strong commitment from all three madrasahs to continue using *ABDUL* as the official academic supervision management system post-research. Madrasah principals have: (1) allocated special budgets for system maintenance, periodic feature upgrades, and server hosting costs; (2) institutionalized *ABDUL* within organizational structure by appointing system administrators and help desks; (3) integrated *ABDUL* usage into madrasah principals' job descriptions and academic supervision standard operating procedures (SOPs); (4) planned

ABDUL training for new teachers and knowledge transfer through peer mentoring; (5) developed advanced analytic dashboards for data-based decision making at madrasah management levels.

However, potential long-term sustainability challenges have been identified: (1) Funding continuity beyond the initial research grant support—after grant funding ends, madrasahs must sustain costs from operational budgets, requiring identification of alternative funding sources including government allocations, foundation support, or cost-sharing models; (2) Technical infrastructure maintenance and scaling capacity as user numbers expand—maintaining server performance and data security requires sustainable technical support structures; (3) Staff turnover and knowledge retention—when experienced *ABDUL* administrators transfer, knowledge about system administration and customization may be lost, requiring comprehensive documentation and training programs; (4) Adaptation to evolving Islamic educational policy contexts—as the Ministry of Religious Affairs introduces new policies or accreditation standards, *ABDUL* must be continuously updated, requiring ongoing system development resources; (5) User onboarding challenges for new staff—recurring training burden for new teachers and principals may strain existing support capacity if not systematically managed.

To address these challenges and strengthen transferability to other sites, comprehensive strategies have been developed: (a) Developing a detailed sustainability plan documenting *ABDUL* operational costs and identifying diversified funding sources beyond research grants, including government madrasah operational assistance budgets (BOM), foundation grants, and cost-sharing models. (b) Establishing technical support networks with designated madrasah IT personnel trained as local system administrators and regional help desk structures, enabling distributed problem-solving. (c) Creating system documentation, including administrative manuals, troubleshooting guides, and training modules, enabling knowledge transfer to new staff. (d) Maintaining ongoing alignment with Ministry of Religious Affairs policies through periodic review mechanisms, ensuring regulatory compliance as policies evolve. (e) Planning for cost-effective scaling through exploring open-source technology alternatives, modular system components adaptable to different contexts, and licensing models affordable for diverse madrasahs. Bireuen Regency madrasah supervisors show high interest in adopting *ABDUL* as reference models, with plans to: (1) socialize *ABDUL* to 18 madrasah principals in the regency; (2) pilot project implementation at five additional madrasahs next year; (3) advocate to

the Regency Ministry of Religious Affairs Office for model replication. Madrasah committees express full support: "*ABDUL* increases madrasah management transparency and accountability. We as committees can see supervision data and learning quality objectively, helping us in oversight and advocacy functions" (Committee Chair, MAN 5). These findings indicate high sustainability potential and significant scalability for diffusion to other Islamic educational institutions in Aceh and nationally.

Theoretical Contribution: Digital Instructional Leadership Integration Framework

This research provides a significant theoretical contribution by developing a new conceptual framework integrating three theory corpora that have developed separately: instructional leadership theory (Hallinger, 2018; Leithwood & Louis, 2022), transformative supervision theory (Glickman et al., 2022; Sergiovanni & Starratt, 2022), and management information systems theory (Laudon & Laudon, 2020). This framework fills a significant gap in Islamic educational management literature regarding digital technology operationalization in madrasah principals' managerial leadership functions. Research findings confirm that digitalization of academic supervision is not merely technology adoption, but a fundamental transformation in supervision management logic—from episodic and reactive to continuous and proactive, from subjective-judgmental to objective-evidence-based, from hierarchical-controlling to collaborative-empowering. The *ABDUL* model demonstrates that information technology can be an enabler for madrasah principals to operationalize instructional leadership principles that have been difficult to implement due to time, resource, and documentation system limitations.

This research enriches literature with theoretical propositions: (1) Technology-Managerial Proposition: effectiveness of madrasah principals' instructional leadership is mediated by quality of supervision management information systems used—systems that are transparent, data-based, and facilitate two-way communication enhance supervision impact on teacher professionalism; (2) Digitalization-Humanization Proposition: supervision digitalization does not eliminate humanistic dimensions in teacher coaching, but actually strengthens them by freeing madrasah principals from administrative burdens so they can focus on quality pedagogical dialogue and collaborative reflection; (3) Contextualization-Innovation Proposition: managerial technology innovation in Islamic educational institutions must integrate Islamic values (musyawarah, ta'awun, tamkin, muhasabah) into system design to ensure

acceptance and sustainability; (4) Empowerment Cycle Proposition: digital academic supervision designed with transformative approaches creates continuous empowerment cycles where improved supervision practices enhance teacher professionalism, which in turn produces improved learning quality, reinforcing the value of the system and sustaining commitment to its use.

Practical Contribution: Technology-Based Operational Instructional Leadership Model

The *ABDUL* model provides an operational blueprint replicable by other madrasah principals to transform their academic supervision systems. Unlike conventional supervision models often trapped in administrative formalities, *ABDUL* demonstrates that digital technology can integrate five managerial functions into one coherent ecosystem. In the planning function, systems facilitate madrasah principals to conduct teacher needs analysis based on historical data, compile systematic supervision schedules with automatic reminders, and establish SMART coaching targets (Specific, Measurable, Achievable, Relevant, Time-bound). In the organizing function, integrated dashboards provide comprehensive visibility about each teacher's supervision status, enable effective coordination between madrasah principals and deputy principals for curriculum affairs, and facilitate transparent multi-directional communication. In the leading function, digital coaching features enable madrasah principals to provide continuous coaching without space and time limitations, share learning resources relevant to individual teacher needs, and build trust through respectful and supportive communication.

In the controlling function, real-time monitoring systems enable madrasah principals to identify early warning signs regarding teachers requiring intensive intervention, track supervision follow-up plan implementation, and ensure accountability without being punitive. In the evaluation function, system analytics generate comprehensive reports about learning quality trends, coaching program effectiveness, and Return on Investment (ROI) from supervision activities for evidence-based decision making. Although short-term improvements in madrasah principals' managerial competence (27.7%), teacher professional competence (24.6%), and learning quality (36.5–45.8%) are well documented, long-term sustainability of these improvements requires addressing potential challenges. Long-term sustainability challenges include ensuring funding continuity beyond initial implementation support, maintaining technical infrastructure as user numbers expand, managing staff turnover and institutional knowledge retention, and adapting the system to evolving Islamic educational

policies. Strategies for scaling beyond initial sites include: (1) Developing comprehensive sustainability plans documenting operational costs and identifying diversified funding sources (government madrasah operational assistance budgets, foundation grants, cost-sharing models) to ensure long-term operation beyond research support. (2) Establishing regional technical support networks with designated IT personnel and help desk structures enabling distributed problem-solving. (3) Creating system documentation and training modules enabling knowledge transfer to new staff, minimizing disruption due to staff turnover. (4) Planning for cost-effective scaling through open-source technology alternatives, modular system components adaptable to different madrasah contexts, and flexible licensing models. (5) Maintaining alignment with Ministry of Religious Affairs policies through periodic review mechanisms, ensuring regulatory compliance as policies evolve.

The *ABDUL* model also demonstrates how madrasah principals can transform their roles from "inspector" to "instructional coach." Research data reveals that when madrasah principals have reliable systems for documentation and analysis, they can allocate more energy to truly important functions: in-depth pedagogical dialogue with teachers about learning, collaborative reflection about learning challenges faced, and co-construction of contextually appropriate improvement strategies. These findings align with distributed leadership theory (Spillane, 2006), emphasizing that instructional leadership effectiveness depends on interaction quality between leaders, followers, and situations—in this case, *ABDUL* as a technological artifact forms situations facilitating high-quality interactions. Important practical implications are that investments in educational management information technology are not merely modernization of administrative systems, but strategic interventions to enhance madrasah principals' instructional leadership capacity and consequently improve student learning quality.

Policy Implications: Digital Transformation of Madrasah Management

Short-term Policy Priorities

Research findings have significant policy implications for the Ministry of Religious Affairs and Islamic education stakeholders. First, the urgency of developing academic supervision management information system standards in madrasahs. Currently, no regulations explicitly govern information technology standards in madrasah academic supervision, causing high variability in practices across madrasahs. The Ministry of Religious Affairs needs to formulate Guidelines for Madrasah Academic Supervision Management Information

Systems encompassing minimum system feature standards, data security protocols, and quality assurance mechanisms.

Second, budget allocation for developing the Islamic educational management information technology infrastructure. Research results show that *ABDUL* implementation requires relatively affordable investment (estimated IDR 15-20 million per madrasah for development, hosting, and first-year maintenance), yet provides high returns in enhanced management effectiveness and learning quality. The Ministry of Religious Affairs can allocate madrasah operational assistance funds (BOM) or special grants for developing similar digital systems in madrasahs meeting readiness criteria.

Third, developing capacity-building programs for madrasah principals in digital leadership. Research findings indicate that *ABDUL* implementation success depends not only on technology quality, but also on madrasah principals' digital leadership competence. The Ministry of Religious Affairs through Religious Education Training Centers needs to design Digital Instructional Leadership training programs for madrasah principals including: (1) data-based instructional leadership concepts and principles; (2) managerial information technology competence; (3) digital coaching skills and effective online communication; (4) data literacy for evidence-based analysis and decision making; and (5) change management for transforming supervision culture.

Fourth, policy regarding the diffusion of innovation for scaling up the *ABDUL* model. This research shows the *ABDUL* model has high replication potential with feasibility levels of 92.5% and user satisfaction levels of 86.5%. The Ministry of Religious Affairs can facilitate: (1) documentation and dissemination of *ABDUL* best practices through publications, workshops, and knowledge sharing platforms; (2) establishment of model madrasahs as centers of excellence for peer learning by other madrasahs; (3) incentives for madrasahs successfully adopting digital supervision systems; and (4) mandatory policies for A-accredited madrasahs to implement information technology-based supervision systems as one accreditation standard.

Long-term Sustainability Challenges and Strategies

While the *ABDUL* model demonstrates significant short-term effectiveness, scaling beyond the initial three pilot sites requires careful consideration of long-term sustainability challenges. First, financial sustainability demands continuous funding mechanisms beyond initial implementation. The Ministry of Religious Affairs should establish a Digital Madrasah Infrastructure Endowment Fund, combining recurring BOM allocations (minimum 5% designated for ICT infrastructure maintenance), special government grants, and potential public-private partnerships with Islamic technology companies. A

cost-sharing model could be developed where the central government covers 70% of costs for public madrasahs in the first three years, gradually reducing to 40% by year five as madrasahs develop self-sustaining mechanisms. Without secure, multi-year funding commitments, many madrasahs risk abandoning digital systems after initial enthusiasm wanes, reverting to paper-based supervision that perpetuates existing inefficiencies.

Second, technical sustainability necessitates a robust support infrastructure. The Ministry should establish Provincial Digital Support Units (PDSU) staffed with 2-3 technical specialists per province to provide: (a) regular system maintenance and security updates; (b) 24/7 helpdesk services via WhatsApp and phone hotlines; (c) quarterly system audits and performance optimization; (d) data backup and recovery services; and (e) technology refresh cycles every 3-5 years to prevent system obsolescence. These units would coordinate with Balai Diklat Keagamaan (Religious Training Centers) to deliver cascading technical training. The estimated cost of IDR 800 million - 1.2 billion per PDSU annually is substantially lower than the aggregate cost of failed implementations and lost productivity from unsupported systems.

Third, human resource sustainability requires systematic capacity building and knowledge management. Beyond initial training, the Ministry should implement: (a) a Digital Leadership Certification program for madrasah principals with mandatory recertification every three years; (b) apprenticeship programs where newly appointed principals spend 2-3 weeks at model madrasahs; (c) development of a cadre of 'super-users' - master trainers who can provide peer coaching within madrasah clusters; and (d) succession planning protocols that ensure knowledge transfer during staff turnover. Research from similar educational technology implementations shows that 60-70% of digital initiatives fail due to inadequate attention to human capacity, not technology failures per se.

Fourth, technological evolution and adaptation must be anticipated. The *ABDUL* system should be architected with modular, cloud-based infrastructure allowing incremental feature additions without complete system overhauls. The Ministry should allocate 15-20% of the annual ICT budget to research and development, exploring integration with emerging technologies such as artificial intelligence for automated learning analytics, mobile-responsive interfaces for areas with limited desktop access, and interoperability with national education management information systems (EMIS). A technology roadmap spanning 5-10 years should guide strategic investments, preventing ad-hoc decisions that create fragmented systems.

Scaling Strategies: Phased Expansion and Replication Framework

Expanding *ABDUL* beyond the three pilot madrasahs requires a systematic, phased approach grounded in implementation science. Phase 1 (Years 1-2): Consolidation and Documentation focuses on strengthening pilot sites while comprehensively documenting implementation processes, challenges, and solutions. This includes developing: (a) standardized implementation manuals with step-by-step procedures adapted to varying madrasah contexts; (b) video case studies showcasing successful practices; (c) cost-benefit analyses demonstrating return on investment; and (d) troubleshooting guides addressing common technical and organizational challenges. Concurrently, pilot madrasahs should be formally designated as Centers of Excellence with dedicated resources for hosting study visits and peer learning exchanges.

Phase 2 (Years 2-4): Strategic Diffusion involves expanding to 30-50 carefully selected madrasahs across diverse geographical and socio-economic contexts. Selection criteria should prioritize: (a) madrasahs with minimum B accreditation demonstrating baseline management capacity; (b) principals with at least two years tenure ensuring implementation continuity; (c) available internet connectivity of at least 10 Mbps; (d) commitment evidenced by madrasah committee endorsement and cost-sharing agreements; and (e) geographical distribution ensuring representation from urban, suburban, and rural settings to test model adaptability. Each expansion cohort should include 10-15 madrasahs to enable intensive support while generating sufficient data on replication fidelity.

Phase 3 (Years 4-7): Accelerated Scaling transitions to broader dissemination once replication protocols are validated. This phase targets 200-300 madrasahs through: (a) mass training programs utilizing cascade models where Phase 2 adopters train Phase 3 participants; (b) online learning modules and webinars reducing face-to-face training costs; (c) regional implementation hubs in each province providing localized support; and (d) integration into national accreditation standards making digital supervision systems a requirement for a accreditation renewal. The Ministry should establish clear quality benchmarks and conduct annual evaluations to ensure fidelity to core model elements while permitting contextual adaptations.

Phase 4 (Years 7-10): Institutionalization and Normalization aims to embed digital academic supervision as standard practice across Indonesian madrasah system. This involves: (a) mandatory policies requiring all public madrasahs to implement approved digital supervision systems; (b) inclusion of digital leadership competencies in principal preparation and licensure programs; (c) integration with national teacher professional development systems; and (d)

establishment of sustainability mechanisms transferring program management from donor/project funding to routine government operations. Throughout all phases, rigorous monitoring and evaluation should track implementation fidelity, user adoption rates, and impact on instructional quality outcomes, with findings informing adaptive management and continuous improvement.

Addressing External Factors: Policy Support, Funding, and Contextual Adaptation

The transferability and sustainability of the *ABDUL* model are significantly influenced by external environmental factors requiring proactive policy interventions. Regarding policy support, the current regulatory vacuum creates uncertainty, hindering widespread adoption. The Ministry of Religious Affairs should issue a comprehensive policy framework including: (a) Peraturan Menteri Agama (Ministerial Regulation) on Standards for Digital Academic Supervision Systems, specifying mandatory features, data privacy protections, and quality assurance processes; (b) revision of madrasah accreditation instruments incorporating digital management capacity as assessment criteria, weighted at 15-20% of total scoring; (c) amendments to principal competency standards explicitly including digital leadership capabilities; and (d) establishment of a National Coordinating Committee for Madrasah Digital Transformation providing strategic oversight and resolving cross-sectoral coordination challenges. International evidence suggests that successful educational technology scaling occurs primarily in contexts with supportive policy environments that provide clear expectations, incentives, and accountability mechanisms.

Regarding funding continuity, over-reliance on project-based financing creates boom-bust cycles, undermining sustainability. A multi-sourced funding strategy should include: (a) permanent budget line items in the Ministry's annual appropriation specifically for madrasah ICT infrastructure, targeting 3-5% of total education budget aligned with UNESCO recommendations; (b) performance-based grants rewarding madrasahs demonstrating effective digital system utilization and learning quality improvements; (c) establishment of a Madrasah Innovation Fund supported by zakat, waqf, and corporate social responsibility contributions from Islamic financial institutions; (d) cost-recovery mechanisms such as modest per-madrasah annual subscription fees (IDR 2-3 million) for premium features and technical support, with cross-subsidies ensuring affordability for under-resourced institutions; and (e) exploration of results-based financing models where government pays for documented improvements in teacher competence and student learning outcomes rather

than inputs. This diversified approach reduces vulnerability to budgetary fluctuations and political changes.

Regarding infrastructure disparities, successful scaling must acknowledge that Indonesia's 28,000+ madrasahs operate in vastly different contexts. In 2024, approximately 35% of madrasahs, particularly in Eastern Indonesia and remote areas, lack reliable internet connectivity essential for cloud-based systems. The Ministry should pursue a differentiated implementation strategy: (a) developing hybrid online-offline versions of *ABDUL* allowing data entry offline with periodic synchronization when connectivity is available; (b) partnering with telecommunications providers to extend subsidized internet access to educational institutions under Universal Service Obligation programs; (c) creating lightweight mobile applications optimized for low-bandwidth environments and smartphone access; (d) establishing regional data centers with local server hosting reducing dependence on centralized cloud infrastructure; and (e) piloting alternative connectivity solutions such as community networks and satellite internet in extremely remote locations. Technology should adapt to contextual realities rather than expecting contexts to transform overnight to accommodate technology.

Regarding user adoption and change management, resistance to digital transformation often stems from legitimate concerns about workload, privacy, technological complexity, and fear of evaluation rather than mere traditionalism. Effective onboarding strategies should include: (a) phased implementation allowing gradual system familiarization, beginning with simple documentation features before advancing to analytical tools; (b) user-centered design incorporating teacher and principal feedback in iterative system improvements; (c) transparent communication about data usage policies, emphasizing that supervision aims to support professional growth rather than punitive evaluation; (d) provision of adequate time and resources for learning, including protected training time and temporary reduction of other administrative burdens during transition periods; (e) cultivation of 'digital champions' - enthusiastic early adopters who provide peer support and model effective practices; and (f) celebration of success stories and recognition of exemplary users through awards and media coverage. Research on educational change indicates that implementation success depends less on technology quality than on the quality of human systems supporting adoption.

Finally, contextual adaptation frameworks should guide localization while maintaining model fidelity to core components. The Ministry should distinguish between essential elements that must be preserved (e.g., systematic planning, classroom observation, reflective feedback, data-driven decision making) and adaptable elements that can be modified (e.g., interface language

supporting regional languages, cultural customization of examples and scenarios, adjustment of supervision frequency to align with madrasah calendars and teacher workloads, integration with existing madrasah management systems). Clear guidance on permissible adaptations prevents well-intentioned modifications that inadvertently undermine model effectiveness while avoiding rigid standardization that ignores legitimate contextual differences.

CONCLUSION

This research successfully developed a digital academic supervision model based on the *ABDUL* application, proven effective in enhancing madrasah principals' instructional leadership functions and learning management quality in Madrasah Aliyah in Bireuen Regency. Expert validation confirms model feasibility with scores of 92.5% (highly feasible), while implementation generates 87% positive responses from users. The research's theoretical contribution is the development of a conceptual framework integrating instructional leadership theory, transformative supervision, and management information systems within Islamic educational contexts, filling literature gaps regarding the digitalization of madrasah principals' managerial functions. Practically, the *ABDUL* model enhances instructional leadership effectiveness through improvements in madrasah principals' managerial competence (27.7%), teachers' professional competence (24.6%), learning quality (36.5-45.8%), and transformation of supervision culture from evaluative-punitive to empowering-collaborative (85%). This model provides operational blueprints replicable in other madrasahs and has significant policy implications for the digital transformation of Islamic educational management in Indonesia. Despite these promising results, this research acknowledges several inherent limitations that warrant careful consideration.

First, the study's scope was confined to three State Madrasah Aliyah within a single regency (Bireuen), representing a relatively homogeneous geographical and administrative context. This limited sample size and regional concentration restrict the generalizability of findings to madrasahs operating in substantially different socio-economic environments, institutional cultures, infrastructure readiness levels, and governance structures—particularly private madrasahs, rural institutions with minimal connectivity, or madrasahs in regions with distinct cultural and linguistic characteristics. Second, the 12-month implementation period, while adequate for demonstrating initial effectiveness and user acceptance, constitutes a relatively short timeframe for observing long-term sustainability dynamics. Critical questions regarding system maintenance after external support withdrawal, user engagement patterns beyond the novelty phase, institutional capacity to manage technology upgrades and security

patches, and resilience to staffing turnover remain partially unanswered. Third, methodological considerations include potential self-reporting bias in user satisfaction instruments, where participants may provide socially desirable responses, and the Hawthorne effect, wherein observed performance improvements may partially reflect participants' awareness of being studied rather than solely intervention impacts. Fourth, while the research design controlled for major confounding variables, definitively attributing all observed improvements exclusively to *ABDUL* implementation remains challenging, as concurrent professional development initiatives, policy changes, or broader educational reform movements may have contributed synergistically to outcomes. Fifth, the study focused primarily on process indicators and immediate outcomes (managerial competence, professional competence, learning quality dimensions) rather than ultimate student learning outcomes, which represent the fundamental goal of instructional leadership interventions. These limitations do not invalidate findings but suggest appropriate caution in extrapolating results to markedly different contexts without contextually-informed adaptations and further validation studies. These limitations illuminate several critical avenues for future research that would substantially advance both theoretical understanding and practical implementation of digital academic supervision in Islamic educational settings. Most urgently, longitudinal studies tracking *ABDUL* implementation across 3–5-year periods are essential for assessing sustainability trajectories, identifying factors differentiating madrasahs that maintain robust system usage from those experiencing declining engagement, documenting institutional strategies for navigating technological obsolescence and vendor dependencies, and examining how supervision practices evolve as users develop deeper proficiency with digital tools. Such studies should employ mixed-methods designs combining quantitative metrics of system usage patterns, supervision frequency and quality, and student learning outcomes with rich qualitative data capturing organizational learning processes, cultural shifts, and emergent practices not anticipated in initial design specifications.

Second, comparative implementation studies across diverse Islamic educational contexts would illuminate boundary conditions of model effectiveness and inform targeted scaling strategies. Research should systematically vary institutional characteristics including: (a) governance type, comparing public madrasahs with government support against private madrasahs relying on tuition and philanthropic funding; (b) educational levels, extending from Madrasah Ibtidaiyah (elementary) through Madrasah Tsanawiyah (junior secondary) to Madrasah Aliyah (senior secondary) to understand how supervision needs and digital tool requirements differ across

student developmental stages; (c) geographical contexts, contrasting resource-rich urban madrasahs in Java with resource-constrained rural institutions in Eastern Indonesia's remote regions; (d) institutional specializations, examining regular madrasahs, pesantren-based boarding madrasahs, and specialized madrasahs focusing on sciences or languages; and (e) performance baselines, investigating whether high-performing madrasahs benefit differently from digital supervision compared to struggling institutions requiring more intensive support. Multi-site comparative case studies employing replication logic would identify core model components requiring faithful implementation versus adaptable elements permitting contextual modification, thereby developing nuanced implementation frameworks rather than one-size-fits-all prescriptions.

Third, research investigating critical success factors and implementation failure modes across larger, more diverse samples would generate actionable insights for practice. Mixed-methods studies should examine: (a) leadership characteristics and behaviors distinguishing madrasah principals who successfully champion digital transformation from those whose initiatives falter; (b) organizational readiness factors including technology infrastructure, staff digital literacy, existing management systems, and change capacity that predict implementation success; (c) support structures and external partnerships enabling effective adoption; (d) resistance sources and change management strategies for overcoming skepticism or opposition; and (e) cost-benefit analyses documenting return on investment across varying implementation scales and institutional contexts. Such research should explicitly theorize implementation as a process unfolding over time rather than a discrete event, attending to initiation decisions, early implementation challenges, institutionalization dynamics, and sustainability mechanisms.

Fourth, studies exploring integration of emerging technologies would position *ABDUL* within evolving digital ecosystems. Research questions include: (a) Can artificial intelligence and machine learning algorithms meaningfully analyze classroom observation data to identify patterns, generate automated feedback, and recommend personalized professional development pathways while maintaining pedagogical validity and avoiding reductionist metrics? (b) How can mobile-responsive designs and progressive web applications extend access in contexts where smartphones are more prevalent than computers? (c) What interoperability standards and data exchange protocols enable seamless integration between academic supervision systems and complementary platforms including learning management systems, student information systems, teacher professional development tracking systems, and national education management information systems? (d) How might learning analytics dashboards synthesize supervision data with student assessment results

to illuminate relationships between instructional practices and learning outcomes? (e) What privacy-preserving technologies and data governance frameworks balance the benefits of data-driven decision making against legitimate concerns about surveillance, evaluation anxiety, and misuse of sensitive information? Such research should critically examine technology not as neutral tools but as socio-technical systems embodying particular values, power relations, and epistemological assumptions requiring careful ethical scrutiny.

Fifth, comparative international research examining digital academic supervision models in other Muslim-majority countries would enable cross-pollination of innovations while attending to important contextual differences. Studies could investigate how Malaysia's School Improvement Specialist Coaches program, Turkey's MEB e-supervision system, Saudi Arabia's Madrasati platform, or UAE's digital inspection framework's structure supervision processes, leverage technology, address cultural considerations, and demonstrate effectiveness. Rather than uncritical transplantation of "best practices" divorced from context, such research should employ comparative education frameworks examining how political structures, religious interpretations, economic resources, technological infrastructure, educational traditions, and societal expectations shape what digital supervision means and how it operates in particular settings. This could generate middle-range theories specifying conditions under which particular approaches prove effective, informing culturally-grounded innovations rather than acontextual universalism.

Sixth, research tracing impacts from instructional leadership interventions through teacher practices to student learning outcomes would strengthen causal chains and provide ultimate effectiveness evidence. While the current study documents improvements in supervision processes and teacher perceptions, theory of action suggests these should ultimately enhance student learning. Rigorous studies employing quasi-experimental designs with matched comparison groups, value-added models accounting for prior achievement, or randomized controlled trials where ethically feasible should test whether digital supervision innovations translate into measurable learning gains. Such studies should examine not only standardized achievement but also broader outcomes including critical thinking, creativity, religious knowledge and character formation, and preparation for higher education and careers—reflecting the holistic educational goals central to Islamic educational philosophy.

Finally, theoretical research advancing conceptual frameworks for technology-mediated instructional leadership in Islamic educational contexts would contribute to scholarship. The *ABDUL* model integrates Western management theories with Islamic educational values, but further theoretical development could explore: (a) How do Islamic concepts of tarbiyah (holistic

education), ta'dib (ethical refinement), and ta'lim (knowledge transmission) inform distinctive approaches to instructional supervision differing from secular Western models? (b) What tensions or complementarities emerge when modern management technologies intersect with traditional authority structures and communal decision-making processes in Islamic institutions? (c) How can digital systems honor principles of shura (consultation), amanah (trustworthiness), and ihsan (excellence) embedded in Islamic organizational ethics? (d) What epistemological assumptions about knowledge, authority, pedagogy, and evaluation are embedded in digital tools, and how do these align or conflict with Islamic educational philosophies? Such inquiries would advance theoretically-grounded, culturally-responsive scholarship rather than merely adapting Western frameworks to Islamic contexts.

In conclusion, while this research makes significant theoretical and practical contributions to understanding digital transformation of academic supervision in madrasahs, it simultaneously opens multiple avenues for future scholarship. The acknowledged limitations—restricted sample size and geographical scope, relatively short implementation period, methodological considerations, and focus on proximal rather than distal outcomes—should be viewed not as fatal flaws but as inherent features of pioneering research establishing initial proof-of-concept. Future research pursuing longitudinal, comparative, multi-level, technologically-innovative, internationally-informed, outcome-focused, and theoretically-sophisticated inquiries will progressively refine understanding, strengthen evidence, and ultimately contribute to educational quality improvements benefiting the millions of students, hundreds of thousands of teachers, and thousands of madrasahs constituting Indonesia's vital Islamic educational sector. Such sustained research programs require institutional commitment, adequate funding, collaborative networks, and patience to generate cumulative knowledge rather than isolated studies—representing an important agenda for Indonesian educational research in the coming decade.■

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