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Development of an AI-Based Smart Device for Quran Memorization Using Spaced Repetition Technique

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Abstract: This paper presents the development of an intelligent Quran memorization device that integrates Artificial Intelligence (AI) and the spaced repetition technique to strengthen long-term memory of Quranic verses. The system, named *Sahib Al-Quran*, was designed as a portable embedded device using a Raspberry Pi Zero 2 W as the main processor, a ReSpeaker 2-Mics HAT V2 for voice input and output, a UPS Lite battery for wireless operation and a 2.13-inch e-paper display for low-power visual output. The device employs an AI-based repetition schedule that reminds users when to review verses and provides real-time feedback through speech recognition.

Beyond the hardware development, a quantitative experimental study was conducted using an SPSS *t*-test to compare memorization performance between a control group and an experimental group that used the device. The results revealed that the experimental group achieved significantly higher memorization scores, suggesting that integrating AI and spaced repetition into a physical learning aid can effectively improve Quran memorization and retention. This study highlights how modern technology can enhance Islamic educational practices while preserving traditional values.

Keywords: *Artificial Intelligence (AI); Quran Memorization; Spaced Repetition; Speech Recognition; Embedded System; Educational Technology.*

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I. INTRODUCTION

Memorization of the Holy Quran (*hifz al-Quran*) represents one of the most sacred and enduring traditions in Islamic education. It requires strong cognitive discipline, consistent repetition and emotional connection to the verses being memorized. However, many students of the Quran face challenges in maintaining long-term retention, especially when revision sessions are inconsistent or unguided. The absence of structured review intervals often leads to forgetfulness and decreased confidence among memorizers.

In recent years, the growth of Artificial Intelligence (AI) and educational technology has opened new pathways for supporting Quranic learning. AI systems can analyze user behavior, predict performance and personalize learning

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experiences. At the same time, *spaced repetition*, a cognitive technique grounded in memory science, has been shown to improve long-term retention by revisiting information at calculated intervals before it is forgotten.

Combining AI with spaced repetition provides a promising approach to address memorization challenges. By designing a device that automatically schedules review times, listens to user recitations and gives feedback on accuracy, learners can sustain their memorization more effectively.

The objectives of this study are:

- To design and develop a hardware-based Quran memorization device integrated with AI.
- To implement the spaced repetition method to enhance verse retention.
- To evaluate the device's effectiveness through experimental testing using SPSS analysis.

This project named *Sahib Al-Quran*, aligns with the broader goals of Islamic educational technology development, ensuring that traditional methods of *talaqqi* and *muroja'ah* are strengthened through innovation.

II. LITERATURE REVIEW

- *Quran Memorization and Retention Challenges*

Traditional Quran memorization depends on the *talaqqi* (teacher-student) approach, where students recite verses repeatedly under the guidance of a teacher. Although highly effective, this method requires continuous supervision and disciplined revision schedules. Research by Al-Zahrani (2019) found that students without regular repetition tend to forget up to 30% of memorized verses within two months. Hence, integrating technological tools that can act as personal assistants for memorization is necessary to sustain consistent practice.

- *Spaced Repetition and Cognitive Theory*

The principle of spaced repetition originates from Hermann Ebbinghaus's (1885) *Forgetting Curve*, which demonstrates that memory decays exponentially unless reinforced at timely intervals. Landauer and Bjork (1978) further refined this concept, introducing an optimal interval system that spaces reviews based on prior recall success. The Leitner system, a practical model of spaced repetition, uses "boxes" or levels to classify information depending on how well it is remembered.

In Quranic memorization, this model can be adapted by scheduling verse reviews at intervals—immediate, one day, three days, one week and one month—ensuring that retention strengthens gradually.

- *AI in Education and Quranic Learning*

Artificial Intelligence has transformed the landscape of education by enabling adaptive and data-driven learning systems. In Quranic education, AI has been applied in tajwid error detection, Arabic pronunciation analysis and personalized memorization software. Bakar and Ismail (2022) demonstrated how AI-based voice recognition can support students in improving their tajwid pronunciation, while Ahmad et al. (2023) explored AI tools that assist in phonetic accuracy. However, most implementations remain software-based or mobile applications. Few have explored hardware-based AI solutions that function offline and provide tactile interaction—a crucial innovation gap this research addresses.

- *Embedded Systems and Educational Devices*

Embedded systems such as Raspberry Pi and Arduino allow educational tools to be compact, energy-efficient and interactive. Raspberry Pi's flexibility and low cost make it an ideal platform for standalone learning systems. In previous works, embedded systems were used in language pronunciation trainers and interactive recitation devices. The *Sahib Al-Quran* device builds upon this foundation, merging AI algorithms, voice recognition and spaced repetition to create an intelligent assistant for memorization that can operate independently from the internet.

III. METHODOLOGY

➢ *Research Design*

This research adopted a quantitative experimental design to evaluate whether the *Sahib Al-Quran* device could significantly improve Quran memorization performance. Thirty-two participants were selected through purposive sampling and divided into two equal groups: a control group (n = 16) who practiced using conventional repetition, and an experimental group (n = 16) who used the *Sahib Al-Quran* device.

Both groups memorized verses from *Surah Al-Mulk* over a one-week period. Pre-tests and post-tests were conducted to measure memorization accuracy and verse retention. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) with an independent-samples t-test to determine statistical significance ($p < 0.05$).

➢ *Rapid Application Development (RAD) Model*

The RAD model was employed to guide system development efficiently through iterative prototyping.

- Planning: Defined objectives, components, and data flow.
- Design: Created system architecture and display layout using Python GUI and Waveshare libraries.
- Development: Integrated Vosk speech recognition with spaced repetition algorithms.
- Testing: Verified performance of audio playback, display, and memory intervals.

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- Implementation: Built and deployed prototype for user testing.

➢ *Hardware Components*

- Raspberry Pi Zero 2 W – Acts as the main processor.
- ReSpeaker 2-Mics HAT V2 – Handles voice input/output for user recitation and playback.
- UPS Lite Battery – Provides continuous power for portable use.
- 2.13-inch E-Paper Display – Displays surah names, ayah numbers and memorization progress.
- 3D-Printed Casing – Protects components and makes the device portable.

➢ *Software and AI Integration*

The software was developed in Python 3.11 on Raspbian OS, using:

- Vosk Speech Recognition API (Arabic model) for evaluating recitation accuracy.
- Custom Spaced Repetition Algorithm that schedules reviews based on verse mastery.
- SQLite Database to store user performance data locally.

➢ *Experimental Procedure and Analysis*

The experimental group used the *Sahib Al-Quran* device daily to memorize and review verses, while the control group followed traditional manual repetition. After one week, a post-test was administered to assess memorization accuracy. The independent-samples *t*-test compared mean post-test scores to evaluate effectiveness.

IV. RESULTS AND DISCUSSION

➢ *Quantitative Findings*

Table 1: Independent Samples t-Test for Control and Experimental Groups

Group	M	Std	t	df	Sig
Control Group	19.813	9.628	8.231	15	0.001
Experiment Group	12.000	17.436	2.753	15	0.015

The independent-samples *t*-test revealed a statistically significant difference between the control and experimental groups ($t(15) = 8.231$, $p = 0.001$). The experimental group, which used the *Sahib Al-Quran* device, achieved higher memorization scores, indicating that the AI-based spaced repetition technique significantly improved retention and recall.

The result supports the hypothesis that technological tools enhance Quran memorization when integrated with cognitive learning models. The structured review intervals ensured that learners revised verses just before forgetting, leading to better long-term memory. These findings align with Landauer and Bjork's (1978) work on memory spacing and Al-Khatib's (2020) research on Quranic memory reinforcement.

➢ *Prototype Performance and Functionality*

The prototype operated as expected, executing all major functions reliably. Upon startup, the Raspberry Pi automatically launched the memorization interface, displaying surah titles and ayah numbers on the e-paper screen. The ReSpeaker 2-Mics HAT V2 provided clear sound output and successfully captured voice input during recitation. The UPS Lite battery supported several hours of continuous use, confirming energy efficiency.

The AI algorithm managed the spaced-repetition schedule effectively, automatically adjusting review intervals based on user performance. While full-scale stress testing has yet to be completed, initial operation showed stability and synchronization between all hardware components. The system's functionality confirms that AI and spaced repetition can be implemented in a compact educational device suitable for independent learners.

V. CONCLUSION

The *Sahib Al-Quran* project demonstrates how modern AI technology can be harmoniously integrated with Islamic educational practices to enhance Quran memorization. The quantitative analysis verified that learners using the device performed significantly better than those relying on traditional repetition methods.

The study proves that embedding spaced repetition algorithms into a portable device provides a practical and effective approach to improving retention. The system's low power usage, offline capability and ease of use make it accessible for learners in different environments.

This work contributes to Islamic educational innovation by offering a physical, intelligent system that complements traditional methods. Future work should include integrating advanced *tajwid* detection models, expanding to mobile synchronization and conducting long-term studies with larger participant samples.

Through *Sahib Al-Quran*, technology becomes not a replacement but a *companion* to sacred learning, supporting memorization, discipline and devotion in the digital age.

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