

Neurologically Compatible Digital Resources: Developing a Brain-Based Learning E-Book for an Introductory Nahw Course

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ABSTRACT

This research aims to develop an introductory Arabic syntax (nahw) textbook integrating the Brain-Based Learning (BBL) approach and educational technology principles to enhance students' syntactic competence and learning motivation in the Arabic Language Education Department at State Islamic University of Kiai Ageng Muhammad Besari, Ponorogo. Employing the Research and Development (R&D) methodology through the ADDIE model, data were collected using interviews, questionnaires, observations, and pre-/post-tests. Expert validation from material, media, and linguistics specialists confirmed that the textbook meets high-quality standards in content accuracy, visual layout, and cognitive-technological design. During implementation, classroom observations and assessments demonstrated significant improvements in students' understanding of basic syntax, practical rule application, and active participation. Statistical analysis using a paired-samples t-test indicated a significant improvement in the experimental group's scores from pre-test ($M = 54,70$, $SD = 14,125$) to post-test ($M = 78,43$, $SD = 11,026$). Furthermore, an independent samples t-test revealed that the experimental group significantly outperformed the control group ($p = 0,023 < 0,05$). These empirical learning gains were supported by positive student feedback regarding the textbook's readability and presentation. The evaluation confirms that blending BBL with modern educational technology tools successfully fosters neurologically compatible, interactive, and meaningful learning experiences. Consequently, the developed textbook is highly feasible, effective, and suitable as an innovative learning resource for undergraduate syntax instruction, serving as an essential reference for future digital textbook development.

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1. INTRODUCTION

Arabic is one of the significant languages in Indonesia, particularly for students in university Arabic language education departments, given its close connection to the historical arrival of Islam in Indonesia (Arifin & Sukandar, 2021). It is also the language of the Holy Qur'an and of Islamic sciences such as fiqh and ethics (Subhan Hi Ali Dodego, 2022), which has made learning Arabic a necessity within educational institutions (Salida & Zulpina, 2023). Yet the reality of teaching this language faces numerous obstacles, since it is not a compulsory subject for all students, this results in weakens motivation and complicates students' grasp of basic language skills.

One of the most important aspects of learning Arabic is the science of nahw (syntax), which examines the relationships and structures within sentences and governs the final vowel markings of words according to their grammatical position (M. Imam Fakhurrozy, 2018). Nahw serves as the fundamental tool for correcting speech and guarding it against error, it is considered the core of grammatical studies, integrated with morphology, for the creation of correct and sound expressions (Sudrajat, 2021). In its technical sense, nahw is confined to determining a word's final vowel marking whether inflected (i'rab) or fixed (bina') based on its position within the sentence (Mualif, 2019). This discipline rests on four principal sources relied upon by grammarians: sama'/naql, meaning oral transmission from the Qur'an, the Sunnah, and the eloquent speech of the Arabs (2002, محمود أحمد نخلة); ijma', the consensus of grammarians (Rizal dkk., 2021); qiyas, the analogical construction of new structures (Pabbajah dkk., 2024); and istishab, the retention of a prior ruling in the absence of evidence to the contrary (Neldi Harianto, 71-88). The study of nahw aims to equip students with the rules needed to avoid linguistic error while cultivating critical thinking and the ability to assess linguistic performance; it is likewise an indispensable tool for understanding the religious texts on which Islam is founded (2002, محمود أحمد نخلة).

Field observations conducted in the Arabic Language Education Department at State Islamic University of Kiai Ageng Muhammad Besari Ponorogo indicate that students struggle to grasp nahw material, a difficulty rooted in traditional teaching methods and a scarcity of instructional resources suited to how the brain actually functions. Compounding this, no dedicated e-book exists for introductory nahw, further heightening students' cognitive fragmentation.

Within the context of educational innovation, brain-based learning has emerged as a holistic, student-centered approach in which course design, activities, and varied learning stimuli are structured to engage students' multiple intelligences with the learning material (Lagoudakis dkk., 2022). This theory stands among the contemporary educational strategies grounded in how the brain naturally functions during learning; it holds that optimal cognitive performance arises from a comfortable, stimulating learning environment, and that the brain processes information in parallel, integrating both rational and creative functions. Brain-based learning emphasizes all parts of the brain, with the right and left hemispheres functioning according to their respective specializations (Funa dkk., 2024). The approach rests on the premise that the brain functions as a parallel processor, carrying out cognitive and creative operations that are integrated simultaneously rather than in a linear sequence (El-Wakeel dkk., 2023). Because both hemispheres participate in the process, learning can combine logical and creative functions at once (Harerimana Jean Paul, 2019).

Research suggests that applying the principles of this approach boosts motivation, activates memory, sharpens creative thinking, and improves learning outcomes; the model also strengthens learners' capacity for critical thinking and problem-solving (Lusiana & Andari, 2020). Other studies note that brain-based learning helps direct students toward using whichever part of the brain suits the material they are studying, allowing them to draw on their cognitive capacity to its fullest in grasping new concepts (Amjad dkk., 2023). In addition, the freedom to construct their own knowledge as they learn keeps students engaged and makes learning enjoyable for them. This type of learning remains effective because it is designed to align with students' natural tendencies and the brain's optimal functioning (Yatim dkk., 2022). Brain-based learning can also harness brain performance by

incorporating interactive digital media, sparking innovative and engaging learning experiences (Yolanda dkk., 2024).

Prior studies on the brain-based learning model span a range of fields, yet a systematic comparison among them reveals a clear research gap. Ardila Putri and colleagues (2019), for instance, conducted a qualitative descriptive study on students' mathematical creative thinking through brain-based learning, finding that the model helped develop creative thinking skills in mathematics, particularly in fluency and flexibility, though the study was limited to examining the model itself without developing any supporting instructional material (Putri dkk., 2019). Ratih Kusumawardani (2017) took an action-research approach in a study on boosting creativity through brain-based learning, showing that average creativity scores rose from 11.61% in the initial test to 48.21% by the second cycle after the model's seven stages were applied, indicating the approach's success in enhancing creativity (Kusumawardani, 2017). Along similar lines, Ana Fauzi (2020) presented action research on improving thematic learning outcomes using the brain-based learning model in fourth grade at SDN 17 Bonjo Alam Ampek Angkek, demonstrating that students' average scores climbed from 82% to 97% following the model's implementation (Ana Fauzi & Yalvema Miaz, 2020). The research gap lies in the scarcity of e-books devoted to Arabic grammar rules that are specifically designed around the functions of both brain hemispheres. Most existing educational e-books fail to balance the left hemisphere's role in analysis, logic, and grammatical rules with the right hemisphere's role in visual perception, color, and creative engagement (Scull, 2010).

This theory is grounded in principles of cognitive neuroscience, which show that the left hemisphere specializes in logic, analysis, and language, while the right handles rhythm, imagination, and color. This necessitates the design of educational materials that engage both hemispheres of the brain and create an enjoyable, stress-free learning environment (Afib Rulyansah, 2017). Psycholinguistic research on the nervous system confirms that one factor behind students' weak language ability lies in the condition of their brains (Zainal Hamdy, 2021). It therefore becomes essential to prime students' brains by embedding brain-based learning principles into the e-book itself. The literature likewise points to the importance of incorporating the seven stages of brain-based learning within the e-book preparation, acquisition, elaboration, incubation, and others (Eric Jensen, 2008). Researchers have mapped these explicitly onto the features and presentation of the e-book they developed, as follows: the pre-exposure stage, realized through a concept map presented at the start of study to give the brain an overview and preliminary structural framework; the preparation stage, achieved by presenting learning objectives to spark students' curiosity; the initiation and acquisition stage, realized through embedded instructional videos and illustrative examples from the material, allowing the brain to take in information; the elaboration/deepening stage, realized by presenting the core material as text followed by practice exercises built on conventional questions, aimed at stimulating logical and analytical thinking; the incubation and internalization stage, achieved by setting aside space for supplementary notes, giving students time to summarize the rules in their own words; the verification and confirmation stage, realized through digital game-based exercises and a self-assessment section that gives students immediate feedback; and the celebration and integration stage, realized by incorporating visual rewards and positive reinforcement immediately upon completing the learning games and self-assessment.

Given recent developments, the current research trend points to a needed shift away from reliance on traditional printed books toward electronic ones. Traditional books tend toward rigidity, generally stimulating only a single sense through passive visual reception of text, which limits engagement of the brain's various regions. E-books, by contrast, stand out as the instructional medium most neurologically compatible with how the brain works, owing to their exceptional capacity to provide multisensory stimulation (Ronca dkk., 2025). This is achieved by integrating interactive media such as embedded instructional videos, audio, and concept maps.

From a neuroscience perspective, this simultaneous stimulation of the brain's visual and auditory cortices forges stronger, more durable neural connections, which in turn enhances long-term retention of information (Bali dkk., 2023). The importance of this approach is particularly evident in the study of

“grammar,” which involves abstract rules and structures; in this context, embedded videos and interactive digital elements help transform these abstract concepts into concrete sensory images that the brain can easily process and comprehend.

Despite the considerable academic attention brain-based learning has drawn within educational contexts, most studies have concentrated on the model's frameworks, methods, and strategies, without delving into the development of actual instructional materials, particularly textbooks built on this model for introductory nahw. The e-book nonetheless plays a fundamental role: it is the student's own book and a supporting resource authored by experts to achieve specific learning objectives, encompassing the knowledge to be acquired, the objectives, content, exercises, strategies, and self-tests (Mukarromah, 2020). Given its importance, producing a strong e-book (particularly one for Arabic as a foreign language) demands adherence to rigorous standards (Aflisia & Hazuar, 2020). These include matching the difficulty of the material and language to the target age group, using standard Arabic exclusively, applying the principles of staged learning, presenting vocabulary and structures systematically, integrating all language elements and skills (listening, speaking, reading, writing) in a unified way, and attending to appealing design, sufficient practice exercises and formative assessments, and support for lecturers in preparing lesson plans (الفوزان, 2010).

These considerations lend the present study both theoretical and practical significance, offering supportive instructional material that helps students grasp grammatical concepts in a way aligned with how the brain works, while equipping lecturers with a tool that lets them deliver the material effectively and engagingly. Its significance lies further in presenting an educational innovation that helps close the gaps between grammatical theory and classroom practice, and between curricular ideals and the realities of learning, serving as a scholarly response to students' need for a clear, graduated, and enjoyable e-book that supports the accumulation of grammatical knowledge and sharpens their thinking skills.

On this basis, the study pursues two objectives: 1) to identify the specifications for producing an introductory nahw textbook grounded in brain-based learning for students in the Arabic Language Education Department at State Islamic University of Kiai Ageng Muhammad Besari Ponorogo; and 2) to determine how effective this instructional product is in improving the process of learning nahw among students at the university level. In doing so, the study seeks to contribute to raising the quality of Arabic language education and to offer a developmental model that similar institutions could adopt, an educational investment attentive to the nature of human learning and to how the brain actually works.

2. METHODS

This study draws on a Research and Development (R&D) approach using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The model aims to produce an introductory nahw textbook grounded in brain-based learning principles, easing students' comprehension and reducing the learning difficulties that stem from traditional teaching methods and a shortage of suitable textbooks.

The study was conducted in the field within the Arabic Language Education Department at State Islamic University of Kiai Ageng Muhammad Besari Ponorogo, carried out on a coherent timeline over the first semester of the 2025–2026 academic year. The study population comprised all first-level students in the 2025–2026 academic year enrolled in the introductory nahw course. The sample was selected purposively and consisted of two groups: Class "A" as the experimental group, taught using the developed e-book, and Class "B" as the control group, taught with the conventional textbook. To safeguard the integrity of the experiment, the homogeneity and comparability of both groups were verified before treatment through a standardized pretest, confirming the absence of any statistically significant difference between the two classes before the study. The research centers on developing an e-book fit for use in light of the learning objectives and on determining its effectiveness in improving grammatical understanding.

The researchers relied on several data-collection instruments: interviews with the course lecturer to gather preliminary information; an open-ended questionnaire to analyze student needs; closed questionnaires for experts and students to gauge the textbook's validity; an observation sheet to monitor classroom implementation; pre- and post-tests to measure comprehension before and after using the textbook; and official documents such as the curriculum, lesson plan, and examinations.

Data were analyzed through two approaches: qualitative analysis, through describing the textbook's components and interpreting the feedback of experts and students during the trial, and quantitative analysis, using statistical processing in SPSS through independent-samples and paired-samples t-tests to measure the significance of differences between means within a single group and between the control and experimental groups applying percentage benchmarks to judge the product's validity according to success levels (85–100% excellent, 70–84% very good, 50–69% good, 0–49% acceptable).

It is hoped, accordingly, that this methodology will help establish the textbook's validity and effectiveness and clarify how brain-based learning principles influence improved nahw learning outcomes among first-level students.

3. FINDINGS AND DISCUSSION

Needs Analysis Stage

Table 1.1 Needs Analysis Results

No	Aspect Analyzed	Analysing Results
1	Teaching Proses	The teaching process relies on a traditional, descriptive method built on rote memorization.
		Interactive activities are absent.
		Students struggle with sentence construction and applying i'rab (grammatical inflection) when using the <i>Jami' al-Durus al-'Arabiyyah</i> textbook.
2	Learning Material/Resources	Students rely on <i>Jami' al-Durus al-'Arabiyyah</i> , a textbook marked by an abundance of information presented without systematic organization.
		The material lacks summaries and does not account for beginner-level learners.
		The explanatory style is dense and descriptive, difficult to grasp without supporting resources.
		Examples drawn heavily from original texts and Qur'anic verses lack contextual explanation, and no readily accessible supplementary materials are provided in the index.
3	Instructional Media	The textbook lacks visual aids.
		Supporting media are absent.
		No summaries or visual/audio activities are included.

The results of this initial development stage revealed that the central problem students face in the introductory nahw course is difficulty understanding classical grammar textbooks such as *Jami' al-Durus al-'Arabiyyah*, owing to their density of information and scarcity of illustrative aids, compounded by a heavily descriptive style that offers little practical application. An interview with the Head of the Arabic Language Education Department, Ika Rusdiana, M.Pd., conducted on 22 June 2025, confirmed that this textbook fails to fully serve the goal of building language competence, since it confines itself to theoretical explanation and weakens motivation through the absence of functional exercises. The lecturer also faces several challenges, including a lack of systematic organization of the content, overly detailed explanations, and the need for supplementary resources to facilitate understanding. These difficulties intensify among beginner students in a rural setting poorly matched to the linguistic context

of authentic Arabic texts. Observations further showed that presenting material in a linear, non-interactive manner contributes to poor information retention, higher absenteeism, and students falling short of the minimum passing score (70) on the midterm exam.

Questionnaire data collected from 28 students in Class "A" corroborate these challenges: 20 of them reported difficulty understanding grammatical material, citing issues such as overly lengthy explanations, a lack of summaries, difficult language, absent illustrations, weak vocabulary, and trouble locating supplementary material within the index. Twenty-three students felt the textbook does not adequately support the development of language skills and expressed a need for functional exercises to strengthen the practical application of grammar rules. Meanwhile, 27 students indicated familiarity with concept maps, and all students agreed that such maps would be a useful summarizing tool to ease comprehension, signaling strong readiness to embrace modern instructional media. These findings point clearly to a pressing educational need for a grammar textbook that presents material through a simplified visual style, respects cognitive progression, and strengthens motivation and engagement, in keeping with the principles of brain-based learning.

Design Stage

The design of the textbook *al-Qawa'id al-'Arabiyyah li-Maddat al-Nahw al-Awwal* (Arabic Grammar Rules for Introductory Syntax) followed a scientific methodology grounded in the needs analysis findings, which had revealed students' difficulty grasping grammar rules through *Jami' al-Durus al-'Arabiyyah*, necessitating the development of an alternative educational product based on the principles of brain-based learning. The scholarly material was drawn from authoritative grammatical sources, with *Jami' al-Durus* serving as the primary reference to preserve the authenticity of each grammatical rule, supplemented by classical and modern references such as al-'Imrithi, *Matn al-Ajurrumiyyah*, and al-Alfiyyah to deepen understanding and broaden the explanations. Content was designed by converting text into visual formats (such as concept maps and color-coded tables) that make grammatical functions easier to grasp, alongside rephrasing explanations in simplified, graduated language attentive to the sequence of students' cognitive reasoning. The textbook was further enriched with instructional videos to support auditory and visual processing, and a range of exercises was incorporated, including multiple-choice, fill-in-the-blank, and sentence analysis, along with individual and group activities to encourage collaborative learning. Content was reinforced with appendices comprising self-assessment sheets and questionnaires, giving the textbook an integrated structure capable of addressing beginner-level students' weaknesses in mastering grammar rules.

Development Stage

At this stage, two experts took part in validating the textbook's design, selected for their expertise in two complementary domains: e-book design and the accuracy of linguistic content. The outcomes of this validation appear in the table below:

Table 1.2 Design Validation Results

Expert	Score
Instructional Book Design Expert	95,4%
Instructional Book Content Expert	78,5%

Based on these expert questionnaire results, the *al-Qawa'id al-'Arabiyyah* textbook for introductory nahw, developed on brain-based learning principles, proved suitable for implementation among students at the State Islamic University of Ponorogo, requiring only minor revision and correction. At this stage the researchers also administered a questionnaire to trial students' responses in a small-group test. The percentage results of this small-group trial appear in the following table.

Table 1.3 Questionnaire Results at the Development Stage

Domain	Results
Instructional Book Design	93%
Instructional Book Content	92%

Based on the table above, the researchers observed that the developed textbook is capable of resolving students' difficulties in learning nahw and is well-suited to the needs of first-level students. These students need a textbook that presents information clearly and systematically through concept maps and color-coded tables to ease understanding and boost motivation and enthusiasm for learning, while offering relevant examples and exercises that deepen grammatical comprehension so that they no longer struggle with learning nahw or with sentence construction when practicing their speaking or writing skills.

Implementation Stage

A field trial of the textbook was conducted with students at State Islamic University of Kiai Ageng Muhammad Besari Ponorogo. The trial involved 58 students divided into two groups: a control group of 28 students and an experimental group of 30 students. The pretest and posttest results for both groups are as follows.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretesteksperimen	54.70	30	14.125	2.579
	Posttesteksperimen	78.43	30	11.026	2.013
Pair 2	Pretestkontrol	53.96	28	19.296	3.647
	Posttestkontrol	70.71	28	13.960	2.638

Based on the table above, the experimental group numbered 30 students and the control group 28 students. The experimental group's mean score rose from 54.70 on the pretest to 78.43 on the posttest, while the control group's mean rose from 53.96 to 70.71. These figures point to a difference between the control and experimental groups' averages. To test this difference for statistical significance, an independent-samples t-test was run, with the results (Sig.) presented below.

Independent Samples Test									
		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower Upper

Nilai	Equal variances assumed	1.025	.316	- 2.345	56	.023	-7.719	3.292	- 14.313	-1.125
	Equal variances not assumed			- 2.326	51.377	.024	-7.719	3.318	- 14.380	-1.058

The researchers found a significance value of $p = 0.023 < 0.05$, falling below the threshold, so H_0 is rejected and H_1 accepted. This confirms a statistically significant difference in learning outcomes between the experimental and control groups, favoring the experimental group. To gauge the textbook's practical effectiveness further, effect size was calculated using Cohen's d , yielding a value of 0.62 indicating a "medium" effect. This provides statistical confirmation that the interactive e-book *al-Qawa'id al-'Arabiyyah li-Maddat al-Nahw al-Awwal* is effective in improving student outcomes.

The marked rise in the experimental group's scores can be explained through the principles of brain-based learning. Presenting material through the e-book's concept maps directly stimulated the visual cortex in students' brains. This visual stimulation helped the brain process abstract grammatical rules, converting them into organized, tangible visual structures (Gkintoni dkk., 2025). As a result, memory-related neural connections were strengthened, cognitive disruption was reduced, and information retrieval during testing became easier, accounting for the experimental group's clear edge in grammatical comprehension and mastery.

Evaluation Stage

At the evaluation stage, the results of this limited trial showed that the textbook developed for introductory nahw on the basis of brain-based learning holds a high degree of quality and instructional suitability. Field observations and the student questionnaire revealed that the textbook's content is easy to understand and organized in a way that facilitates the gradual learning of nahw, while its design stands out for its appeal and its integration of visual media and illustrative tables. To reinforce these field observations, the researchers distributed a practical questionnaire to the students who took part in the trial, aiming to assess the textbook from their direct point of view. The questionnaire results were as follows:

Table 1.4 Questionnaire Results at the Evaluation Stage

Domain	Results
Instructional Book Design	83,9%
Instructional Book Content	85,4%

The overall average of student evaluations reached 84.9%, placing the textbook in the "good and scientifically applicable" category, with a few minor points that could still be refined in the content structure. Students also displayed clear, positive engagement with the varied activities that stimulated multiple senses and helped raise their motivation to learn nahw, confirming the effectiveness of a design grounded in brain-based learning principles in supporting gradual comprehension and developing grammatical thinking skills.

4. CONCLUSION

This study concludes that the *al-Qawa'id al-'Arabiyyah li-Maddat al-Nahw al-Awwal* textbook, developed based on brain-based learning, stands as a formal instructional resource directed at students in the Arabic Language Education Department at State Islamic University of Kiai Ageng Muhammad Besari Ponorogo, designed to enable them to understand and apply correct Arabic grammatical structures in both speech and writing. The textbook is distinguished by an instructional structure that unites grammatical authenticity drawn from *Jami' al-Durus al-'Arabiyyah* and other traditional references with modern design through concept maps and color-coded tables that ease the mastery of grammar rules. It also incorporates varied exercises that account for individual differences and different student levels, making it flexible and suitable for use across various educational stages. Statistical analysis showed a significance value of $p = 0.023 < 0.05$, below the significance threshold, indicating that using this textbook to teach introductory nahw effectively improves students' proficiency and understanding of grammar rules. It can therefore be said that this textbook makes a clear contribution to providing a grammatical learning environment that is stimulating and aligned with how the brain works, strengthening motivation and comprehension among university-level Arabic students.

The findings of this study carry broad theoretical and practical implications. Theoretically, the study enriches the literature on educational neuroscience by offering empirical insight into how the human brain processes Arabic grammar rules, affirming that combining visual and multisensory stimulation eases the comprehension of abstract grammatical structures. Practically, the study puts forward an innovative methodological framework that digital Arabic-language curricula worldwide could adopt, integrating the stages of brain-based learning with educational technology to develop interactive e-books offering an international standard for designing neurologically compatible digital resources to serve Arabic-language students everywhere.

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