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Integration of Internet of Things (IoT) in Islamic Religious Education Learning: Implications for Adaptive Curriculum Development and TPACK-Based Learning Management in Higher Education

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Abstract: The implementation of Islamic Religious Education (PAI) in higher education plays a strategic role in shaping students' character, spirituality, and academic integrity. However, its implementation still faces several challenges, including disparities in teaching practices, limited technology utilization, non-adaptive learning approaches, and non-integrated academic management systems. This study specifically aims to: (1) identify disparities in lecturers' teaching practices in PAI learning; (2) analyze students' needs for interactive and adaptive learning environments; (3) examine the limitations of existing academic management systems; and (4) explore how the integration of the Internet of Things (IoT) can address these challenges through adaptive curriculum development and TPACK-based learning management. This research employs a qualitative approach with a phenomenological design conducted at an Islamic higher education institution. The participants consisted of 24 individuals, including lecturers, students, and educational staff selected through purposive sampling based on data saturation principles. Data sources include primary data obtained through in-depth interviews and observations, as well as secondary data from institutional documents. Data collection techniques involved interviews, participatory observation, and documentation, while data analysis used the Colaizzi phenomenological method supported by triangulation and member checking to ensure validity. The findings reveal significant disparities in lecturers' teaching practices, a strong need for interactive and adaptive learning environments, and limitations in existing academic management systems. The integration of IoT demonstrates considerable potential in enabling real-time data processing, supporting adaptive learning systems, and enhancing data-driven decision-making processes. In conclusion, IoT integration represents a strategic solution for transforming PAI learning into a more adaptive, interactive, and efficient system. However, its successful implementation depends on infrastructure readiness, digital competence, and institutional policy support.

Keyword : Internet of Things, Adaptive Learning, Islamic Religious Education, TPACK, Higher Education

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Introduction

Islamic Religious Education (PAI) in higher education has a strategic role in shaping the character, spirituality, and academic integrity of students (Muldiah &

Wulandari, 2025). In the context of Islamic higher education, PAI not only functions as a transmission of religious knowledge, but also as a means of developing students' moral values, tolerance, and religious identity. Various studies show that a spirituality-based educational approach is able to improve the well-being and quality of student learning holistically (Hakim & Haryadi, 2025). However, the implementation of PAI learning in higher education still faces various complex challenges, both in pedagogical and managerial aspects.

The main problems that arise include the disparity in lecturers' teaching styles (Ondeng & Usman, 2026), limitations in the use of technology (Agista & Hendrawati, 2025), and incompatibility of learning methods with heterogeneous student characteristics (Ardiansyah et al., 2025). The difference in teaching approach between lecturers based on curriculum and those based on personal experience causes inconsistency in learning outcomes. In addition, learning methods that still tend to be conventional have not been able to accommodate the diversity of students' learning styles, backgrounds, and cognitive capacities, thus hindering the creation of adaptive and inclusive learning. On the other hand, weaknesses in academic management, such as a manual evaluation system and low technological literacy of education personnel, further worsen the effectiveness of educational services (Elyus et al., 2025).

Theoretically, these problems can be explained through several conceptual frameworks. Vygotsky's theory of constructivism emphasizes the importance of scaffolding and the Zone of Proximal Development (ZPD) in supporting optimal learning processes (Mutmainna et al., 2025). Meanwhile, the differentiated instruction approach emphasizes the need for learning strategies that are adaptive to the diversity of students (Qomariah et al., 2025). On the other hand, the Technological Pedagogical Content Knowledge (TPACK) framework highlights the importance of integration between aspects of technology, pedagogy, and content in creating effective modern learning (Cao et al., 2026). However, in practice, there is still a gap in technological competence among lecturers and education staff, so that technology integration has not been able to support the development of adaptive curriculum optimally (Rizky, 2026).

In the context of digital transformation of education, the Internet of Things (IoT) has emerged as one of the innovative solutions that has the potential to overcome these various problems. IoT not only functions as a technological infrastructure, but also as an intelligent system capable of integrating learning processes, curriculum management, evaluation, and academic services in a data-driven manner (Wahyudi et al., 2025). Through the use of sensors and learning analytics, IoT can map lecturers' teaching patterns, identify student learning gaps, and provide real-time feedback to support more responsive decision-making. Thus, IoT has the potential to encourage the creation of more personalized, adaptive, and

efficient learning, while improving the quality of education management (Kobandaha et al., 2025).

However, a review of the literature shows that research on the integration of IoT in education is still dominated by the general context or aspects of education management at large. Research that specifically examines the application of IoT in PAI learning in Islamic universities is still very limited (Rodin et al., 2025). In addition, there have not been many studies that have explored in depth how IoT can bridge pedagogical gaps, support the development of adaptive curricula, and respond to students' cognitive diversity in the context of religious education. This shows that there is a significant research gap and is an important basis for this research.

The results of a comparative analysis of the five most recent studies (2025–2026) show that most studies still focus on the development of TPACK frameworks in the context of technologies such as AI and adaptive learning, but have not specifically examined the integration of IoT in empirical experiential learning. In addition, previous research tends to focus on pedagogical aspects without integrating the dimension of academic management comprehensively. In contrast to this study, which not only examines the integration of IoT in PAI learning, but also explores its implications for the development of adaptive curricula and data-driven academic management systems through a multi-actor phenomenological approach (Sivaci & Hakkoymaz, 2026). Thus, this study makes a more holistic and contextual contribution than previous studies.

The following is a table of the Summary of the Latest TPACK Research in Technology-Based Learning

Table 1.
Summary of Latest TPACK Research in Technology-Based Learning

No	References	I (Introduction)	M (Method)	R (Result)
1	Deb, J.P. et al. (2026). *S-TPACK Systematic Review* (Deb et al., 2026)	Focus on the integration of TPACK with sustainability and technology	Systematic review (literature-based)	TPACK evolves towards integrative (S-TPACK)
2	Chiu, T.K.F. (2026). *Smart-TPACK (I-TPACK)* (Chiu, 2026)	Development of AI-based TPACK and digital competencies	Conceptual model + framework validation	I-TPACK improves the quality of adaptive learning
3	Gökbulut, B. (2026). *AI-*	Integration of AI in teacher learning	Mixed method (quantitative + qualitative)	AI improves teachers' TPACK competencies

	TPACK Mixing Method (Gökbulut, 2026)			
4	Putri, D.H. et al. (2025). *TPACK & Virtual Lab* (Putri et al., 2025)	Integration of technology (IoT, AR, AI) in science learning	Bibliometrics + pedagogical analysis	Trend of increasing the use of technology in learning
5	Marlina, R. et al. (2023) Trends in Reflective Practitioner TPACK Research (Marlina et al., 2023)	Focus on the integration of TPACK in the development of pedagogical competencies of reflective practitioners in higher education	Systematic review with PRISMA (5 stages) using the Scopus & ScienceDirect database	Dominant themes: implementation and identification of TPACK (21.88%); Lowest: Instrument Development (14.06%) of 64 articles

Based on the identified research gaps and the complexity of the problems described above, this study specifically aims to: (1) identify disparities in lecturers' teaching practices in PAI learning; (2) analyze students' needs for interactive and adaptive learning environments; (3) examine the limitations of existing academic management systems; and (4) explore how the integration of the Internet of Things (IoT) can address these challenges through adaptive curriculum development and TPACK-based learning management in higher education.

These objectives are formulated to provide a more structured and operational direction for the study, ensuring alignment between the identified problems, data analysis, and research findings.

The contribution of this research is expected to be not only practical in improving the quality of learning and education management, but also to make a theoretical contribution to the development of technology-based Islamic education studies. In addition, this research offers an integrative framework between IoT, constructivism, differentiated instruction, and TPACK as a basis for building an adaptive, inclusive, and sustainable learning ecosystem in the digital era (Deb et al., 2026).

Methodology

This study uses a qualitative approach with a phenomenological design to deeply understand the experiences, perceptions, and practices of educational actors in integrating the Internet of Things (IoT) into Islamic Religious Education (PAI) learning in higher education (Irfanda & Triasnawa, 2025). This approach was chosen because it was able to reveal the essential meaning of the participants' subjective experiences, especially in learning dynamics, pedagogical interactions, and the management of technology-based academic systems. The research participants were determined through purposive sampling techniques involving 24 people consisting of lecturers, students, and education staff, based on the principle of data saturation. This multi-actor involvement aims to obtain a comprehensive perspective so that the phenomenon can be understood holistically from both pedagogical and managerial aspects.

Data collection was carried out through in-depth interviews, participatory observations, and documentation studies that were used simultaneously to ensure the depth and validity of the data through triangulation methods. The researcher as the main instrument is supported by interview guidelines, observation sheets, and documentation checklists compiled based on the TPACK framework, constructivism, and IoT. Data analysis uses the phenomenological approach of the Colaizzi (1978) model through the stages of identifying meaning to the preparation of essential structures, which are then validated through member checking (Aristina et al., 2025). The validity of data is guaranteed through the principles of trustworthiness which includes credibility, transferability, dependability, and confirmability, and is supported by the application of research ethics such as informed consent, data confidentiality, and responsible use of data for academic purposes (Yanti et al., 2025).

Data analysis in this study was conducted following the seven systematic stages of the Colaizzi (1978) phenomenological model to ensure a rigorous and transparent interpretive process. First, the researcher engaged in familiarization by repeatedly reading the interview transcripts of the 24 participants (lecturers, students, and educational staff) to gain a holistic understanding of their experiences. Second, significant statements directly related to IoT integration and academic management challenges were extracted. Third, formulated meanings were developed by translating these statements into theoretical concepts while preserving the original essence of the participants' perspectives. Fourth, these meanings were clustered into major themes, such as pedagogical disparities and managerial limitations. Fifth, the results were synthesized into an exhaustive description of the digital transformation phenomenon within the PAI learning environment. Sixth, the essential structure of the phenomenon was identified to capture the fundamental nature of the integration. Finally, the analysis was validated through member checking, where findings were returned to the participants to ensure that the descriptions accurately reflected their

lived experiences, thereby maintaining the trustworthiness and credibility of the research.

Results and Discussion

The results of this study were derived from a phenomenological analysis of data collected through in-depth interviews, participatory observations, and documentation involving lecturers, students, and educational staff. As this study is based on field research, documentation in the form of photographs and field records was collected during interviews, observations, and academic activities. This documentation supports the credibility of the data and provides contextual evidence of the research process.

Figure 1. Interview Process with Research Participants

Figure 2. Classroom Observation during PAI Learning Activities

Figure 3. Documentation of Academic Administrative Activities

The documentation presented above illustrates several field research activities conducted during the data collection process, including interviews, classroom observations, and institutional academic activities. These documentations provide contextual evidence that supports the credibility and authenticity of the research findings. Based on the phenomenological analysis of the collected data, the findings of this study are organized into several major themes that reflect the dynamics and challenges of integrating technology-oriented learning in Islamic Religious Education (PAI) in higher education. Furthermore, the findings are systematically organized into four main themes that are explicitly aligned with the research objectives, ensuring coherence between the research focus, data analysis, and interpretation of results.

Disparities in Lecturers' Teaching Practices

The results of the study show that there is a significant disparity in the teaching style of Islamic Religious Education (PAI) lecturers, which has a direct impact on the unevenness of students' learning experience. This variation in approach is reflected in the results of interviews which reveal that some lecturers rely more on a personal experience-based approach and open discussions without strictly referring to the Semester Learning Plan (RPS). On the other hand, there are also lecturers who consistently follow RPS as the main reference to ensure the achievement of measurable and systematic learning outcomes. This difference in orientation shows that there are inconsistencies in the implementation of the curriculum that have the potential to affect the overall quality of learning.

This finding is strongly supported by interview data, where one lecturer stated that teaching is often adjusted based on personal experience rather than strictly following the Semester Learning Plan (RPS), indicating inconsistency in instructional design and delivery. In addition, classroom observations demonstrate noticeable variation in teaching methods. Some lecturers still rely heavily on conventional lecture-based approaches, while others attempt to incorporate discussion and student participation, although not yet in a structured manner. These observational findings indicate the absence of standardized pedagogical practices across learning sessions.

Documentation analysis further reveals a discrepancy between the planned learning outcomes outlined in the RPS and their actual implementation in classroom practices, highlighting a gap between curriculum design and execution.

From a theoretical perspective, this condition reflects that the scaffolding process, as emphasized in Vygotsky's constructivist theory, has not been optimally implemented. Learning strategies tend to overlook students' Zone of Proximal Development (ZPD), resulting in less effective instructional support. Within the TPACK framework, this also indicates a lack of integration between technological, pedagogical, and content knowledge, particularly in designing structured and adaptive learning experiences.

In this context, the integration of IoT offers a promising pathway to minimize such disparities. By utilizing learning analytics and real-time monitoring systems, lecturers can gain deeper insights into students' learning progress and needs, enabling more consistent and data-informed teaching practices.

Thus, Internet of Things (IoT) integration has strategic potential as a solution to overcome these disparities through the provision of data-driven learning systems. Through the use of learning analytics and IoT-based monitoring systems, lecturers can obtain more accurate information about students' characteristics, needs, and learning developments. This allows lecturers to adjust teaching strategies in a more structured, adaptive, and evidence-based manner, so as to improve the consistency and quality of PAI learning in higher education.

Students' Need for Interactive and Adaptive Learning

Another important finding of this study is the strong demand among students for more interactive and adaptive learning environments. Conventional teaching methods are increasingly perceived as less engaging and insufficient in supporting meaningful learning experiences. Interview findings clearly indicate that students feel more motivated and engaged when learning involves interactive elements and the use of digital technology, as reflected in one student's statement that technology-supported learning makes the material easier to understand and more interesting.

This perception is consistent with classroom observations, which show that student participation tends to decline in sessions dominated by one-way communication. Conversely, learning environments that incorporate discussion and interaction demonstrate higher levels of engagement. These observational results reinforce the importance of adopting more student-centered learning approaches. Supporting this, documentation data such as attendance records and participation reports also reveal lower engagement levels in conventional classes, indicating that current teaching practices have not fully accommodated diverse student learning needs.

From the perspective of differentiated instruction, these findings suggest that existing learning approaches have not adequately addressed variations in students' learning styles, backgrounds, and cognitive abilities. Therefore, a more flexible and adaptive learning model is required. In this regard, IoT integration provides significant opportunities to support adaptive learning systems. Through real-time data collection and analysis, lecturers can adjust instructional strategies based on individual student needs, thereby creating a more personalized and effective learning experience.

Limitations in Academic Management

The study also identifies critical limitations in academic management systems, which continue to rely on manual and fragmented processes. This condition affects not

only administrative efficiency but also the overall quality of educational services. Interview data with educational staff reveal that academic data management is still conducted manually, often resulting in delays and inefficiencies, particularly when data is required for evaluation and decision-making purposes.

These findings are further supported by observations of administrative practices, which show a lack of integration between various academic components, including learning processes, assessment, and reporting systems. Such observations indicate that existing systems are not yet capable of supporting real-time and data-driven management. Documentation analysis also shows that academic reports are typically generated periodically without real-time system support, leading to outdated and less responsive information.

From a management perspective, this condition represents a significant barrier to achieving effective and data-based academic governance. Within the TPACK framework, this limitation reflects insufficient integration of technological knowledge in academic management practices. The implementation of IoT offers a strategic solution by enabling the development of integrated systems capable of managing academic data automatically and providing real-time analytics. Such systems can significantly improve efficiency, transparency, and responsiveness in academic management.

In this context, the Internet of Things (IoT) offers solutions through the development of an integrated system that is able to manage data automatically and provide dashboard analytics to support data-driven decision-making. With the existence of an IoT-based system, academic data can be accessed in real-time, integrated between units, and used as a basis for planning, evaluation, and policy-making. Thus, IoT integration not only contributes to improving the quality of learning, but also encourages the transformation of academic management systems towards a more efficient, transparent, and responsive model to educational needs in the digital era.

IoT Integration as a Transformative Solution

Building upon the three main findings above, this study identifies IoT integration as a comprehensive solution that addresses pedagogical, technological, and managerial challenges in a holistic manner. In the pedagogical dimension, IoT supports a shift from lecturer-centered approaches to more adaptive and student-centered learning. This transformation emphasizes interactivity, personalization, and active student engagement. In the technological dimension, IoT facilitates real-time data processing, enabling the use of learning analytics to enhance instructional effectiveness. Meanwhile, in the managerial dimension, IoT enables the transition from manual systems to integrated, data-driven academic management.

Based on the synthesis of all research findings, the integration of the Internet of Things (IoT) can be understood as the main catalyst in educational transformation, especially in the learning of Islamic Religious Education (PAI) in universities. This transformation includes three main dimensions that are integrated with each other, namely pedagogical, technological, and managerial aspects. In the pedagogical dimension, there is a paradigm shift from a conventional lecturer-centered learning approach to adaptive learning that is more responsive to students' needs, characteristics, and abilities. This approach emphasizes the importance of interactivity, personalization, and active involvement of students as learning subjects, so as to be able to create a more meaningful and contextual learning process.

However, the implementation of IoT is not without challenges. Interview findings indicate that limited digital competence among lecturers remains a major obstacle, reflecting gaps in TPACK mastery. Observational data also highlight infrastructure x`limitations, such as inadequate network systems, which hinder the optimal implementation of IoT-based learning environments.

Conclusion

This study highlights that Islamic Religious Education (PAI) learning in higher education still faces key challenges, including disparities in teaching practices, limited learning interactivity, and non-integrated academic management systems. These issues indicate that current learning approaches have not fully met the demands of adaptive and technology-based education.

The findings suggest that the Internet of Things (IoT) holds strong potential as a conceptual and strategic solution to support adaptive, interactive, and data-driven learning, as well as to enhance the efficiency of academic management systems. However, its implementation requires adequate institutional readiness, including technological infrastructure, digital competence, and policy support. Overall, IoT integration offers a promising direction for developing a more adaptive and sustainable PAI learning ecosystem in the digital era.

Furthermore, this study formulates an integrative framework that connects Internet of Things (IoT) technology, Vygotsky's constructivist theory, differentiated instruction, and the TPACK framework as a unified system in Islamic Religious Education (PAI) learning. In this framework, IoT functions as a technological infrastructure that enables real-time data collection and adaptive learning support, while constructivism emphasizes interactive learning processes through scaffolding and social engagement. Differentiated instruction serves as a pedagogical approach to accommodate students' diverse learning needs and characteristics, whereas TPACK provides the foundation for integrating technology, pedagogy, and content knowledge effectively. The integration of these four dimensions creates a more adaptive, student-

centered, and data-driven learning ecosystem, thereby offering a conceptual foundation for the future development of Islamic education in the digital era.

Limitations and Suggestions

This section is presented at the end of the article to highlight the limitations of the study and provide directions for future research.

Despite its contributions, this study has several limitations that need to be acknowledged. First, the research was conducted within a single Islamic higher education institution, which may limit the generalizability of the findings to broader educational contexts. Second, the study relies on a qualitative phenomenological approach, which focuses on in-depth understanding rather than generalization, thus future studies are encouraged to incorporate mixed-method or quantitative approaches to validate and expand the findings. Additionally, the implementation of IoT discussed in this study remains at a conceptual and exploratory level, indicating the need for empirical testing through experimental or development-based research designs.

For future research, it is recommended to explore large-scale implementation of IoT in diverse educational settings, as well as to examine its effectiveness in improving learning outcomes through measurable indicators. Further studies should also investigate the development of IoT-based learning models integrated with TPACK in a more practical and operational framework. Moreover, strengthening digital literacy among educators and developing supportive institutional policies are essential areas that require deeper investigation to ensure sustainable and effective technology integration in education.

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Conflict of Interest Statement

The author confirms that there are no conflicts of interest related to this study. This research was carried out independently without any financial, personal, or professional relationships that could potentially influence the research process, data interpretation, or presentation of the findings. Furthermore, no external parties had any involvement that could compromise the objectivity and integrity of this research.

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