

Bridging the Pedago-Technical Gap: A Critical Evaluation of AI-Powered Speech Recognition in Sacred Language Acquisition

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Abstract:

The global landscape of education has undergone a profound digital transformation, yet the application of Artificial Intelligence (AI) in transmitting sacred knowledge faces unique pedagogical and phonetic challenges. The Qur'an is preserved through a deeply rooted oral tradition known as talaqqī, requiring precise face-to-face transmission to master tajwīd (articulation and intonation rules). While a new wave of AI-powered applications promises real-time pronunciation feedback via Automatic Speech Recognition (ASR), significant concerns exist regarding their linguistic accuracy, handling of diverse accents, and fundamental pedagogical alignment. This paper presents a heuristic evaluation and systematic review of three leading digital Qur'an platforms (Tarteel, Ayat, and Quran.com) against a synthesized theoretical framework combining Western learning sciences with traditional Islamic pedagogy. The findings reveal a critical "pedago-technical gap," characterized by binary feedback mechanisms, accent biases, and the decontextualization of sacred learning. The study proposes a comprehensive enhancement framework prioritizing accent-inclusive ASR, teacher-linked supervision, and actionable phonetic feedback to ensure technology serves as a faithful supplement to traditional oral reception.

Keywords: Artificial Intelligence (AI), Automatic Speech Recognition (ASR), Qur'anic Recitation, Tajwīd, Islamic Pedagogy, Talaqqī, Educational Technology.

1. Introduction

The proliferation of digital and remote learning technologies has disrupted traditional educational paradigms across multiple disciplines. In language acquisition, AI-powered applications utilize natural language processing and adaptive algorithms to provide personalized learning pathways and instant grammatical feedback. Parallel to this trend, methods for transmitting Qur'anic education have intersected with the digital age, seeking to overcome global accessibility barriers related to geography, financial constraints, and the availability of qualified instructors.

However, Qur'anic education is fundamentally different from general language learning; it relies on an unbroken chain of oral transmission (*sanad*) and a precise phonetic science (*tajwīd*). The first wave of digital tools functioned primarily as static digital libraries, offering text and pre-recorded audio but lacking the interactive feedback loop provided by a human teacher [1][2]. Recently, a "second wave" of AI applications has emerged, integrating ASR to evaluate a user's recitation and provide real-time corrections [3][4][5].

Despite rapid adoption, recent studies from 2024 and 2025 demonstrate a significant disconnect between the technological capabilities of these tools and the pedagogical necessities of Qur'an education. Current ASR models, often trained heavily on Modern Standard Arabic (MSA), struggle with the phonemic depth of classical Qur'anic recitation and the diverse accents of the global Muslim community, resulting in high rates of false positives and negatives. Furthermore, these applications often lack meaningful personalization, treating all errors equally and neglecting critical areas such as exegesis (*tafsir*) and spiritual mentorship (*tarbiyah*). This paper addresses a

specific scientific gap in the literature: the lack of a standardized, cross-platform comparative analysis that tests AI Qur'an tools for both technical accuracy and pedagogical validity.

2. Theoretical Framework

To holistically evaluate the efficacy of AI-powered Qur'an applications, this study establishes a hybrid theoretical framework that synthesizes established learning sciences with traditional Islamic pedagogical principles.

2.1 Western Learning Sciences

- **Constructivism and Self-Regulated Learning (SRL):** Effective learning requires the active construction of knowledge. Utilizing Zimmerman's SRL model[8], an effective educational tool must support Forethought, Performance, and Self-Reflection. Applications must offer clear analytical dashboards rather than merely checking recitation.
- **Cognitive Load Theory (CLT):** Developed by Sweller [6], CLT dictates that instructional design must minimize unnecessary mental effort. Applications must minimize Extraneous Load (confusing interfaces) and maximize Germane Load (features that explain *why* an error occurred).
- **Zone of Proximal Development (ZPD):** Vygotsky's ZPD [7] requires a "More Knowledgeable Other" (MKO) to provide scaffolding. In AI applications, the system itself must function as the MKO by adapting difficulty and providing targeted hints.

2.2 Traditional Islamic Pedagogy

- **Primacy of Talaqqī and Mushāfahah:** The tradition is fundamentally oral, requiring face-to-face reception and direct correction to preserve authenticity. AI applications must possess exceptionally accurate ASR to prevent the digital corruption of this oral tradition.
- **Holistic Tarbiyah and Adab:** Qur'an learning is a spiritual and ethical endeavor [1]. The learning environment must promote reverence and be free from inappropriate commercial distractions.
- **Corrective, Not Punitive, Feedback:** Traditional teachers correct errors with wisdom (*hikmah*). AI tools that merely flash binary, red "WRONG" signals are culturally and pedagogically misaligned.

3. Related Work

Early Qur'an learning was deeply personal, community-based, and reliant on *talaqqī* and memorization (*hifẓ*) under the supervision of a qualified teacher. The digital transformation accelerated with the advent of mobile technology, transitioning learners toward intelligent tutoring systems like Tarteel [5].

Research on Computer-Assisted Language Learning (CALL) for general languages is mature, highlighting the challenges of handling non-native accents. Conversely, empirical studies on AI-powered Qur'an applications remain highly fragmented. A critical synthesis of recent literature reveals a stark disciplinary divide: computer science literature focuses almost exclusively on measuring Word Error Rate (WER) in ASR models, largely neglecting usability and educational impact. Simultaneously, Human-Computer Interaction (HCI) studies evaluate user interfaces but lack the religious expertise to assess the theological correctness of the AI's feedback. Consequently, the literature lacks a rigorous, comparative study that evaluates multiple applications against a unified framework grounded in both technical heuristics and Islamic pedagogy.

4. Methodology

To address this gap, this study employs a qualitative, multi-stage research design as shown in Figure 1.

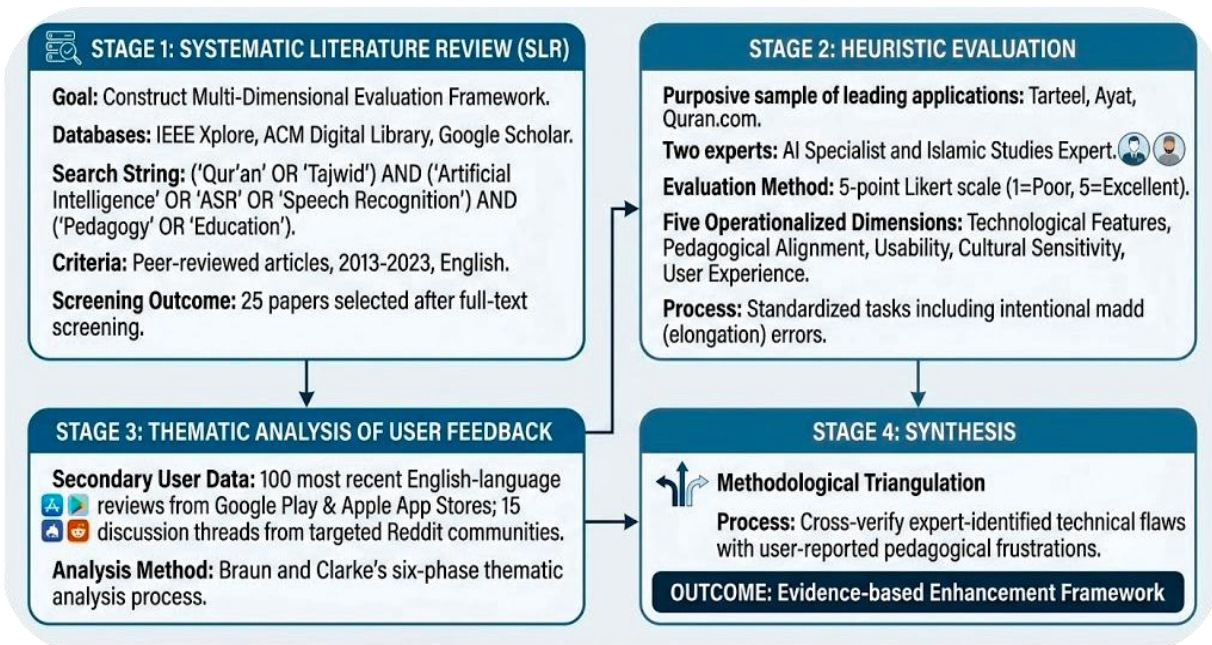


Figure 1: Proposed system stages

- **Stage 1: Systematic Literature Review (SLR):** A systematic review was conducted to construct the Multi-Dimensional Evaluation Framework.
 - *Databases:* IEEE Xplore, ACM Digital Library, and Google Scholar.
 - *Search String:* ("Qur'an" OR "Tajwid") AND ("Artificial Intelligence" OR "ASR" OR "Speech Recognition") AND ("Pedagogy" OR "Education").
 - *Criteria:* Peer-reviewed articles published between 2013 and 2023 in English. Non-educational applications were excluded.
 - *Screening:* A total of 25 papers were retrieved, with 25 meeting the final inclusion criteria after full-text screening.
- **Stage 2: Heuristic Evaluation:** A purposive sample of leading applications (Tarteel, Ayat, Quran.com) was selected. The evaluation was conducted by two experts specializing in Artificial Intelligence and Islamic Studies, respectively. Evaluators used a 5-point Likert scale (1 = Poor, 5 = Excellent) across five operationalized dimensions: Technological Features, Pedagogical Alignment, Usability, Cultural Sensitivity, and User Experience. Evaluators performed standardized tasks, including intentionally making *madd* (elongation) errors during recitation.
- **Stage 3: Thematic Analysis of User Feedback:** To understand real-world efficacy, secondary user data was collected comprising the 100 most recent English-language reviews (selected to maintain linguistic consistency during coding) from the Google Play and Apple App Stores. Additionally, 15 discussion threads from targeted Reddit communities (e.g., r/Islam) were systematically sampled. Data was analyzed using Braun and Clarke's six-phase thematic analysis process[4].
- **Stage 4: Synthesis:** Findings from the expert heuristic evaluation and user thematic analysis were methodologically triangulated to cross-verify technical flaws identified by experts with pedagogical frustrations reported by actual users, culminating in an evidence-based enhancement framework.

5.Result and Analysis

5.1 Platform Evaluations

As illustrated in Table 1, Tarteel demonstrates advanced real-time speech recognition, but heuristic testing revealed it suffers from significant accent recognition issues. Ayat offers high credibility but lacks real-time correction. Quran.com functions as a vital data hub but remains an entirely passive learning experience.

Table 1: Comparative Summary of Evaluated Platforms

Dimension	Tarteel	Ayat	Quran.com
Technological Features	4/5: Advanced ASR tracking, detects skipped words	2/5: Strong static library, no real-time ASR	2/5: Robust API, lacks voice recognition
Pedagogical Alignment	2/5: Identifies errors but lacks rule-based tajwīd explanations	4/5: Excellent tafsir integration and qira'at options	2/5: Passive learning experience only
Cultural Sensitivity	3/5: Generally respectful, but binary feedback lacks <i>ḥikmah</i>	5/5: High credibility (King Saud University)	4/5: Respectful ad-free environment
User Experience (HCI)	4/5: Modern, intuitive UI	3/5: Functional but dated interface	5/5: Highly accessible, responsive web design
Primary Weakness	Accent recognition bias; siloed learning	Lacks adaptive learning pathways	Lacks memorization tracking and AI feedback

5.2 Thematic Findings

The thematic analysis of user reviews yielded three primary themes regarding the current state of Qur'anic AI applications (Table 2).

Table 2: Thematic Analysis Results of User Feedback

Theme	Illustrative Anonymized User Quote	Pedagogical/Technical Implication
Accent Bias & ASR Failures	"The app keeps flagging my pronunciation of 'Qaf' as wrong, but my local Sheikh says it is correct. It doesn't understand my accent."	ASR models trained primarily on Arab accents fail non-Arab users, leading to false corrections.
Teacher Integration Deficiency	"I use this to memorize, but I have no way to share my progress or errors with my actual teacher for review."	Applications encourage isolated self-study and lack teacher supervision or sanad verification mechanisms.
Infrastructural Barriers	"Great app, but it freezes when my connection drops. I can't use the recitation checker at the mosque because the internet is slow."	Cloud-dependent systems exclude learners in low-resource environments; offline functionality is needed.

6. Discussion and Proposed Enhancements

- To bridge the pedago-technical gap, developers must transition from creating isolated technical features to designing holistic, hybrid learning environments.
- Accent-Aware and Phonetically Precise ASR:** To ensure global inclusivity, machine learning models must be trained on diverse phonetic datasets encompassing African, South Asian, and Southeast Asian recitation accents. Furthermore, models must advance beyond word-level recognition to perform *tajwīd*-specific error detection.

3. **Actionable, Germane Feedback:** Rooted in Cognitive Load Theory[6], applications must replace binary pass/fail indicators with descriptive feedback. If a learner makes an articulation error, the AI should isolate the word, explain the governing phonetic rule, and provide an accurate audio reference.
4. **Integration of Teacher-Linked Dashboards:** AI cannot replace the spiritual mentorship provided by a human Sheikh. Applications should develop educator dashboards allowing formal institutions to assign digital revisions and review flagged audio snippets asynchronously.
5. **Offline Accessibility:** Core recitation correction features must be capable of running locally on devices without constant cloud processing requirements.

6.1 Limitations and Future Work

This study presents certain limitations. The thematic analysis was restricted to English-language reviews, potentially excluding valuable feedback from users utilizing the applications in Arabic, Urdu, or other native languages. Furthermore, the evaluation framework relies heavily on expert heuristics rather than quantitative, large-scale user testing measuring actual recitation improvement over time.

Future research must prioritize addressing the technical and ethical challenges of collecting diverse, labeled Qur'anic recitation datasets to train accent-aware ASR models. Additionally, developers and researchers must transparently address data privacy implications, ensuring that audio data of sacred practices is protected and ethically processed.

7. Conclusion

Artificial Intelligence represents a transformative capability in scaling access to Qur'anic education. However, the precision required by the sacred oral tradition of *talaqqī* demands more than standard speech recognition algorithms. By critically evaluating the current landscape, it is evident that platforms must evolve from mere technological novelties into pedagogically sound, culturally sensitive, and highly inclusive educational environments. By implementing accent-aware models, actionable feedback, and bridging the gap between digital self-study and traditional teacher oversight, AI can fulfill its potential as a highly effective supplement to traditional Islamic knowledge transmission.

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سدّ الفجوة البيداغوجية-التقنية: تقييم نقدي للتعرف على الكلام المدعوم بالذكاء الاصطناعي في اكتساب اللغة المقدسة

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الملخص:

شهد المشهد العالمي للتعليم تحولاً رقمياً عميقاً، إلا أن تطبيق الذكاء الاصطناعي في نقل المعرفة المقدسة يواجه تحديات تربوية وصوتية فريدة. يُحفظ القرآن الكريم من خلال تقليد شفوي متجذر يُعرف بالتلقي، والذي يتطلب نقلاً دقيقاً وجهاً لوجه لإتقان التجويد (قواعد النطق والتنغيم). وفي حين تعد موجة جديدة من التطبيقات المدعومة بالذكاء الاصطناعي بتقديم ملاحظات فورية على النطق عبر التعرف الآلي على الكلام، توجد مخاوف كبيرة بشأن دقتها اللغوية، وتعاملها مع اللهجات المتنوعة، وتوافقها التربوي الأساسي. تقدم هذه الورقة تقييماً نوعياً متعدد المراحل لأبرز منصات القرآن الرقمية (ترتيل، آيات، و (Quran.com) استناداً إلى إطار نظري مدمج يجمع بين علوم التعلم الغربية والتربية الإسلامية التقليدية. تكشف النتائج عن "فجوة تربوية تقنية" حرجية، تتسم بآليات التقييم الثنائية، والتحيز للهجات، وتجريد التعلم المقدس من سياقه. وتقتترح الدراسة إطاراً شاملاً لتحسين يعطي الأولوية للتعرف على الكلام الشامل للهجات، والإشراف المرتبط بالمعلم، والملاحظات الصوتية القابلة للتطبيق لضمان أن التكنولوجيا تعمل كمكمل وفي التلقي الشفوي التقليدي.

الكلمات المفتاحية: الذكاء الاصطناعي، التعرف الآلي على الكلام، التلاوة القرآنية، التجويد، التربية الإسلامية، التلقي.