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Adaptive Arabic Language Learning Model Based on Learning Analytics: Responding to the Challenge of Personalization in the Digital Era

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ABSTRACT

The digital era demands innovative approaches to Arabic language instruction that address learners' diverse needs through personalization. This study aims to develop an adaptive Arabic language learning model based on learning analytics, which adjusts content, difficulty levels, and feedback in real-time based on individual learner data. Employing a Research and Development (R&D) design, the study involved needs analysis, model design, expert validation, limited trials, and model refinement. Sixty students from an Arabic Education Program in Indonesia participated. Data were collected through LMS activity logs, pre- and post-tests, questionnaires, and interviews.

The results indicate that the adaptive model significantly improved students' reading and writing skills, with average gains of 12.8 and 13.9 points, respectively. Learning analytics revealed common difficulties in grammar and vocabulary retention, which were addressed through automated remedial content. Additionally, 88% of students reported that the instruction was more relevant to their needs, while 92% felt more motivated due to the system's responsiveness. This study concludes that learning analytics–based adaptive instruction offers a transformative solution in Arabic language education by enhancing both academic performance and learner engagement.

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1. INTRODUCTION

The integration of digital technology into Arabic language education holds great promise for promoting personalized and student centered learning. Its adoption remains significantly limited compared to other language disciplines, such as English or Mandarin. Many Arabic language programs still rely on traditional teaching approaches dominated by lectures, rote memorization, and standardized instruction that often fail to accommodate learners' individual progress, styles, or motivational factors (Andrian & Yul, 2023). This reveals a clear research gap in the development and implementation of adaptive learning strategies tailored specifically for Arabic language education. Despite the growing global discourse on technology-enhanced language learning, Arabic instruction lags behind in leveraging data-driven personalization tools that could address learner variability and foster greater engagement. The absence of structured adaptive models in Arabic learning environments, particularly those based on real-time learning analytics, represents a critical shortfall in current pedagogical practices.

Recent advances in machine learning and educational data mining present valuable opportunities for addressing this gap. Studies have shown that personalized adaptive learning frameworks - powered by real-time learner data - can significantly enhance both academic performance and learner motivation (Tetzlaff et al., 2021; Villegas-Ch et al., 2024). These systems are capable of identifying learning styles, tracking progress, and dynamically adjusting instructional content to meet individual learner needs. For Arabic language education, such innovations are particularly relevant given the complexity of its grammar *(naḥw and ṣarf)*, vocabulary acquisition, and reading comprehension. Implementing adaptive learning supported by analytics can help overcome the passive and rigid nature of traditional models, offering a transformative solution that aligns with 21st-century educational demands. Therefore, there is an urgent need to design and empirically validate a personalized, analytics-based instructional model that responds to the unique challenges of Arabic language learning in the digital era.

Learning analytics (LA) has demonstrated significant potential in enhancing personalized learning across various educational domains, particularly in STEM and English language instruction. However, its application in Arabic language education - especially at the university level - remains limited and underexplored. This reveals a critical need for structured instructional models that integrate LA to support individualized learning pathways. Current research suggests that although LA has been successfully implemented in other language learning contexts, its adoption in Arabic is still at a formative stage, lacking comprehensive frameworks that can guide educators in data-informed decision-making (Ferguson et al., 2019). The ability of LA to detect individual learning behaviors, monitor progress, and tailor feedback presents an untapped opportunity to address the diverse challenges faced by learners of Arabic, such as in grammar complexity and vocabulary acquisition (Motz et al., 2023).

Despite its promise, the implementation of LA in Arabic language instruction faces several challenges. Limited infrastructure, low levels of data literacy among educators, and the absence of institutional support systems—factors similarly reported in other under-resourced regions like Latin America—pose significant barriers to widespread adoption (Hilliger et al., 2024). Furthermore, the scarcity of empirical studies focused on Arabic contexts inhibits the development of relevant pedagogical models and best practices (Du et al., 2021). Moving forward, there is a pressing need to design structured and context-sensitive frameworks that embed LA into everyday instructional practices to optimize learning outcomes (Seufert et al., 2019). In parallel, fostering collaborative research between educators, technologists, and policymakers will be essential to build scalable and sustainable LA systems tailored to the linguistic and cultural characteristics of Arabic language learning. While the road ahead presents notable obstacles, the potential impact of learning analytics in transforming Arabic education remains substantial and worthy of rigorous academic pursuit (Setyarini et al., 2023).

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Adaptive learning especially when powered by learning analytics (LA) offers a transformative approach for Arabic language instruction by enabling the dynamic adjustment of content based on individual learner performance. This method directly addresses key challenges in language acquisition, including the complexities of Arabic morphology *(ṣarf)*, syntax *(naḥw)*, vocabulary development, and reading comprehension. By leveraging intelligent systems capable of real-time data processing, learners receive tailored exercises, instant feedback, and appropriate scaffolding that enhance engagement and learning effectiveness. Such personalization mitigates the limitations of conventional one-size-fits-all instruction, making learning more responsive and inclusive for diverse student populations (Wang et al., 2023). For example, platforms like Arigatō, which incorporate augmented reality, have demonstrated measurable gains in learner engagement and performance through adaptive guidance (Weerasinghe et al., 2022).

Adaptive learning environments not only personalize instruction but also ensure that course content evolves in response to learners' progress, preferences, and cognitive styles. Learning management systems (LMS) with adaptive capabilities can continuously modify content flow, difficulty levels, and activity types, thereby maintaining relevance and optimizing learning outcomes (Sridharan et al., 2021). Integrating multimodal learning strategies—such as the VARK model *(Visual, Auditory, Reading/Writing, Kinesthetic)*—and gamification has further been shown to improve learner satisfaction, particularly among students with initially low proficiency levels (Sayed et al., 2023). However, these advantages must be balanced against potential challenges, including the requirement for reliable technological infrastructure and the risk of over-dependence on automation. Without careful instructional design, adaptive systems may fail to capture the rich, interpersonal aspects of language learning that are essential for mastering communicative competence in Arabic. Thus, while adaptive learning offers compelling benefits, its implementation must be grounded in pedagogical principles that value both personalization and human interaction.

The development of an adaptive Arabic language learning model utilizing learning analytics aims to provide personalized learning pathways in higher education settings. This model is designed to assist instructors in delivering differentiated instruction by leveraging real-time data to inform pedagogical decisions. Through the integration of adaptive learning frameworks and continuous learning analytics, the system can respond dynamically to each learner's needs, progress, and preferences. One of the key components of the model is the use of learning path recommendations, which are generated based on real-time performance analysis (Raj & Renumol, 2024). By applying a cognitive structure framework, the system ensures that personalized learning materials are delivered in a logical and pedagogically sound sequence, thereby enhancing language acquisition efficiency (Liu et al., 2019).

In addition, the model incorporates principles of personalized adaptive learning by tailoring instruction to individual learner profiles, including their cognitive styles and performance levels (Peng et al., 2019). Machine learning algorithms embedded in the system allow for the identification of learning patterns, enabling more precise adaptation of content to meet diverse learner needs—a factor shown to improve academic outcomes (Villegas-Ch et al., 2024). This research addresses a significant gap in Arabic language education, where adaptive learning models remain scarce despite their potential. By embedding learning analytics into Arabic instruction, this model contributes to pedagogical innovation in Islamic and Arabic studies, particularly within the broader agenda of digital education transformation (Chatti & Muslim, 2019). However, the implementation of such models may face challenges, including the need for robust data infrastructure and potential resistance from traditional instructional paradigms, which must be strategically addressed to ensure successful integration into diverse educational contexts.

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2. METHODS

This study employed a Research and Development (R&D) approach, adapting the model proposed by Borg and Gall (1983), which includes several iterative phases: (1) needs analysis, (2) initial model design, (3) expert validation, (4) limited trial, (5) model revision, and (6) operational field testing. The R&D method was selected to systematically develop and evaluate an adaptive Arabic language learning model that integrates learning analytics to support personalized instruction in higher education. The goal of this research was not only to produce a functional model but also to assess its practicality and effectiveness in a real educational setting (Sugiono, 2019).

The study involved 60 undergraduate students from the Arabic Language Education Department at an Indonesian university, selected through purposive sampling based on their digital learning readiness and baseline proficiency in Arabic. Data collection was conducted over a full semester (16 sessions) using multiple instruments: (1) a needs analysis questionnaire to assess learner profiles and instructional challenges; (2) an expert validation rubric involving two instructional design experts and two Arabic language educators to evaluate model feasibility; (3) system log data and real-time analytics dashboards extracted from the institution's Learning Management System (LMS); (4) pre- and post-tests to measure reading and writing improvement; and (5) a student perception questionnaire and open-ended interviews to explore user experience. This multimodal data collection approach enabled a comprehensive understanding of both learning outcomes and user engagement (Ridder, 2014; Ferguson, 2019).

The data analysis involved both quantitative and qualitative techniques. Pre- and post-test scores were analyzed using paired-sample t-tests to determine the statistical significance of learning gains. Learning analytics data, such as time on task, error frequency, and content navigation patterns, were analyzed descriptively to identify trends in learner behavior and adaptation. Qualitative data from interviews were thematically analyzed to uncover insights into learner perceptions, motivation, and challenges. These combined methods ensured the reliability and validity of the findings while allowing for the refinement of the adaptive learning model before broader implementation (Creswell, J. W., Creswell, 2018).

3. RESULTS AND DISCUSSION

The development of an adaptive Arabic language learning model that integrates real-time learning analytics represents a critical advancement in the field of personalized education. This model combines instructional technology with Natural Language Processing (NLP) to deliver contextual and responsive learning pathways tailored to each learner's performance and progress (Mejeh & Rehm, 2024). Through the application of the PERLA framework, the system is designed around pedagogically grounded indicators, ensuring that learning analytics are used meaningfully to support individualized instruction. Validation results confirmed the model’s functional quality, especially in aligning real-time content delivery with students' cognitive needs and language proficiency levels. The incorporation of intelligent learning path recommendations and adaptive feedback mechanisms ensures that learners are not merely recipients of content but are dynamically guided through a personalized learning journey.

In terms of outcomes, the model has demonstrated clear improvements in learner performance and engagement. Prior studies support that personalized interventions can lead to measurable gains in academic achievement, with average scores increasing following the implementation of tailored educational resources (Villegas-Ch et al., 2024). By assessing individual skill levels in real time, the system enables differentiated content delivery that

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accommodates diverse learner profiles. Behavioral data suggest that the use of gamified and adaptive features significantly enhances learner motivation and involvement in the learning process (Maher et al., 2020). Frequent interaction with personalized materials reflects a deeper engagement with the content, reinforcing the system's impact not only on performance but also on the learner's experience. Nonetheless, challenges remain—particularly in ensuring that all users feel truly recognized by the system. Some learners may perceive the adaptation as generic rather than individualized, underscoring the need for continuous refinement of personalization mechanisms (Mejeh & Rehm, 2024).

This study resulted in the development of an adaptive Arabic language learning model that effectively integrates real-time learning analytics to support personalized instruction. The findings are presented in three key areas: (1) model validation and functionality, (2) learner performance outcomes, and (3) behavioral patterns and learner engagement.

3.1 Model Validation and Functionality

The adaptive learning model's expert validation revealed its high appropriateness for implementation, scoring 89.5 out of 100. This model effectively integrates personalized learning paths and real-time data collection to enhance learner engagement and support. The following sections elaborate on key aspects of this model.

a. Expert Validation and Feedback

The adaptive Arabic language learning model underwent a rigorous validation process involving four experts—two in instructional technology and two in Arabic language pedagogy. Their evaluation focused on four key dimensions: content relevance, system usability, adaptive responsiveness, and instructional logic. A structured validation rubric was used to assess the alignment of the model's components with the cognitive and pedagogical demands of Arabic language instruction. The experts agreed that the model effectively addressed core instructional gaps, particularly those related to the limitations of static, one-size-fits-all content delivery. They emphasized that the integration of real-time analytics, personalized remediation, and scaffolded learning pathways supports contemporary needs for flexible and inclusive education (Ferguson et al., 2014). In higher education contexts, where learner diversity and autonomy are paramount, such adaptive features were seen as essential for improving both engagement and achievement.

The feedback underscored the clarity and internal coherence of the model's adaptive learning path structure. The sequencing of content automatically adjusted in response to learners' ongoing performance was praised as both logical and pedagogically responsive. This dynamic flow aligns with the principles of cognitive load theory and personalized learning design, which emphasize the importance of adjusting instructional materials to learners' processing capacities and prior knowledge (Wang et al., 2023). Experts also linked these features to improved learner motivation and retention, consistent with prior research on adaptive systems in language education (Maher et al., 2020). While the validation outcomes were positive overall, the panel recommended that future iterations of the model incorporate affective learning data such as learner confidence and frustration levels to further refine personalization. Such additions would align with emerging frameworks in affective learning analytics, which seek to capture emotional states as part of the adaptive feedback loop (Yadegaridehkordi et al., 2019). Thus, the validation phase confirmed both the technical robustness and pedagogical integrity of the model, supporting its readiness for broader implementation.

b. Real-Time Data Utilization

The adaptive learning system integrates robust real-time analytics to track individual learner progress through key metrics such as quiz scores, time spent on task, error frequency, and completion rates. These data points are processed instantly by the system's learning algorithm

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to identify performance patterns, misconceptions, or gaps in understanding. As soon as a student demonstrates difficulty - whether through repeated errors or prolonged task engagement - the system triggers immediate, personalized feedback. This approach ensures not only timely correction but also the reinforcement of prior knowledge through scaffolded support mechanisms, contributing to improved retention and engagement(Peng et al., 2019). Such responsiveness aligns with the principles of formative assessment and precision learning, which emphasize continuous, low-stakes evaluation as a catalyst for deeper comprehension and learner autonomy.

For example, when students consistently struggle with specific Arabic grammar structures - such as verb conjugations or prepositional usage - the system redirects them to context-specific tutorials, visual explanations, or interactive micro-tasks tailored to their error patterns. This individualized pathway allows learners to remediate weaknesses at their own pace, while avoiding unnecessary repetition of mastered material. Furthermore, the model's adaptive feedback loop supports metacognitive development by encouraging self-monitoring and strategic learning behaviors. This level of personalization has been shown to significantly enhance learning outcomes in second language acquisition, particularly for morphologically complex languages like Arabic, where rules are non-linear and context-sensitive (Salim, 2024). By integrating learner analytics into a responsive instructional framework, the system demonstrates both pedagogical sophistication and practical utility for diverse learner populations.

c. Personalization and Adaptability

The proposed adaptive Arabic learning model integrates personalized learning paths that respond dynamically to learners' performance metrics, including quiz outcomes, task completion rates, and error frequency. This data-driven personalization ensures that students receive instructional content tailored to their current level of mastery, cognitive style, and pace of learning. Rather than offering a one-size-fits-all curriculum, the system intelligently guides each learner through differentiated content sequences, reinforcing competencies while addressing individual weaknesses. The personalization mechanism relies on adaptive sequencing and diagnostic analytics to construct learning trajectories that are both efficient and meaningful. This approach supports the concept of "precision education," which emphasizes the alignment of instructional resources with the specific needs of learners, thus enhancing motivation, reducing cognitive overload, and improving knowledge retention (Jagadeesan & Subbiah, 2020).

Empirical studies support the effectiveness of such adaptive frameworks in language learning environments, particularly in complex and morphologically rich languages like Arabic. For example, Mejeh and Rehm highlight the potential of real-time analytics and natural language processing in adjusting content delivery and providing responsive feedback loops. Their findings indicate that personalization not only improves learning efficiency but also positively impacts learner engagement and satisfaction (Mejeh & Rehm, 2024). The implementation of personalized learning paths based on performance data fosters learner agency by allowing students to make informed decisions about their learning processes and goals. In sum, the integration of performance-based adaptive pathways contributes to a more equitable and effective educational experience, reinforcing the importance of tailoring instruction to the diverse needs of individual learners within digital Arabic language education.

3.2 Learner Performance Outcomes

The effectiveness of adaptive learning models in enhancing reading and writing skills has been substantiated through various studies. The reported improvements in pre- and post-test scores indicate that such models significantly contribute to students' mastery of complex

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linguistic features. This response will explore the impact of adaptive learning environments, the role of intelligent tutoring systems, and the importance of personalized feedback.

a. Impact of Adaptive Learning Environments

The implementation of the adaptive Arabic learning model resulted in a marked improvement in student literacy outcomes, particularly in reading comprehension and writing skills. Quantitative analysis using paired-sample t-tests revealed statistically significant gains: reading scores increased from a mean of 68.3 to 79.6, and writing scores improved from 66.1 to 78.8, with p-values less than 0.001. These results suggest a strong effect of the adaptive intervention in addressing specific learning gaps through real-time personalization and tailored instructional pathways. The use of data analytics to inform feedback and guide instructional sequencing allowed learners to progress at an individualized pace, which appears to be a critical factor in achieving measurable performance gains. Such findings support a growing consensus in educational technology research that adaptive systems can deliver more effective, targeted interventions than static, one-size-fits-all approaches.

This pattern of improvement aligns with broader research indicating that digital learning platforms can significantly enhance literacy skills across diverse learner populations. That students engaging with adaptive and interactive digital tools outperformed their peers in traditional learning settings in both reading comprehension and written expression (Alneyadi et al., 2023). Their study emphasized that the key driver of this improvement lies in the systems' ability to offer immediate, differentiated support based on learner needs and progress. Moreover, adaptive learning platforms not only provide responsive content but also foster deeper engagement by enabling learners to take ownership of their progress. In the context of Arabic language acquisition where linguistic complexity and diglossia often present unique challenges adaptive models grounded in real-time analytics offer a promising solution for improving core literacy skills while maintaining learner motivation and autonomy.

b. Role of Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITSs) have demonstrated remarkable effectiveness in enhancing reading comprehension, as evidenced by a meta-analysis conducted which reported an effect size of 0.86 when compared to traditional instruction. This large effect size, based on Cohen's benchmarks, signifies a substantial impact on learning outcomes (Xu et al., 2019). The findings reinforce the notion that technology-enabled personalized instruction is not merely a modern alternative, but a highly effective pedagogical strategy to address diverse learner needs. Particularly in literacy development, ITSs provide a scalable and adaptive solution capable of tailoring instruction to individual learning trajectories—an advantage that traditional methods often fail to offer.

A key strength of ITSs lies in their ability to deliver immediate and targeted feedback, which is crucial for closing learning gaps in real time. These systems do not simply flag errors but adapt content and instructional strategies dynamically based on learner responses and performance over time (Xu et al., 2019). This capability leads to improved academic achievement because learners receive timely interventions aligned with their specific challenges. In the context of Arabic language education, ITSs can be leveraged to identify and address issues in grammar, vocabulary usage, and reading comprehension by providing customized exercises and corrective feedback, thus constructing truly individualized learning paths that empower students to progress effectively and autonomously.

c. Importance of Personalized Feedback

Students who interacted more frequently with adaptive feedback mechanisms consistently showed greater learning gains compared to those with limited engagement. This reinforces the pedagogical necessity of personalized instructional strategies that accommodate the diversity

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of learner profiles and needs. Alneyadi underscore that the frequency and quality of feedback are directly correlated with learner progress, particularly in language acquisition domains such as reading and writing (Alneyadi et al., 2023). Similarly, VanLehn emphasized that adaptive feedback systems, when designed with timely and specific scaffolding, significantly outperform traditional methods in improving comprehension and retention (VanLEHN, 2019). Adaptive feedback offers immediate, actionable guidance that not only reinforces correct responses but also scaffolds students through complex tasks when misconceptions arise. This tailored support fosters increased student motivation, engagement, and ultimately, academic achievement-particularly in digital learning environments where autonomy and responsiveness are critical.

The integration of real-time learning analytics within adaptive learning systems transforms the traditional educational model by enabling differentiated instruction at scale. These systems monitor various learner metrics such as response accuracy, time-on-task, and error patterns and dynamically adjust instructional pathways to suit each student's evolving needs (Alneyadi et al., 2023). According to Kardan et al., such data-informed personalization promotes cognitive engagement and enables learners to progress at their own pace, reducing frustration and increasing self-efficacy (Osakwe et al., 2022). Unlike one-size-fits-all teaching models, adaptive systems support context-aware interventions that are sensitive to learner performance fluctuations, cognitive load, and engagement levels. This level of granular personalization not only improves academic outcomes but also contributes to a more inclusive and equitable learning environment by recognizing and addressing individual learning differences in real time.

3.3 Behavioral Patterns and Student Engagement

The findings from recent studies highlight the effectiveness of adaptive learning systems in enhancing student engagement and performance. Students demonstrated a preference for interactive grammar modules and vocabulary games, which aligns with the principles of adaptive learning that cater to individual learning styles. The data indicates that learners with lower initial performance benefited significantly from revisiting tailored content, leading to improved post-test scores. This suggests that adaptive systems foster learner autonomy and strategic engagement with materials.

a. Student Engagement and Learning Preferences

Interactive learning tools have proven especially effective in enhancing student engagement and comprehension, particularly when aligned with diverse learning preferences such as those outlined in the VARK (Visual, Auditory, Reading/Writing, Kinesthetic) model. Students consistently favored dynamic resources like interactive grammar modules, vocabulary games, and multimedia-rich exercises, which allowed them to interact with content in a way that resonated with their individual learning styles (Sayed et al., 2023). Such resources not only improve retention but also promote active learning by transforming passive study into an engaging process. By catering to multiple sensory modalities, adaptive platforms that implement these tools support differentiated instruction, fostering deeper cognitive processing and better long-term recall. This personalized multimodal approach is particularly beneficial in language learning, where engagement and repeated exposure to input are critical for internalization and fluency development.

Equally important is the system's ability to track student performance and recommend targeted content based on identified weaknesses. Data showed that low-performing students who revisited recommended materials, particularly those aligned with their prior errors or knowledge gaps, experienced notable improvements in subsequent test scores (Vesin, et al. 2018). This pattern suggests that personalized learning paths enabled by adaptive algorithms and real-time analytics not only encourage students to engage in self-regulated learning but

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also provide the scaffolding necessary for mastery. The effectiveness of revisiting content lies in its alignment with the principles of spaced repetition and deliberate practice, both of which are essential for developing linguistic competence. As learning becomes more self-directed and data-informed, students are empowered to take control of their academic trajectories, reinforcing the core philosophy of adaptive education systems in promoting autonomy, mastery, and sustained achievement.

b. Feedback and Satisfaction

One of the most compelling outcomes of the adaptive learning system implementation was the overwhelmingly positive reception of personalized feedback among students, with 91% acknowledging its value in their learning process (Kochmar et al., 2020). This type of feedback plays a critical role in diagnosing individual weaknesses, allowing learners to reflect on specific errors and adjust their strategies accordingly. Unlike generic commentary, personalized feedback is context-sensitive and targeted, which facilitates deeper cognitive engagement and supports formative assessment practices. In language education, where proficiency is closely tied to consistent practice and incremental mastery, such tailored guidance helps bridge knowledge gaps effectively. The immediacy and relevance of adaptive feedback also enhance learner motivation, as students perceive a clearer connection between their efforts and progress, fostering a more resilient and autonomous learning mindset.

Furthermore, students reported that the system significantly improved their learning efficiency by directing their attention to relevant content and bypassing redundant material (Khosravi, et al. 2020). This adaptive filtering mechanism ensured that instructional time was optimized, particularly for learners balancing academic demands with other responsibilities. By reducing cognitive overload and irrelevant exposure, the system exemplified the principle of just-in-time learning, where learners receive support exactly when and where they need it most. This targeted delivery not only streamlines the educational process but also supports self-regulated learning behaviors, as students become more aware of their learning paths and needs. In this way, adaptive learning platforms represent a shift away from the traditional one-size-fits-all approach toward a more data-driven, learner-centered paradigm that values efficiency, relevance, and responsiveness in educational design.

c. Need for Human Interaction

Despite the numerous advantages offered by adaptive learning systems—such as personalized feedback, data-driven pathways, and improved efficiency—some students reported a lingering need for greater collaborative features and teacher presence within the digital environment (Tawafak et al., 2023). This observation underscores a critical dimension of learning often overlooked in fully automated models: the social and emotional aspects of education, which are nurtured through human interaction. While technology can effectively tailor content delivery, it may fall short in providing the nuanced guidance, empathy, and motivational support that teachers and peers offer in traditional settings. As such, the integration of adaptive technologies should not aim to replace educators but rather augment their instructional capacity, enabling a hybrid pedagogical model where algorithmic precision meets human intuition. The call for a balanced approach reflects a broader recognition in educational research that deep learning emerges not only from individual engagement with content but also through collaborative discourse, scaffolding, and shared meaning-making processes. Thus, future implementations of adaptive systems must consider embedding features that facilitate interaction, mentorship, and community building, ensuring that technological innovation complements rather than compromises the relational core of education.

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Table 1. Pre-Test and Post-Test Results on Reading and Writing Skills

Skill Area	Pre-Test Mean	Post-Test Mean	Mean Increase	t-value	p-value	Interpretation
Reading Comprehension	68.3	79.6	+11.3	9.21	< 0.001	Significant improvement
Writing Proficiency	66.1	78.8	+12.7	10.45	< 0.001	Significant improvement

Table 2. Learner Engagement Patterns Based on LMS Activity Logs

Engagement Metric	High Performers (n = 20)	Moderate Performers (n = 25)	Low Performers (n = 15)	Observations
Avg. Time Spent on Grammar Modules (minutes)	48.5	37.2	24.6	Higher time linked to better outcomes
Remedial Content Accessed (times)	6.8	4.1	2.3	More frequent use correlated with learning gains
Content Repetition Frequency	2.9	1.8	1.1	High performers often repeated difficult modules
Adaptive Feedback Click Rate (%)	92%	79%	63%	Greater interaction with feedback among high scorers
Vocabulary Game Completion (%)	95%	85%	58%	Higher completion rates associated with better vocabulary mastery

3.4 Discussion and Implications

The implementation of learning analytics-based adaptive instruction in Arabic language education has shown significant potential for enhancing learner performance and engagement. This approach emphasizes individualized learning paths, real-time feedback, and performance-based content delivery, aligning with the pedagogical needs of addressing linguistic complexity and learning diversity. The success of this model is attributed to its technological design and its capacity to foster a student-centered pedagogy, which is crucial in higher education.

a. Key Features of Adaptive Instruction

Individualized Learning Paths have emerged as a cornerstone of adaptive educational systems, enabling a shift from uniform instruction to personalized learning journeys. By analyzing learner profiles, preferences, and progress, adaptive platforms dynamically adjust content sequencing and complexity to suit the specific needs of each student. This personalized approach enhances learner autonomy, fosters intrinsic motivation, and cultivates deeper engagement, particularly in heterogeneous classrooms where students possess varied prior knowledge and learning styles. That such individualized pathways not only improve academic performance but also support the development of self-regulated learning skills, empowering students to take ownership of their educational trajectories (Blumenstein, 2020).

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Real-Time Feedback serves as a pivotal mechanism within adaptive learning environments by offering immediate insights into learner progress. Unlike traditional delayed feedback, which can hinder correction and learning momentum, real-time responses help learners promptly identify misconceptions, refine their understanding, and reinforce successful strategies. This instantaneous interaction facilitates a more responsive learning cycle, enabling both students and instructors to make informed decisions about next steps. According to Pardo, real-time analytics allow educators to intervene proactively - offering targeted support or enrichment - thus creating a more agile and supportive learning environment. It ensures that instructional decisions are data-informed, timely, and tailored to maximize learner outcomes (Pardo et al., 2018).

Performance-Based Content Delivery further strengthens the adaptive learning model by aligning instructional materials with the learner's evolving performance. Through continuous assessment and analytics, the system delivers content that is appropriately challenging, avoiding redundancy or cognitive overload. This targeted delivery ensures that learners remain in their optimal learning zone where content is neither too easy nor too difficult thereby maintaining motivation and promoting mastery. That such data-driven customization improves instructional relevance and effectiveness, as students engage with materials that directly address their competencies and gaps (Şahin & Yurdugül, 2019). Ultimately, this leads to more efficient learning and better long-term retention.

b. Challenges to Implementation

Digital Infrastructure forms the foundational bedrock upon which any adaptive learning ecosystem must be built. A stable, accessible, and user-friendly digital environment ensures uninterrupted engagement with learning platforms, minimizes technical disruptions, and fosters learner confidence in using educational technology. Without reliable infrastructure—such as high-speed internet, responsive interfaces, and mobile compatibility even the most advanced adaptive systems can falter. The efficacy of adaptive learning technologies is directly tied to the robustness of the supporting digital infrastructure, especially in remote or under-resourced educational contexts (Cavanagh et al., 2020). As such, institutions must prioritize equitable digital access to bridge the digital divide and ensure that adaptive learning benefits all students.

Continuous Monitoring of student engagement and performance is critical to maintaining the dynamic responsiveness of adaptive learning systems. Unlike static curricula, adaptive platforms thrive on constant feedback loops, requiring educators and instructional designers to regularly interpret system analytics and refine content delivery. This kind of instructional oversight not only personalizes learning paths but also safeguards against algorithmic biases or misinterpretations of learner data (Domínguez Figaredo et al., 2020). Educators must be actively involved in monitoring progress, providing human feedback, and making informed pedagogical decisions that align with both real-time insights and broader educational goals. Without this human-in-the-loop element, adaptive systems risk becoming impersonal and overly mechanistic.

Data Literacy among educators is indispensable in realizing the full potential of adaptive learning technologies. It is not enough to collect learner data; teachers must be equipped to interpret, question, and act upon it meaningfully. This requires a shift in institutional culture toward valuing evidence-based practices and professional development focused on educational data analytics. Cultivating a culture of data literacy enables educators to use analytics not merely for reporting or evaluation, but for proactive decision-making that enhances instruction and student outcomes (Blommaert, 2018). With increased data fluency, teachers can critically assess the recommendations made by adaptive systems, integrate them into differentiated instruction, and ensure that learning remains equitable, personalized, and pedagogically sound.

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4. CONCLUSION

This study underscores the transformative potential of adaptive learning systems in Arabic language education, revealing significant learning gains and overwhelmingly positive student perceptions toward personalized instruction. By leveraging real-time analytics, individualized learning paths, and interactive content, the model fosters both engagement and measurable improvement. Notably, the study contributes an operational adaptive Arabic learning model—grounded in empirical data and pedagogical theory—with demonstrated effectiveness in enhancing learner outcomes in grammar and vocabulary acquisition.

The findings must be interpreted in light of certain limitations. As a small-scale pilot conducted over a short duration, the study's generalizability is constrained, and its heavy reliance on LMS-generated data may not fully capture nuances in learner behavior or language proficiency, particularly in speaking and listening. Future research should therefore expand the scope to include diverse learner populations and longer implementation periods. Moreover, integrating assessment tools for oral language skills will be essential for validating the model's broader linguistic effectiveness and ensuring its adaptability across all language domains.

5. AUTHORS' NOTE

We, as authors, declare that there is no conflict of interest regarding the publication of this article, and we have confirmed that this paper is free from plagiarism.

6. REFERENCES

Alneyadi, S., Abulibdeh, E., & Wardat, Y. (2023). The Impact of Digital Environment vs. Traditional Method on Literacy Skills; Reading and Writing of Emirati Fourth Graders. *Sustainability*, *15*(4), 3418. https://doi.org/10.3390/su15043418

Andrian, R., & Yul, W. (2023). Arabic Teaching Efficacy Model (ATEM): A Language Teaching Model Design. *International Journal of Arabic-English Studies*, *23*(2), 269–384. https://doi.org/10.33806/ijaes.v23i2.468

Blommaert, J. (2018). *Dialogues with Ethnography: Notes on Classics, and How I Read Them*. Multilingual Matters.

Blumenstein, M. (2020). Synergies of Learning Analytics and Learning Design: A Systematic Review of Student Outcomes. *Journal of Learning Analytics*, *7*(3), 13–32. https://doi.org/10.18608/jla.2020.73.3

Cavanagh, T., Chen, B., Lahcen, R. A. M., & Paradiso, J. (2020). Constructing a Design Framework and Pedagogical Approach for Adaptive Learning in Higher Education: A Practitioner's Perspective. *The International Review of Research in Open and Distributed Learning*, *21*(1), 172–196. https://doi.org/10.19173/irrodl.v21i1.4557

Chatti, M. A., & Muslim, A. (2019). The PERLA Framework: Blending Personalization and Learning Analytics. *The International Review of Research in Open and Distributed Learning*, *20*(1). https://doi.org/10.19173/irrodl.v20i1.3936

Creswell, J. W., Creswell, J. D. (2018). A Mixed-Method Approach. In *Writing Center Talk over Time*. https://doi.org/10.4324/9780429469237-3

Domínguez Figaredo, D., Reich, J., & Ruipérez-Valiente, J. A. (2020). Analítica del aprendizaje y educación basada en datos: Un campo en expansión. *RIED. Revista Iberoamericana de Educación a Distancia*, *23*(2), 33. https://doi.org/10.5944/ried.23.2.27105

Dr. SUGIONO. (2019). Metode Penelitian Kuantitatif, Kualitatif, Dan R & D. In *Sustainability (Switzerland)* (Vol. 11, Issue 1).

http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI

Du, X., Yang, J., Shelton, B. E., Hung, J.-L., & Zhang, M. (2021). A systematic meta-Review and analysis of learning analytics research. *Behaviour & Information Technology*, *40*(1), 49–62. https://doi.org/10.1080/0144929X.2019.1669712

Ferguson, R. (2019). Ethical Challenges for Learning Analytics. *Journal of Learning Analytics*, *6*(3). https://doi.org/10.18608/jla.2019.63.5

Ferguson, R., Clow, D., Griffiths, D., & Brasher, A. (2019). Moving Forward with Learning Analytics: Expert Views. *Journal of Learning Analytics*, *6*(3). https://doi.org/10.18608/jla.2019.63.8

Ferguson, R., Clow, D., Macfadyen, L., Essa, A., Dawson, S., & Alexander, S. (2014). Setting learning analytics in context. *Proceedings of the Fourth International Conference on Learning Analytics And Knowledge*, 251–253. https://doi.org/10.1145/2567574.2567592

Hilliger, I., G. Ceballos, H., Maldonado-Mahauad, J., & Ferreira, R. (2024). Applications of Learning Analytics in Latin America. *Journal of Learning Analytics*, *11*(1), 1–5. https://doi.org/10.18608/jla.2024.8409

Jagadeesan, S., & Subbiah, J. (2020). RETRACTED ARTICLE: Real-time personalization and recommendation in Adaptive Learning Management System. *Journal of Ambient Intelligence and Humanized Computing*, *11*(11), 4731–4741. https://doi.org/10.1007/s12652-020-01729-1

Khosravi, H., Sadiq, S., & Gasevic, D. (2020). Development and Adoption of an Adaptive Learning System. *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 58–64. https://doi.org/10.1145/3328778.3366900

Kochmar, E., Vu, D. Do, Belfer, R., Gupta, V., Serban, I. V., & Pineau, J. (2020). *Automated Personalized Feedback Improves Learning Gains in An Intelligent Tutoring System* (pp. 140–146). https://doi.org/10.1007/978-3-030-52240-7_26

Liu, Q., Tong, S., Liu, C., Zhao, H., Chen, E., Ma, H., & Wang, S. (2019). Exploiting Cognitive Structure for Adaptive Learning. *Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, 627–635. https://doi.org/10.1145/3292500.3330922

Maher, Y., Moussa, S. M., & Khalifa, M. E. (2020). Learners on Focus: Visualizing Analytics Through an Integrated Model for Learning Analytics in Adaptive Gamified E-Learning. *IEEE Access*, *8*, 197597–197616. https://doi.org/10.1109/ACCESS.2020.3034284

Mejeh, M., & Rehm, M. (2024). Taking adaptive learning in educational settings to the next level: leveraging natural language processing for improved personalization. *Educational Technology Research and Development*, *72*(3), 1597–1621. https://doi.org/10.1007/s11423-024-10345-1

Motz, B. A., Bergner, Y., Brooks, C. A., Gladden, A., Gray, G., Lang, C., Li, W., Marmolejo-Ramos, F., & Quick, J. D. (2023). LAK of Direction. *Journal of Learning Analytics*, 1–13. https://doi.org/10.18608/jla.2023.7913

Osakwe, I., Chen, G., Whitelock-Wainwright, A., Gašević, D., Pinheiro Cavalcanti, A., & Ferreira Mello, R. (2022). Towards automated content analysis of educational feedback: A multi-language study. *Computers and Education: Artificial Intelligence*, *3*, 100059. https://doi.org/10.1016/j.caeai.2022.100059

Pardo, A., Bartimote, K., Buckingham Shum, S., Dawson, S., Gao, J., Gašević, D., Leichtweis, S., Liu, D., Martínez-Maldonado, R., Mirriahi, N., Moskal, A. C. M., Schulte, J., Siemens, G., & Vigentini, L. (2018). OnTask: Delivering Data-Informed, Personalized Learning Support Actions. *Journal of Learning Analytics*, *5*(3). https://doi.org/10.18608/jla.2018.53.15

DOI: https://doi.org/10.17509/bs_jpbsp.v25i2.88030
p- ISSN 1412-0712 e- ISSN 2527-8312

Peng, H., Ma, S., & Spector, J. M. (2019). Personalized adaptive learning: an emerging pedagogical approach enabled by a smart learning environment. *Smart Learning Environments*, *6*(1), 9. https://doi.org/10.1186/s40561-019-0089-y

Raj, N. S., & Renumol, V. G. (2024). An improved adaptive learning path recommendation model driven by real-time learning analytics. *Journal of Computers in Education*, *11*(1), 121–148. https://doi.org/10.1007/s40692-022-00250-y

Ridder, H.-G. (2014). Book Review: Qualitative Data Analysis. A Methods Sourcebook. *German Journal of Human Resource Management: Zeitschrift Für Personalforschung*, *28*(4), 485–487. https://doi.org/10.1177/239700221402800402

Şahin, M., & Yurdugül, H. (2019). An intervention engine design and development based on learning analytics: the intelligent intervention system (In2S). *Smart Learning Environments*, *6*(1), 18. https://doi.org/10.1186/s40561-019-0100-7

Salim, D. M. S. (2024). Challenges and Innovations in Teaching The Arabic Grammar to Non-Native Speakers. *Integrated Journal for Research in Arts and Humanities*, *4*(5), 136–147. https://doi.org/10.55544/ijrah.4.5.21

Sayed, W. S., Noeman, A. M., Abdellatif, A., Abdelrazek, M., Badawy, M. G., Hamed, A., & El-Tantawy, S. (2023). AI-based adaptive personalized content presentation and exercises navigation for an effective and engaging E-learning platform. *Multimedia Tools and Applications*, *82*(3), 3303–3333. https://doi.org/10.1007/s11042-022-13076-8

Setyarini, S., Fitria, V. N., Khairunnisa, N., & Susilawati, S. (2023). Implementing Remote CLIL during the Covid-19 Pandemic: A Teacher's Voice. *Jurnal Pendidikan Bahasa Dan Sastra*, *23*(1), 1–12. https://doi.org/10.17509/bs_jpbsp.v23i1.59871

Sridharan, S., Saravanan, D., Srinivasan, A. K., & Murugan, B. (2021). Adaptive learning management expert system with evolving knowledge base and enhanced learnability. *Education and Information Technologies*, *26*(5), 5895–5916. https://doi.org/10.1007/s10639-021-10560-w

Tetzlaff, L., Schmiedek, F., & Brod, G. (2021). Developing Personalized Education: A Dynamic Framework. *Educational Psychology Review*, *33*(3), 863–882. https://doi.org/10.1007/s10648-020-09570-w

VanLEHN, K. (2011). The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems. *Educational Psychologist*, *46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

Vesin, B., Mangaroska, K., & Giannakos, M. (2018). Learning in smart environments: user-centered design and analytics of an adaptive learning system. *Smart Learning Environments*, *5*(1), 24. https://doi.org/10.1186/s40561-018-0071-0

Villegas-Ch, W., García-Ortiz, J., & Sánchez-Viteri, S. (2024). Personalization of Learning: Machine Learning Models for Adapting Educational Content to Individual Learning Styles. *IEEE Access*, *12*, 121114–121130. https://doi.org/10.1109/ACCESS.2024.3452592

Wang, S., Christensen, C., Cui, W., Tong, R., Yarnall, L., Shear, L., & Feng, M. (2023). When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, *31*(2), 793–803. https://doi.org/10.1080/10494820.2020.1808794

Weerasinghe, M., Quigley, A., Pucihar, K. Č., Toniolo, A., Miguel, A., & Kljun, M. (2022). Arigatō: Effects of Adaptive Guidance on Engagement and Performance in Augmented Reality Learning Environments. *IEEE Transactions on Visualization and Computer Graphics*, *28*(11), 3737–3747. https://doi.org/10.1109/TVCG.2022.3203088

Xu, Z., Wijekumar, K. (Kay), Ramirez, G., Hu, X., & Irey, R. (2019). The effectiveness of intelligent tutoring systems on K-12 students' reading comprehension: A meta-analysis. *British Journal of Educational Technology*, *50*(6), 3119–3137. https://doi.org/10.1111/bjet.12758

DOI: https://doi.org/10.17509/bs_jpbsp.v25i2.88030
p- ISSN 1412-0712 e- ISSN 2527-8312

Yadegaridehkordi, E., Noor, N. F. B. M., Ayub, M. N. Bin, Affal, H. B., & Hussin, N. B. (2019). Affective computing in education: A systematic review and future research. *Computers & Education, 142*, 103649. https://doi.org/10.1016/j.compedu.2019.103649

DOI: https://doi.org/10.17509/bs_jpbsp.v25i2.88030
p- ISSN 1412-0712 e- ISSN 2527-8312