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Data-Driven Constructivism: A Pedagogical Framework for Integrating Deep Learning into Arabic Second Language Acquisition

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ABSTRACT

This study developed and validated a Data-Driven Constructivist Framework for integrating Deep Learning (DL) into Arabic second language acquisition. Using a phenomenological approach, it examined the experiences of 12 stakeholders at an Islamic junior and senior high school in Gresik, Indonesia, through interviews, observations, and reflective documentation. The findings validated a five-stage pedagogical model (Orientation, Identification, Discussion, Decision, and Implementation) and showed that DL-enhanced scaffolding made Project-Based Learning more reflective and iterative. The approach increased learner autonomy and intrinsic motivation by supporting competence and relatedness, consistent with Self-Determination Theory. However, sustainability depended on addressing the digital divide and strengthening teacher readiness through Professional Learning Communities. Overall, aligning adaptive DL algorithms with Islamic values offers a scalable precision-education model that balances AI integration with linguistic and cultural preservation.

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Keyword

Deep Learning Pedagogy; Adaptive Curriculum Framework; Arabic Second Language Acquisition; Self-Determination Theory (SDT); Data-Driven Constructivism.

مستخلص البحث

طوّرت هذه الدراسة إطارًا بنائياً قائماً على البيانات، وقامت بالتحقق من صلاحيته، بهدف دمج التعلّم العميق في اكتساب اللغة العربية بوصفها لغة ثانية. واعتمدت الدراسة مقارنة ظاهرية لفحص خبرات (١٢) من أصحاب المصلحة في مدرسة إسلامية للمرحلتين المتوسطة والثانوية في مدينة غريسك بإندونيسيا، وذلك من خلال المقابلات، والملاحظات الميدانية، والوثائق التأملية. وأثبتت نتائج الدراسة صلاحية نموذج بيداغوجي مكوّن من خمس مراحل متتابعة، هي: التوجيه، والتحديد، والمناقشة، واتخاذ القرار، والتنفيذ، كما بيّنت أن توظيف الدعائم التعليمية المدعومة بالتعلّم العميق أسهم في جعل التعلّم القائم على المشاريع أكثر تأملية وتكرارية. وقد أدّى هذا التوجّه إلى تعزيز استقلالية المتعلمين ودافعيتهم الذاتية، من خلال دعم بُعدي الكفاءة والانتماء، بما ينسجم مع نظرية التحديد الذاتي. ومع ذلك، أظهرت النتائج أنّ استدامة هذا الإطار التعليمي مشروطة بمعالجة الفجوة الرقمية، وتعزيز جاهزية المعلمين عبر مجتمعات التعلّم المهنية. وتلخص الدراسة إلى أنّ مواءمة خوارزميات التعلّم العميق التكيفية مع القيم الإسلامية تتيح نموذجًا قابلاً للتوسّع في التعليم الدقيق، يوازن بين تكامل الذكاء الاصطناعي والحفاظ على الخصوصية اللغوية والثقافية في تعليم اللغة العربية.

التربية القائمة على التعلّم العميق؛ إطار المنهج التكيفي؛ اكتساب اللغة العربية كلفة ثانية؛ نظرية التحديد

كلمات أساسية

الذاتي *SDT*: البنائية القائمة على البيانات.

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INTRODUCTION

Arabic language learning is mostly delivered using a traditional approach, emphasizing on language structure and vocabulary mastery, with lesser association to social and cultural contexts. The traditional approach often leads to superficial learning, where students might find difficulties in using Arabic in real-life situations in a meaningful way. The deep learning-based curriculum offers an alternative to overcome this gap.

Deep learning in language learning emphasizes high cognitive engagement, reflection, and the connection between learning materials and students' experiences and social contexts. The approach accommodates language form memorization as well as meaning, function, and use of the language in various contexts. The approach also stimulates students' higher-order thinking skills, creativity, and effective communication skills.

The deep learning curriculum design should be adjusted to meaningful learning, practical application, contextual and authentic learning materials, interactive and collaborative learning methods, and an evaluation system that assesses thinking skills and the practical application of Arabic. This approach also changes the role of the teacher from information resource to facilitator and helps students autonomously develop comprehensive language skills.

In the context of education at *Madrasah Tsanawiyah* (MTs) (Islamic Junior High School) and *Madrasah Aliyah* (MA) (Islamic Senior High School), particularly at MTS and MA Mambau Sholihin Gresik, the development of a deep learning-based curriculum is very strategic for improving the quality of Arabic language learning. This curriculum is expected to make Arabic language learning more meaningful, contextual, and relevant to the needs of students in today's digital and globalized era.

Prior researchers have examined the deep learning-based curriculum development for Arabic language learning at the MTs and MA levels. A study was performed to examine the application of the deep learning approach in Arabic vocabulary learning (*mufradāt*) based on three pillars of learning, namely mindful learning, meaningful learning, and joyful learning, using interactive technology. In the study, students' engagement, contextual understanding, and emotional motivation in Arabic language learning were successfully improved. However, such model might not be applicable in remote areas with limited infrastructure (Istiqomah & Sopian, 2025). Another study was done to develop a deep learning framework for Arabic language courses in higher education, focusing on pedagogical practices, learning partnerships, learning environments, and digital utilization. The study emphasized the importance of innovative approaches that promote conceptual understanding and practical application, as well as collaboration between stakeholders. The integration of digital tools is also a

transformative strategy for creating interactive and adaptive learning experiences (Albantani et al., 2025).

A comprehensive literature review has been conducted on the application of artificial intelligence in the context of Arabic, including learning, natural language processing, and translation. This study highlights the opportunities and challenges of using AI in Arabic language development to improve the effectiveness of language learning (Hanandeh et al., 2024). AI utilization in the education sector is more adaptable to serve students' personal learning needs (Syaikhudin & Laili, 2024). The use of technology in Arabic language learning has been widely examined in studies from 1993 to 2024. Since then, the use of technology has become common, including deep learning, speech recognition, and machine-based learning systems (Khusnadin et al., 2024).

The available studies on the application of deep learning in Arabic language learning in higher education have not yet tapped into the development of learning-based curricula for the MTs and MA levels. The perspectives of teachers and students of the deep learning curriculum at the college level have never been explored. To address this gap, the present study was performed to develop a contextual and applicable deep learning-based curriculum model using a phenomenological approach to take into account the authentic experiences of stakeholders. This study also analyzed the potential impact of the curriculum on Arabic language motivation and competence. The results are expected to contribute significantly to the development of Arabic language education in Islamic schools/*madrasahs*.

This study explored the reception and adaptability of Deep Learning-based curricula among non-native Arabic stakeholders and validated a Data-Driven Constructivist Framework for a deep learning-based curriculum for Arabic. Furthermore, this study examined the correlation between adaptive algorithms and the enhancement of learner autonomy (Self-Determination Theory) and linguistic competence at MTS and MA Mambaus Sholihin Gresik.

This study provides an in-depth understanding of how the integration of deep learning into the Arabic language curriculum can enrich the learning process at the MTS and MA levels. This study also proposes an innovative and relevant pedagogical framework model as a practical reference for curriculum developers and educators in designing a more adaptive Arabic language learning approach. The potential impact of deep learning-based curricula on student motivation and competence in improving the quality and outcomes of Arabic learning is also explored, while also assisting school policies in strategically adopting educational technology. The results of this study contribute to the development of educational science, the improvement of Arabic language learning quality, and the utilization of deep learning technology.

METHOD

This phenomenological study was performed using the qualitative research framework to analyze the "lived experience" of teachers and students regarding the integration of Deep Learning (DL) in the Arabic language curriculum. The approach facilitates a profound exploration of subjective perceptions of how educational stakeholders interpret the transition from traditional methodologies to AI-driven pedagogies. The researcher adopted the role of a human instrument, balancing participatory engagement and objective observation (bracketing/epoche) to reduce personal bias during data collection (Pazurek & Köseoğlu, 2022).

The research was conducted at MTs and MA Mambaus Sholihin in Suci Village, Manyar District, Gresik Regency, East Java. The school has unique educational ecosystem, where the National Curriculum is used simultaneously with *Pesantren* (Islamic Boarding School) curriculum. Therefore, the adaptability of advanced Deep Learning algorithms within can be examined (Eslit, 2023). Participants were purposively selected based on the inclusion criteria: (1) Arabic teachers actively involved in the curriculum pilot project, and (2) students who exhibited varying levels of engagement with the new system. A total of 12 informants participated in this study, comprising the Madrasah Principal, Arabic teachers, and students from both educational levels. The demographic profile of the participants is presented in Table 1.

Table 1. The Demographic profile of the participants

Participant Code	Role	Gender	Level / Experience	Description
P1	Principal	Male	> 20 Years of Experience	Head of Madrasah (Policy Maker)
T1	Teacher	Male	15 Years of Experience	Senior Arabic Teacher (Curriculum Coordinator)
T2	Teacher	Female	8 Years of Experience	Arabic Teacher (Digital Implementation Lead)
T3	Teacher	Male	4 Years of Experience	Arabic Teacher (Educational Technology Focus)
S1	Student	Male	MTs (Grade 9)	High achiever in Arabic subjects
S2	Student	Female	MTs (Grade 8)	Active user of the learning application
S3	Student	Male	MTs (Grade 7)	Represents novice learner perspective
S4	Student	Female	MTs (Grade 9)	Student Council Representative
S5	Student	Male	MA (Grade 12)	Language Program Major (MAK)
S6	Student	Female	MA (Grade 11)	Science Program Major (MIPA)
S7	Student	Male	MA (Grade 10)	New student with high digital literacy
S8	Student	Female	MA (Grade 11)	Represents average student engagement

Data collection involved three primary techniques for triangulation. **First**, non-participant observation was performed to understand classroom dynamics during the implementation of the Deep Learning (DL) curriculum, aiming to capture contextual engagement and technical challenges. **Second**, semi-structured in-depth interviews were conducted with teachers, the school principal, and students to explore their perspectives on pedagogical shifts and motivational factors. **Third**, documentation analysis was done on existing syllabi, lesson plans (RPP), and digital log data to evaluate the intended curriculum against the enacted reality to gain comprehensive and adequate data (Jurs et al., 2023).

The data were analyzed using a systematic thematic analysis through data reduction, data display, and conclusion drawing. The analytical process comprised three specific phases. Data analysis began with open coding, in which interview transcripts and observation notes were transcribed verbatim to identify preliminary keywords (e.g., internet lag, enthusiasm, personalized feedback). Axial coding then grouped related codes into broader categories, such as Technological Barriers and Intrinsic Motivation. Finally, selective coding synthesized these categories into a pedagogical framework, resulting in the OIIDDI Model (Orientation, Identification, Discussion, Decision, and Implementation). This stage allowed theoretical data interpretation to meet the objectives (Z. Ali et al., 2023; Werner et al., 2023).

The validity of the findings was tested using methodological triangulation by comparing interview data with observation notes. The completeness of the data was also checked to make sure that participants' responses were accurately represented. Furthermore, an audit trail also ensured that each step of the decision-making process throughout the analysis was documented (Carillo et al., 2023).

RESULTS & DISCUSSION

The OIIDDI Pedagogical Framework: Integrating Deep Learning in Pesantren Context

The present study successfully developed the OIIDDI (Orientation, Identification, Discussion, Decision, Implementation) pedagogical framework tailored specifically for the MTs and MA levels at Madrasah Mambaus Sholihin. The model effectively integrates deep learning algorithms as a means of promoting active and contextualized Arabic learning experiences.

Classroom observations provide empirical support for this efficacy. Field notes from the Identification phase showed a clear shift from uniform instruction

to real-time differentiated learning: lower-proficiency groups received visual vocabulary scaffolding, while advanced groups engaged in complex sentence construction. This seamless differentiation illustrates the system's capacity to address diverse learning needs dynamically.

Moreover, the Identification and Decision phases enable analysis of student interaction data, supporting adaptive and personalized learning beyond traditional methods. This advantage was explicitly acknowledged by an Arabic teacher (T2), who noted the limitations of manual assessment:

"Previously, it was difficult for me to map the abilities of 30 students in one class accurately. However, in the Identification phase, the system provides real-time data. I was surprised to see that student A was actually weak in 'Istimā' (listening) even though his 'Qirā'ah' (reading) was good. This data helps me not to generalize the teaching method." (Teacher T2, 8 years of experience).

Students also reported reduced anxiety due to the personalized nature of the 'Decision' phase. One student (S5) described the experience:

"I usually feel embarrassed if I can't answer questions in front of the class. But with this model, the application gives me exercises that fit my level. It feels like the system understands me. If I am weak in vocabulary, it gives me more vocabulary drills, It makes me more confident." (Student S5, MA Grade 11).

Crucially, the framework aligns technological innovation with the core values of Islamic boarding schools. The principal (P1) noted that technology does not undermine cultural identity: "Our concern initially was that technology would make children individualistic. But the OIDDI framework creates a balance. Technology is used for analysis, but in the Discussion and Implementation phases, they still interact with ethics, sit politely, and discuss using Arabic properly." The cultural identity of these institutions needs to be amidst digital transformation (Assiddiqi, 2025; Rasyidin & Yusuf, 2024; Sumanti et al., 2024).

The OIDDI model represents a substantial theoretical evolution within the educational frameworks by modifying traditional Project-Based Learning (PBL) and collaborative learning theories. Conventional PBL typically relies on human judgment, whereas the OIDDI model employs an adaptive approach via deep learning algorithms to allow scaffolding in the learning process (Pahrudin, 2025; Zhu & Niyozov, 2024). This adaptation enhances learning efficiency based on the principles of Constructivism in reshaping knowledge construction in educational contexts (Saldivar, 2025).

The integration of deep learning technologies within the OIDDI model addresses well-documented pedagogical challenges. Adaptive technology in the

"Decision" phase responds effectively to the traditional challenges faced by educators in maintaining curriculum relevance (Safiuddin, 2022). The use of transformative technology fosters dynamic and responsive learning environments to meet the modern educational demands (A. Ali & Dian, 2024; Laila et al., 2025).

The OIDD model utilizes deep learning technology to process real-time interaction data and adjusts the learning path to students' learning readiness. Hence, educators can move beyond traditional assessment methods by modifying the "static syllabus." (Mu'awanah et al., 2025).

The application of the OIDD model within the context of Islamic education recognizes the significance of maintaining cultural integrity while also utilizing technological innovations. The OIDD framework offers an innovative solution that enhances educational quality without compromising traditional values (Rasyidin & Yusuf, 2024; Sumanti et al., 2024). It also resonates with broader educational shifts observed in Indonesia to integrate technology for more relevant and effective learning (Triantoro et al., 2023).

The OIDD framework signifies a forward-thinking approach to education that bridges deep learning with the cultural demands of *Pesantren* settings. This model improves pedagogical practices and contextuality of the learning activities.

Impact on Learner Autonomy and Linguistic Competence (Self-Determination Theory)

OIDD framework brings significant positive impact on learners' intrinsic motivation and linguistic competence. In this study, the students exhibited stronger enthusiasm and confidence as shown by their active engagement in the creative learning process. Unlike the passive listening often found in traditional *Sorogan* classes, students actively had debates on the lexical choices suggested by the AI in analyzing linguistic nuances rather than merely accepting information.

This psychological shift was further articulated in student interviews. One student (S4) highlighted the role of the non-judgmental nature of the technology in building confidence:

"Usually, during *Sorogan*, I am afraid of being scolded if I read the '*Harakat*' wrong. But with this Deep Learning application, I feel safe. If my pronunciation is wrong, the AI just tells me to try again until it's green. It makes me confident to speak loud without fear."
(Student S4, MTs Grade 9).

The impact of this shift was most apparent in the deep learning-based curriculum, which significantly strengthened aural-oral skills and text comprehension through sustained engagement with machine learning-supported

digital content. Formative assessment results revealed marked improvements in phonological awareness and vocabulary acquisition, with students demonstrating greater accuracy and fluency in Arabic than under traditional instructional approaches (Konyrova, 2024; Luo, 2023). These quantitative outcomes were further validated by qualitative feedback from the teaching staff, as noted by a teacher specializing in educational technology (T3):

"The most significant change is in their 'Makharijul Huruf' (articulation points). Because the system provides repeated audio examples from native speakers and forces them to mimic it precisely, their accent has become much more natural compared to when they only memorized vocabulary from books." (Teacher T3).

This finding aligns with the role of emotional involvement and accurate feedback in facilitating language acquisition (Konyrova, 2024; Luo, 2023).

This study shows that a deep learning framework enhances learner autonomy and linguistic competence by strengthening intrinsic motivation through technologies aligned with self-determination theory (SDT). Adaptive feedback meets key psychological needs of competence, autonomy, and relatedness (Saini et al., 2024; Vansteenkiste et al., 2020), enabling deeper and more confident engagement in Arabic learning. These findings support prior research emphasizing the role of emotional engagement and accurate feedback in language acquisition (Wellhöfer & Lühken, 2021).

Students' intrinsic motivation improved based on their psychological needs. By allowing learners to progress at their own pace, the deep learning system caters to individual learning preferences while reducing the anxiety often associated with traditional classrooms (Zhai et al., 2021). This confirms existing theories that suggest environments supporting autonomy enhance intrinsic motivation, which in turn correlates positively with improved learning outcomes (Saini et al., 2024). Technology can profoundly influence emotional engagement and educational effectiveness through an adaptive learning environment (Colliot et al., 2024).

The adaptiveness of the OIDD framework provides real-time feedback for a more personalized learning experience. The data-driven insights enable the system to dynamically adjust instructional content based on the individual learner's progress (Qin, 2024; Wang & Chen, 2025). This integration shifts passive reception to active construction, where students take an active role in building their knowledge (Hooda et al., 2022; Zhang, 2024)

Pesantren maintains traditional educational values while embracing modern technological advancements. In this context, the OIDD model effectively addresses the dual imperatives of enhancing language skills and fostering learner

independence without compromising the cultural integrity of Islamic educational practices (Onesi-Ozigagun et al., 2024; Saleem et al., 2025). This study also explores the potential use of deep learning to create meaningful educational transformations across diverse contexts (Onesi-Ozigagun et al., 2024).

Teacher Readiness and Infrastructure: The Determinants of Sustainability

This study found that significant infrastructural and human resource challenges persisted at Madrasah Mambaus Sholihin. While teachers recognize the potential of deep learning as a valuable educational innovation, they simultaneously express a pressing need to enhance their digital literacy. This gap between enthusiasm and capability was shared by a senior Arabic teacher (T1), who expressed frustration despite his willingness to adapt:

"I honestly admire this OIIDDI model; the students are indeed more active. But technical preparation is exhausting for me. Sometimes, I spend 15 minutes just ensuring the tablets are connected to the server, eating into teaching time. I feel I need intensive training, not just on 'how to use' the app, but on how to troubleshoot when errors occur." (Teacher T1, 15 years of experience).

Limited access to devices and inconsistent internet connectivity constitute the primary barriers to the consistent application of the deep learning framework. Field observations conducted on November 2, 2025, showed this infrastructural fragility. During a peak usage hour (09:00 AM), the local server bandwidth bottlenecked, causing the 'Decision' phase interface to freeze for approximately 10 minutes. The observer noted:

"The class momentum was disrupted. While the AI was supposed to generate personalized questions, the screens kept loading. Teachers had to switch back to the whiteboard manually to keep the class quiet. This incident highlights that the sophistication of the algorithm is rendered ineffective without a stable network backbone." (Field Note, Class VIII).

Data from interviews revealed a 'Digital Divide' among learners. While some students with personal smartphones could practice easily at the dormitory, others relied solely on the limited hours in the computer lab.

"I want to do the 'Daily Speaking Challenge' assigned by the AI, but I don't have a smartphone. I have to borrow my friend's phone or wait for the lab to open. Sometimes I feel left behind because my friends have already leveled up in the app while I'm still waiting for a turn." (Student S3, MTs)

Grade 7).

Without adequate infrastructure support and professional development, the implementation of AI-driven curricula can become inconsistent and unsustainable. The enthusiasm of teachers and students is strong, but structural support is the prerequisite for continuity (Rissi & Sinaga, 2025).

This study identifies critical challenges related to teacher readiness and infrastructural limitations as determinants of the sustainability of deep learning curricula in Indonesian educational contexts. While effective pedagogical strategies may have been established, they are undermined by infrastructural inadequacies, which hinder teachers' abilities to effectively employ AI technologies in their teaching practices (Ifenthaler et al., 2020). These challenges highlight how infrastructural readiness and teacher training foster the environment for deep learning and AI integration (Šmitienė et al., 2024).

The digital divide highlights how unequal access to technology undermines educational equity (Harrington & Sellberg, 2024). Although teachers are eager to use technology, insufficient training limits their ability to interpret learning analytics, weakening the "Decision" phase of the OIIDDI model and reducing opportunities for personalized and adaptive learning (Yacobson et al., 2021). Strengthening teacher agency through targeted professional development is therefore essential to bridging these gaps and enabling effective AI-driven pedagogy (Khan, 2025).

The study proposes a systemic transformation that encompasses the establishment of Professional Learning Communities (PLCs) to facilitate ongoing professional development and enable teachers to evolve from mere "operators" of technology to informed "analysts" of student data (Wahidmurni et al., 2024). Investment in educational infrastructure will significantly enhance the feasibility and sustainability of integrating deep learning curricula (Yokus, 2025). It is also necessary to conduct teacher training in maximizing the benefits of learning analytics (Roffi et al., 2020).

The findings of this study highlight the complexity of implementing deep learning in a diverse and rapidly evolving technological context. As the Merdeka Curriculum is updated to meet contemporary demands, strong infrastructure and teacher readiness are increasingly critical (Djazilan et al., 2024; Rissi & Sinaga, 2025). Effective AI integration depends not only on technological sophistication but also on systemic support that enables educators to use these tools effectively (Fudalan, 2025). Without addressing these foundations, deep learning risks remaining a temporary trend rather than a transformative strategy.

The implementation of Deep Learning is context-dependent. Based on the data of this study, without addressing the 'Digital Divide' inherent in developing contexts like Indonesia, even the most sophisticated pedagogical models (like

OIDDI) might become unsustainable. Thus, infrastructural readiness is a prerequisite for pedagogical transformation in this specific educational landscape.

CONCLUSIONS

The integration of Deep Learning (DL) into the Arabic language curriculum at MTs and MA Mambaus Sholihin Gresik is beyond a technological upgrade; it represents a pedagogical shift towards Data-Driven Constructivism. By implementing the OIDDI (Orientation, Identification, Discussion, Decision, and Implementation) framework, this study shows that adaptive algorithms significantly enhance contextual language mastery and learning engagement. The findings also provide empirical support for Self-Determination Theory, confirming that personalized, non-judgmental feedback from the DL system fosters students' intrinsic motivation by satisfying their psychological needs for autonomy and competence. The sustainability of this model in Pesantren and Islamic schools depends on teacher agency and infrastructure readiness. Limited digital literacy and unreliable technological access exacerbate the digital divide, threatening equitable implementation. Technology should therefore support, rather than replace, traditional values and align with institutional cultural identity. Future implementation should prioritize human capital development through Professional Learning Communities over hardware investment alone. Further research should assess the model's scalability and examine the long-term relationship between algorithmic adaptability and student linguistic retention to ensure inclusive, ethical, and sustainable modernization of Arabic education.

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