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Research Article

From Rule-Based *Nahwu* to Adaptive Learning Systems: Reconceptualizing Arabic Grammar Instruction in the AI Era

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Abstract: Arabic grammar (*nahwu*) instruction has long been dominated by rule-based approaches that emphasize memorization and formal analysis, often resulting in rigid learning structures and limited responsiveness to learners' cognitive diversity. While such approaches play an important role in preserving grammatical accuracy, they frequently overlook individual learning trajectories, cognitive readiness, and adaptive instructional needs. In the era of artificial intelligence (AI), language education is increasingly shaped by adaptive learning systems that personalize content, pacing, and instructional strategies based on learners' profiles. This study aims to reconceptualize Arabic grammar instruction by proposing a conceptual framework that integrates traditional *nahwu* principles with adaptive learning systems informed by AI. Using a qualitative conceptual analysis, this paper synthesizes classical Arabic grammar pedagogy, contemporary theories of adaptive learning, and recent developments in AI-supported language instruction. The proposed framework highlights key components, including learner profiling, cognitive-level alignment, hierarchical *nahwu* content structuring, and AI-assisted scaffolding mechanisms. The findings suggest that adaptive learning systems offer significant pedagogical potential to transform *nahwu* instruction from a static, rule-centered model into a flexible, learner-centered process. This reconceptualization is expected to enhance grammatical comprehension, reduce cognitive overload, and promote learner autonomy in Arabic language education, particularly in Islamic higher education contexts. The study concludes by discussing pedagogical implications and directions for future empirical research on AI-assisted Arabic grammar learning.

Keywords: Adaptive Learning; AI; Arabic Grammar; Cognitive Readiness; Learner Autonomy

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1. Introduction

Arabic grammar (*nahwu*) occupies a central position in Arabic language education, particularly within formal and religious learning traditions. Historically, *nahwu* has functioned as a rule-based system designed to preserve linguistic correctness, ensure accurate interpretation of classical texts, and maintain the structural integrity of Arabic (Allen, 1976; Allen & Ryding, 2013). Classical pedagogical practices have emphasized the systematic transmission of grammatical rules, paradigms, and syntactic classifications, often through deductive instruction and memorization. While this tradition has played a crucial role in sustaining grammatical competence across generations, it has also produced a learning culture in which grammar is frequently perceived as rigid, abstract, and cognitively demanding, especially for contemporary learners with diverse backgrounds and learning needs (Ellis, 2006; Larsen-Freeman, 2015).

In many Arabic language classrooms, *nahwu* instruction continues to rely on a "one-size-fits-all" model, where learners are exposed to identical content sequences, instructional pacing, and assessment standards regardless of their prior knowledge, cognitive readiness, or learning trajectories (Zurqoni et al., 2020). This rule-centered orientation often prioritizes formal accuracy over meaningful language use, leading to cognitive overload and limited engagement among learners (Sweller et al., 2011). Numerous studies in Arabic language

pedagogy have highlighted that students commonly struggle with grammatical comprehension not because of the inherent complexity of Arabic grammar itself, but due to instructional rigidity and the lack of adaptive support embedded in traditional teaching approaches (Ismail et al., 2022; Salim, 2024). Consequently, *nahwu* is frequently regarded as one of the most challenging components of Arabic language learning, particularly at the tertiary level (Allen & Ryding, 2013).

At the same time, the broader landscape of education is undergoing a profound transformation driven by advances in digital technology and artificial intelligence (AI). In recent years, AI-powered learning environments have introduced adaptive learning systems capable of personalizing instructional content, sequencing learning materials dynamically, and providing real-time feedback based on learners' performance data (Holmes et al., 2019; Luckin & Holmes, 2016). These systems are designed to respond to individual differences by adjusting instructional strategies, difficulty levels, and learning pathways, thereby supporting more effective and meaningful learning experiences. Within language education, adaptive learning has been increasingly recognized as a promising approach for addressing learner diversity and enhancing instructional efficiency, particularly in contexts that demand personalization and flexibility (Pane et al., 2017; Zawacki-Richter et al., 2019).

Despite these global developments, the integration of adaptive learning principles into Arabic language education particularly in grammar instruction remains limited. Although digital platforms and e-learning tools have been increasingly adopted in Arabic language classrooms, many of these applications merely replicate traditional rule-based instruction in digital form, offering limited pedagogical adaptivity (Zurqoni et al., 2020; Salim, 2024). As a result, technological integration often enhances accessibility without fundamentally addressing instructional rigidity or learner diversity. This situation reflects a broader pattern identified in AI-in-education research, where technological innovation advances more rapidly than pedagogical integration, leading to a persistent gap between instructional design and learner-centered adaptivity (Zawacki-Richter et al., 2019). In the context of Arabic grammar learning, existing instructional models continue to fall short in providing systematic adaptive support aligned with learners' cognitive needs (Ismail et al., 2022).

From a pedagogical and cognitive perspective, grammar learning is not merely a mechanical process of memorizing rules but a complex cognitive activity involving pattern recognition, abstraction, hypothesis testing, and application. Research in second language acquisition emphasizes that learners progress through different stages of grammatical development, moving from controlled knowledge toward more automatized and functional use of grammatical structures (DeKeyser & Suzuki, 2025; Larsen-Freeman, 2015). When instructional design fails to align with learners' cognitive capacity, grammar learning can impose excessive cognitive load, hindering comprehension and long-term retention (Sweller et al., 2011). Therefore, effective grammar instruction requires systematic scaffolding that supports learners within their zones of proximal development, enabling gradual internalization of grammatical concepts (Vygotsky, 1978).

In the context of Arabic grammar, these cognitive considerations are particularly salient due to the hierarchical and interdependent nature of *nahwu* concepts. Grammatical topics such as *iʿrāb*, syntactic functions, and sentence structures require mastery of prerequisite knowledge before learners can meaningfully engage with more complex rules (Allen & Ryding, 2013). However, traditional instructional practices often overlook these dependencies, introducing advanced grammatical concepts without adequate diagnostic assessment or mastery verification. Empirical studies have shown that such sequencing issues contribute significantly to learners' persistent difficulties in Arabic grammar learning (Ismail et al., 2022; Salvaggio, 2022). In contrast, mastery-oriented and personalized learning approaches emphasize adaptive progression based on demonstrated competence, offering a more cognitively aligned pathway for grammar acquisition (Pane et al., 2017).

The emergence of artificial intelligence in education does not imply the replacement of teachers or the abandonment of established pedagogical traditions. Rather, AI is increasingly conceptualized as a pedagogical enabler that supports instructional decision-making, learner modeling, and adaptive scaffolding (Holmes et al., 2019; Luckin & Holmes, 2016). In grammar learning contexts, AI-assisted systems can analyze learner interactions, identify recurring patterns of difficulty, and recommend targeted instructional interventions aligned with individual learning needs (Graf et al., 2009). However, research has emphasized that the educational value of AI depends largely on its pedagogical integration, as technological innovation often outpaces instructional design and educator involvement (Zawacki-Richter et al., 2019).

This perspective underscores the importance of grounding AI-assisted grammar instruction in sound pedagogical frameworks rather than purely technical implementations.

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2. Literature Review

Rule-Based *Nahwu* Instruction in Arabic Language Education

Traditional *nahwu* instruction has historically been grounded in a rule-based pedagogical paradigm that emphasizes formal grammatical accuracy, syntactic classification, and deductive reasoning. Rooted in classical Arabic linguistic scholarship, this approach prioritizes the systematic transmission of grammatical rules (*qawāʿid*), paradigms, and terminologies as a means of preserving linguistic correctness and enabling accurate interpretation of canonical texts (Allen, 1976; Allen & Ryding, 2013). In many contemporary Arabic language programs, particularly within religious and formal educational institutions, *nahwu* instruction continues to rely heavily on teacher-centered lectures, memorization of rules, and written exercises focused on *iʿrāb* and syntactic analysis (Khitam, 2025; Salim, 2024).

While rule-based instruction contributes to learners' explicit grammatical knowledge and analytical awareness, numerous studies have reported persistent pedagogical challenges associated with this approach. Learners frequently perceive Arabic grammar as abstract, rigid, and disconnected from meaningful language use, which negatively affects motivation and engagement (Ellis, 2006; Larsen-Freeman, 2015). Empirical research in Arabic language education further indicates that students' difficulties in mastering *nahwu* often stem not from the intrinsic complexity of grammatical content, but from instructional rigidity and insufficient scaffolding embedded in traditional teaching practices (Ismail et al., 2022; Zurqoni et al., 2020).

Despite these limitations, scholars caution against dismissing rule-based *nahwu* instruction altogether. The deductive tradition plays an important role in developing grammatical accuracy and metalinguistic awareness, particularly for advanced learners and text-based analysis. Consequently, recent pedagogical discussions increasingly emphasize the need to retain the intellectual rigor of classical *nahwu* while rethinking its instructional delivery in more learner-responsive and cognitively aligned ways (Allen & Ryding, 2013; Salvaggio, 2022).

Adaptive Learning Systems in Language Education

Adaptive learning systems represent a shift from static, content-centered instruction toward personalized and data-informed learning environments. These systems are designed to modify instructional content, sequencing, and feedback based on learners' interactions, performance, and learning profiles, thereby accommodating individual differences in pace, readiness, and learning needs (Brusilovsky & Millán, 2007; Pane et al., 2017). Grounded in principles of mastery learning and continuous assessment, adaptive systems aim to optimize learning experiences by ensuring that learners progress only after demonstrating sufficient understanding of prerequisite concepts.

Within language education, adaptive learning has been increasingly recognized as an effective approach for addressing learner heterogeneity and improving instructional efficiency. Studies on personalized learning environments suggest that adaptive sequencing and targeted feedback can enhance learners' engagement and achievement, particularly in complex domains such as grammar learning (Graf et al., 2009; Pane et al., 2017). By dynamically adjusting task difficulty and instructional pathways, adaptive systems help learners manage cognitive demands and maintain sustained engagement over time.

Importantly, adaptive learning aligns closely with cognitive and sociocultural theories of learning that emphasize scaffolding and staged development. By supporting learners within their zones of proximal development, adaptive systems facilitate gradual knowledge construction and skill automatization (Vygotsky, 1978; Sweller et al., 2011). These theoretical foundations provide a strong rationale for exploring adaptive learning models in grammar

instruction, where conceptual dependencies and cognitive load present persistent pedagogical challenges.

AI-Supported Grammar Learning: Global Perspectives

Recent advances in artificial intelligence have significantly influenced the development of technology-enhanced language learning environments, including grammar instruction. AI-supported learning systems enable automated feedback, learner modeling, and adaptive task sequencing by analyzing learners' interactions and performance data (Holmes et al., 2019; Zawacki-Richter et al., 2019). In grammar learning contexts, such systems have demonstrated potential in identifying recurring learner errors, providing immediate corrective feedback, and supporting individualized learning trajectories, thereby enhancing instructional responsiveness.

Empirical and review studies in language education indicate that AI-assisted grammar instruction can contribute positively to learners' engagement and learning outcomes when pedagogically integrated into instructional design. For instance, research on AI-supported feedback highlights improvements in learners' accuracy, revision behavior, and overall language performance, particularly when feedback is timely and context-sensitive (Mekheimer, 2025). These findings underscore the importance of aligning AI functionalities with pedagogical objectives rather than treating AI merely as a technological add-on.

Despite these promising developments, the application of AI in Arabic grammar instruction remains limited and uneven. Existing digital tools for Arabic language learning often emphasize rule presentation and practice without meaningful adaptivity or learner profiling, resulting in instructional models that replicate traditional rule-based approaches in digital formats (Ismail et al., 2022; Salim, 2024). Moreover, many AI-related studies prioritize technical system performance over pedagogical coherence, leaving a gap between technological innovation and instructional theory, particularly in less commonly taught languages such as Arabic (Zawacki-Richter et al., 2019).

From a pedagogical standpoint, scholars increasingly argue that the effectiveness of AI in language education depends on its capacity to support learner-centered design, scaffolding, and cognitive alignment. When framed as an enabling technology, AI can operationalize adaptive learning principles at scale, offering instructional support that would be difficult to achieve through traditional classroom instruction alone (Holmes et al., 2019; Luckin & Holmes, 2016). This perspective provides a critical foundation for rethinking the role of AI in Arabic grammar pedagogy.

Research Gap and Conceptual Positioning

A synthesis of the existing literature reveals a clear research gap at the intersection of Arabic grammar (*nahwu*) pedagogy, adaptive learning theory, and AI-supported instructional design. While traditional *nahwu* instruction has been extensively discussed in terms of pedagogical challenges and learner difficulties, these discussions largely remain within rule-based or method-centered paradigms without addressing adaptive instructional frameworks (Allen & Ryding, 2013; Khitam, 2025; Salim, 2024). Studies proposing solutions to grammar learning problems often focus on localized interventions or specific methodological models, offering limited guidance for scalable and adaptive instructional design (Ismail et al., 2022).

Conversely, research on adaptive learning systems and artificial intelligence in education has predominantly focused on widely taught languages or general educational contexts, with insufficient attention to the unique linguistic structure and pedagogical traditions of Arabic grammar (Brusilovsky & Millán, 2007; Zawacki-Richter et al., 2019). As a result, existing adaptive and AI-supported models rarely account for the hierarchical and interdependent nature of *nahwu*, which poses distinctive challenges for instructional sequencing and learner scaffolding.

Furthermore, much of the AI-in-education literature emphasizes technological innovation and empirical tool evaluation, often overlooking the need for theoretically grounded pedagogical frameworks that guide instructional design and educator practice (Luckin & Holmes, 2016; Holmes et al., 2019). This imbalance limits the practical applicability of AI-based solutions in language education settings, particularly in contexts where pedagogical tradition and cognitive considerations play a central role.

In response to these gaps, the present study positions itself as a conceptual contribution that bridges classical *nahwu* pedagogy with contemporary adaptive learning principles informed by AI. Rather than proposing a technical system, this study advances a pedagogically grounded framework that foregrounds learner profiling, cognitive-level alignment, hierarchical content structuring, and AI-assisted scaffolding. By articulating how adaptive learning systems can be meaningfully aligned with the epistemological foundations of Arabic grammar,

this study seeks to provide a theoretical foundation for future empirical research and instructional innovation in Arabic grammar education.

3. Research Method

Research Approach and Conceptual Design

The conceptual design follows a theory-driven model-building process. First, core characteristics of traditional rule-based *nahwu* instruction are identified, including hierarchical content organization, deductive reasoning patterns, and emphasis on grammatical accuracy (Allen & Ryding, 2013; Khitam, 2025). Second, key principles of adaptive learning such as personalization, mastery progression, and continuous assessment are derived from research on adaptive and personalized learning systems (Pane et al., 2017; Graf et al., 2009). Third, these domains are integrated through an AI-informed pedagogical perspective, in which artificial intelligence functions as an enabling mechanism for instructional adaptivity rather than as a technical objective in itself (Holmes et al., 2019; Luckin & Holmes, 2016).

The outcome of this process is a conceptual framework that repositions *nahwu* instruction as an adaptive learning system. This framework is intended to guide educators and curriculum designers in reconceptualizing Arabic grammar pedagogy in ways that preserve its linguistic rigor while responding to learners' cognitive diversity and instructional needs (Allen & Ryding, 2013; Salim, 2024)..

Conceptual Framework for Adaptive *Nahwu* Instruction

The proposed conceptual framework reconceptualizes *nahwu* instruction by shifting its pedagogical orientation from a static, rule-centered model to a dynamic, learner-centered adaptive system. Traditional grammar instruction typically assumes uniform learner readiness and linear progression through grammatical content. In contrast, adaptive learning theory emphasizes instructional flexibility and responsiveness to individual learning trajectories (Brusilovsky & Millán, 2007; Pane et al., 2017).

Central to this framework is the assumption that *nahwu* learning unfolds as a staged cognitive process. Learners gradually move from basic recognition of grammatical forms toward higher-order analytical and applicative competencies, consistent with theories of skill acquisition and grammar learning (DeKeyser & Suzuki, 2025; Larsen-Freeman, 2015). Aligning *nahwu* instruction with learners' cognitive development is therefore essential for reducing cognitive overload and supporting meaningful grammatical internalization (Sweller et al., 2011).

Artificial intelligence is conceptualized within the framework as a pedagogical enabler that supports adaptive learning processes. Rather than prescribing specific algorithms, the framework outlines pedagogical functions that AI technologies can fulfill, including learner profiling, adaptive sequencing, and scaffolding support. This approach reflects contemporary views that emphasize pedagogy-driven AI integration in education (Holmes et al., 2019; Zawacki-Richter et al., 2019).

Key Components of the Proposed Framework

The proposed adaptive *nahwu* instruction framework consists of four interrelated components:

Learner Profile

Learner profiling constitutes the foundation of adaptivity within the proposed framework. It involves identifying learners' prior grammatical knowledge, learning pace, error patterns, and cognitive readiness. Research on adaptive educational systems highlights learner modeling as a critical component for enabling personalized instructional pathways (Brusilovsky & Millán, 2007; Graf et al., 2009). In Arabic grammar learning contexts, such profiling is particularly important due to the heterogeneity of learners' educational backgrounds (Zurqoni et al., 2020).

Cognitive-Level Alignment

Grammar learning is mapped onto progressive cognitive levels that reflect learners' developing grammatical competence. Aligning instructional tasks with learners' cognitive stages helps prevent excessive cognitive load and supports gradual skill automatization (DeKeyser & Suzuki, 2025; Sweller et al., 2011). This alignment also resonates with research emphasizing the need to move beyond rote memorization toward deeper grammatical understanding (Ellis, 2006; Larsen-Freeman, 2015).

Hierarchical Nahwu Content Structure

Nahwu content is inherently hierarchical and interdependent, requiring mastery of prerequisite concepts before progression to more complex grammatical structures. Studies in Arabic grammar pedagogy indicate that failure to account for these dependencies contributes

to persistent learning difficulties (Allen & Ryding, 2013; Ismail et al., 2022). By explicitly modeling grammatical hierarchies, the framework enables adaptive sequencing based on demonstrated learner mastery.

AI-Assisted Adaptive Scaffolding

Adaptive scaffolding represents the instructional mechanism through which learner support is dynamically adjusted. Drawing on sociocultural learning theory, scaffolding supports learners within their zones of proximal development through guided practice and feedback (Vygotsky, 1978). AI-assisted systems can operationalize this scaffolding by providing timely, targeted feedback and instructional recommendations aligned with learners' evolving needs (Holmes et al., 2019; Mekheimer, 2025).

Together, these components form an integrated system in which *nahwu* instruction becomes responsive, flexible, and learner-centered without compromising grammatical rigor.

Instructional Flow and Adaptivity Mechanism

The instructional flow within the proposed framework follows an adaptive cycle rather than a linear progression. Learning begins with diagnostic engagement to identify learners' existing grammatical competence, a practice widely recommended in adaptive and mastery-oriented learning research (Pane et al., 2017). Based on diagnostic information, learners are directed to appropriate entry points within the *nahwu* content hierarchy.

As learners interact with instructional materials, continuous assessment informs instructional adjustments. Learners demonstrating sufficient mastery progress to more advanced grammatical structures, while those encountering difficulties receive additional scaffolding and reinforcement. This adaptive cycle reflects principles of mastery learning and cognitive load management, ensuring that grammatical competence develops progressively and coherently (Sweller et al., 2011; DeKeyser & Suzuki, 2025).

From a pedagogical standpoint, this adaptive instructional flow transforms *nahwu* from a gatekeeping subject characterized by abstraction and difficulty into a guided cognitive learning process. Teachers remain central as instructional designers and facilitators, while AI-assisted systems enhance instructional responsiveness and scalability. This alignment between pedagogical intentionality and technological affordance is consistent with contemporary perspectives on responsible AI integration in education (Luckin & Holmes, 2016; Zawacki-Richter et al., 2019).

4. Results and Discussion

Conceptual Outcomes of the Proposed Framework

The primary outcome of this study is the formulation of a pedagogically grounded conceptual framework that reconceptualizes Arabic grammar (*nahwu*) instruction as an adaptive learning process. The framework articulates a shift from static, rule-centered instruction toward a learner-centered model that integrates hierarchical grammatical content, cognitive-level alignment, and adaptive scaffolding. This reconceptualization responds directly to long-standing pedagogical challenges identified in Arabic grammar education, including instructional rigidity, cognitive overload, and limited learner engagement (Allen & Ryding, 2013; Ismail et al., 2022; Salim, 2024).

A central result of the framework is the explicit modeling of *nahwu* as a staged cognitive learning process. Rather than treating grammatical competence as the cumulative memorization of rules, the framework emphasizes progressive mastery, where learners move from basic grammatical recognition toward higher-order analysis and application. This staged progression aligns with theories of skill acquisition and grammar learning that emphasize gradual automatization and meaningful use of grammatical knowledge (DeKeyser & Suzuki, 2025; Larsen-Freeman, 2015).

Another key outcome concerns the integration of adaptive learning principles into Arabic grammar pedagogy. By incorporating learner profiling, diagnostic assessment, and adaptive sequencing, the framework addresses learner heterogeneity and supports individualized learning trajectories. Research on adaptive educational systems has consistently highlighted the effectiveness of such mechanisms in managing learner diversity and enhancing instructional efficiency (Brusilovsky & Millán, 2007; Pane et al., 2017). Within the context of *nahwu* instruction, these mechanisms offer a structured response to the hierarchical and interdependent nature of grammatical content (Allen & Ryding, 2013).

Finally, the framework positions artificial intelligence as an enabling pedagogical mechanism rather than a prescriptive technological solution. AI-supported functions such as learner modeling, adaptive feedback, and scaffolding are conceptualized as tools that enhance

instructional responsiveness while preserving the central role of educators in pedagogical decision-making (Holmes et al., 2019; Luckin & Holmes, 2016). This positioning reflects contemporary perspectives that emphasize pedagogy-driven AI integration in education (Zawacki-Richter et al., 2019).

Pedagogical Implications for *Nahwu* Instruction

The findings of this conceptual study contribute to ongoing discussions on the future of grammar instruction by demonstrating how adaptive learning principles can be meaningfully aligned with the epistemological foundations of Arabic grammar. Traditional *nahwu* pedagogy has long prioritized formal accuracy and deductive reasoning, often at the expense of learner engagement and cognitive accessibility (Ellis, 2006; Larsen-Freeman, 2015). The proposed framework does not reject this tradition; rather, it reframes rule-based instruction within a learner-responsive pedagogical model that retains grammatical rigor while enhancing instructional flexibility (Allen & Ryding, 2013).

From a cognitive perspective, the framework's emphasis on staged learning and mastery progression directly addresses concerns related to cognitive load and instructional sequencing. Cognitive load theory suggests that learning is most effective when instructional design aligns with learners' processing capacity and avoids overwhelming working memory (Sweller et al., 2011). By ensuring that learners engage with grammatical content appropriate to their cognitive readiness, the adaptive framework supports more sustainable grammatical development and long-term retention (DeKeyser & Suzuki, 2025).

The discussion also highlights the pedagogical value of adaptive scaffolding in Arabic grammar learning. Drawing on sociocultural theory, scaffolding supports learners within their zones of proximal development through guided assistance and gradual release of responsibility (Vygotsky, 1978). AI-assisted adaptive systems can operationalize this scaffolding at scale by providing timely feedback and differentiated instructional pathways, addressing limitations commonly reported in traditional classroom-based grammar instruction (Graf et al., 2009; Mekheimer, 2025).

Importantly, this study situates AI within a human-centered pedagogical framework. Consistent with critical perspectives on AI in education, the framework emphasizes that technological innovation must be guided by pedagogical intent and educator expertise rather than driven solely by system capabilities (Luckin & Holmes, 2016; Zawacki-Richter et al., 2019). In this sense, the proposed framework contributes to a growing body of literature advocating responsible and theory-informed integration of AI in language education.

Overall, the results and discussion underscore the potential of adaptive learning systems to transform *nahwu* instruction into a more cognitively aligned, engaging, and learner-centered process. By bridging classical grammatical traditions with contemporary learning theory and AI-supported adaptivity, the proposed framework offers a conceptual foundation for future empirical research and instructional innovation in Arabic grammar education.

Discussion in Relation to Previous Studies and Theory

The proposed conceptual framework can be meaningfully situated within existing scholarship on Arabic grammar pedagogy, adaptive learning, and artificial intelligence in education. Previous studies on *nahwu* instruction have consistently highlighted persistent learner difficulties, particularly in relation to instructional rigidity, overreliance on deductive rule presentation, and limited responsiveness to learner diversity (Allen & Ryding, 2013; Ismail et al., 2022; Salim, 2024). These studies largely converge on the diagnosis of the problem but tend to propose localized methodological adjustments rather than comprehensive instructional frameworks. In contrast, the present study extends this line of inquiry by offering a systemic reconceptualization of *nahwu* instruction grounded in adaptive learning principles.

From the perspective of second language acquisition theory, the framework aligns with research emphasizing grammar learning as a gradual and cognitively mediated process rather than immediate rule internalization. Studies by Ellis (2006) and Larsen-Freeman (2015) underscore that effective grammar instruction requires opportunities for meaningful engagement, staged development, and functional application. Similarly, skill acquisition theory posits that learners progress from declarative knowledge toward procedural and automatized use through guided practice and appropriate sequencing (DeKeyser & Suzuki, 2025). By explicitly modeling *nahwu* learning as a staged cognitive process, the proposed framework operationalizes these theoretical insights within the context of Arabic grammar pedagogy.

The framework also resonates strongly with cognitive load theory, which emphasizes the importance of aligning instructional design with learners' processing capacity. Sweller et al. (2011) argue that excessive cognitive demands hinder learning when instructional materials fail to account for learners' prior knowledge and conceptual readiness. Traditional *nahwu*

instruction, which often introduces complex grammatical rules without sufficient diagnostic assessment or scaffolding, exemplifies this misalignment (Ismail et al., 2022). The adaptive sequencing and mastery-based progression proposed in this study directly address these concerns by regulating cognitive load and supporting gradual knowledge construction.

In relation to adaptive learning research, the proposed framework reflects established principles of learner modeling, personalization, and mastery learning articulated in studies of adaptive educational systems (Brusilovsky & Millán, 2007; Pane et al., 2017). However, while much of the adaptive learning literature focuses on general education or widely taught languages, it rarely engages with the specific epistemological and structural characteristics of Arabic grammar. This study contributes to the literature by demonstrating how adaptive learning theory can be contextually aligned with the hierarchical and interdependent nature of *nahwu*, thereby extending the applicability of adaptive learning models to Arabic language education.

With respect to artificial intelligence in education, prior research has emphasized both the potential and the limitations of AI-supported learning environments. Systematic reviews indicate that AI applications often prioritize technical performance over pedagogical coherence, resulting in a gap between innovation and instructional practice (Zawacki-Richter et al., 2019). Scholars such as Luckin and Holmes (2016) and Holmes et al. (2019) argue that AI should be positioned as a pedagogical enabler that supports educators rather than replaces them. The present framework is consistent with this human-centered perspective, as it conceptualizes AI as a mechanism for implementing adaptive scaffolding and learner profiling under pedagogical control.

Compared to recent studies on AI-assisted language learning that focus on specific tools or feedback mechanisms (e.g., Mekheimer, 2025), this study offers a higher-level pedagogical contribution by articulating a conceptual framework that integrates theory, pedagogy, and technology. Rather than evaluating the effectiveness of a particular AI application, the framework provides theoretical guidance for designing adaptive *nahwu* instruction that can be implemented across different technological platforms and educational contexts.

Overall, the discussion demonstrates that the proposed framework not only synthesizes insights from prior studies and learning theories but also advances the literature by bridging gaps between Arabic grammar pedagogy, adaptive learning theory, and AI-informed instructional design. In doing so, this study positions itself as a conceptual contribution that complements existing empirical research and lays the groundwork for future experimental and design-based studies in Arabic grammar education.

5. Comparison

This section compares the proposed adaptive *nahwu* instructional framework with existing approaches to Arabic grammar teaching and technology-supported language learning. Traditional *nahwu* instruction has long relied on rule-based, deductive pedagogy that emphasizes uniform content delivery and formal grammatical accuracy. While this approach has been effective in preserving linguistic rigor, it has also been associated with instructional rigidity and limited responsiveness to learner diversity (Allen & Ryding, 2013; Ellis, 2006).

In comparison, pedagogical models that seek to address challenges in Arabic grammar learning such as communicative approaches, methodological adjustments, or localized instructional innovations have contributed valuable insights into learner difficulties and teaching strategies. However, many of these models focus on specific techniques or classroom practices without offering a comprehensive framework for adaptive instructional design (Ismail et al., 2022; Salim, 2024; Khitam, 2025). As a result, instructional sequencing and learner support often remain largely standardized.

Compared to these approaches, the proposed framework introduces a systematic adaptive learning perspective that explicitly accounts for learner profiling, cognitive readiness, and hierarchical content dependencies. Drawing on principles of adaptive educational systems, the framework enables dynamic instructional sequencing and mastery-based progression rather than fixed curricular pathways (Brusilovsky & Millán, 2007; Pane et al., 2017). This distinction is particularly significant for *nahwu* instruction, where grammatical concepts are highly interdependent and require careful cognitive scaffolding.

When contrasted with existing AI-supported language learning studies, the proposed framework differs in both scope and orientation. Prior research on AI in language education has largely concentrated on tool-based applications such as automated feedback or performance analytics, often evaluated in isolation from broader pedagogical models (Mekheimer, 2025; Zawacki-Richter et al., 2019). While such studies demonstrate the technical potential of

AI, they provide limited guidance on how AI can be systematically integrated into grammar pedagogy.

In contrast, this study positions artificial intelligence as a pedagogical enabler embedded within an adaptive instructional framework rather than as an independent instructional solution. Consistent with human-centered perspectives on AI in education, the framework emphasizes educator control, pedagogical intentionality, and cognitive alignment as guiding principles for AI integration (Luckin & Holmes, 2016; Holmes et al., 2019). This positioning distinguishes the proposed model from both traditional rule-based instruction and technology-driven approaches that lack pedagogical coherence.

Overall, the comparison highlights that the proposed framework does not seek to replace existing pedagogical traditions or technological innovations. Instead, it integrates the strengths of classical *nahwu* instruction, adaptive learning theory, and AI-supported scaffolding into a coherent conceptual model. By doing so, it offers a more comprehensive and pedagogically grounded alternative to existing approaches to Arabic grammar instruction.

Table 1. Comparison of *Nahwu* Instructional Approaches

Aspect	Traditional Rule-Based Instruction	Static E-Learning Instruction	Adaptive *Nahwu* Framework (Proposed)
Instructional orientation	Teacher-centered, rule-focused	Content-centered, technology-mediated	Learner-centered, adaptive
Content sequencing	Fixed and linear	Fixed, digitally delivered	Dynamic and mastery-based
Learner differentiation	Minimal	Limited	High (learner profiling)
Cognitive alignment	Implicit, often assumed	Weakly addressed	Explicit and systematic
Feedback mechanism	Teacher-driven, delayed	Generic, automated	Targeted, adaptive scaffolding
Role of technology	Minimal or none	Delivery tool	Pedagogical enabler
Learning flexibility	Low	Moderate	High
Potential learner autonomy	Limited	Moderate	High

6. Conclusion

This study has reconceptualized Arabic grammar (*nahwu*) instruction by positioning it within the paradigm of adaptive learning systems informed by artificial intelligence. Departing from traditional rule-based approaches that emphasize uniform content delivery and deductive instruction, the proposed framework offers a learner-centered model that aligns grammatical instruction with learners' cognitive readiness, learning trajectories, and mastery levels. Through a qualitative conceptual analysis, this paper has demonstrated that *nahwu* learning can be more effectively understood as a staged cognitive process rather than a static accumulation of grammatical rules.

The primary contribution of this study lies in the development of a pedagogically grounded conceptual framework that integrates classical *nahwu* principles with contemporary adaptive learning theory. By incorporating learner profiling, cognitive-level alignment, hierarchical content structuring, and AI-assisted adaptive scaffolding, the framework addresses long-standing challenges in Arabic grammar education, including cognitive overload, instructional rigidity, and limited learner engagement. Importantly, the framework preserves the intellectual rigor of Arabic grammar while enhancing instructional flexibility and responsiveness.

From a pedagogical perspective, the findings suggest that adaptive *nahwu* instruction has the potential to transform grammar learning into a more meaningful and accessible experience. The framework supports differentiated instruction, promotes mastery-oriented learning, and fosters learner autonomy outcomes that are particularly relevant in higher education contexts characterized by learner diversity. Moreover, by conceptualizing AI as an enabling pedagogical mechanism rather than a technical endpoint, this study contributes to ongoing discussions on responsible and theory-informed integration of AI in language education.

Despite its contributions, this study is not without limitations. As a conceptual work, the proposed framework has not yet been empirically tested in classroom or technology-mediated learning environments. Future research should therefore focus on validating the framework through experimental or design-based studies, exploring its implementation in AI-supported learning platforms, and examining its impact on learners' grammatical competence, motivation, and long-term retention. Additionally, further studies may investigate how adaptive

nahwu instruction can be integrated with communicative language teaching and other contemporary pedagogical approaches.

In conclusion, reconceptualizing *nahwu* instruction through adaptive learning systems offers a promising pathway for bridging classical Arabic grammatical traditions with the demands of modern education. By aligning linguistic rigor with pedagogical innovation, the proposed framework provides a foundation for future research and instructional development in Arabic grammar education in the AI era.

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