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The Effectiveness of an AI-Supported Neurolinguistic Strategy in Developing Functional Vocabulary and Reducing Digital Fatigue Among Non-Native Learners of Arabic

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ABSTRACT
When teaching Arabic to speakers of other languages, novice learners face challenges in acquiring practical vocabulary and in dealing with pressures associated with digital learning environments. Therefore, this study aimed to examine the effectiveness of an AI-supported neurolinguistic approach in enhancing functional vocabulary and decreasing digital fatigue among these learners. The research employed a quasi-experimental design involving two groups of learners: an experimental group and a control group, each comprising 30 learners. The strategy incorporated elements of multi-sensory contextual learning, mental activation through auditory and visual stimuli, collaborative communicative tasks, and immediate feedback via ChatGPT integrated into Google Sites. Data were collected and analyzed to compare the performance of both groups across all dimensions of functional vocabulary, including recognition, comprehension, and production, as well as levels of digital fatigue (physical, cognitive, emotional, and social-sensory). The results showed that learners in the experimental group significantly outperformed the control group in all aspects of functional vocabulary while experiencing less digital fatigue. These findings show that integrating neurolinguistic principles with AI-supported interactive learning to develop functional vocabulary and enhance learner motivation within digital contexts. Based on these results, we recommend incorporating AI-supported neurolinguistic strategies into Arabic language teaching for non-native speakers to create more effective and supportive learning environments.

KEYWORDS
Strategy; interactive digital environment; AI-supported learning; functional vocabulary; digital fatigue; Arabic for non-native speakers.

INTRODUCTION

Functional vocabulary is essential for second-language acquisition, particularly for novice-level non-native learners of Arabic. It represents the primary entry point for communication in daily situations, enabling learners to express their basic needs and interact in practical life scenarios such as greeting, shopping, and requesting basic information (Ahmed, 2019; Nation, 2022; Schmitt & Schmitt, 2020). These vocabulary items are characterized by clarity, brevity, frequency, and ease of integration into practical contexts, which facilitates their retrieval and effective use (Abdel-Azim, 2019). Despite their importance, functional vocabulary poses challenges in understanding, memory, and language production, especially without progression and structured contextual repetition (Mohamed & Mousa, 2024). Therefore, researchers recommend selecting vocabulary based on specific criteria, including frequency of use, ease of pronunciation, relevance to practical contexts, and the importance of gradual learning from simple to complex. This should be combined with sensory and cognitive representation using images, sounds, and movements to enhance retention and reduce learning fatigue (Abu Aida & Oukbar, 2025). Among modern trends that can advance the field of vocabulary instruction is the Neurolinguistic Theory, which links brain functions to language acquisition. It posits that effective learning occurs when vocabulary and structures are presented through audiovisual input that mimics mother-tongue acquisition, relying on contextual repetition and interactive practice rather than rote memorization. Studies have shown that integrating neural principles into the design of language activities enhances long-term memory and reduces anxiety, particularly at the beginner level (Lightbown & Spada, 2021; Oxford, 2016).

The Neurolinguistic Theory is based on the premise that language is a neurocognitive process linked to brain function and perceptual mechanisms. It suggests that learning takes place through sensory representation via visual, auditory, and kinesthetic patterns, and that linguistic behavior can be reshaped through programming techniques such as modeling and reframing (Lashkarian & Sayadian, 2015; Purnama et al., 2023; Vedaschi Ozzola, 2025). Consequently, the practical applications of such a theory in the proposed strategy demonstrate a strong capacity to enhance sensory and emotional interaction, presenting vocabulary in realistic life situations through organized repetition, thereby contributing to the development of solid communicative competence among non-native Arabic learners.

Based on the principles mentioned earlier, an instructional approach rooted in Neurolinguistic Theory was created and named "Contextual Neuro-Learning of Vocabulary." This approach includes the following steps: brain priming, natural contextual input, repeated contextual exposure, sensory and emotional engagement, group interaction, and an emphasis on meaning over form. It aims to help non-native Arabic learners at the novice (A) level, focusing on practical vocabulary for everyday communication.

With rapid digital progress, teaching functional vocabulary extends beyond traditional classrooms. It now heavily depends on intelligent electronic environments powered by Artificial Intelligence (AI) tools, providing vast possibilities for customization, interaction, instant

feedback, and greater learner independence (Alshahrani & Qureshi, 2024; Holmes et al., 2021; Makeleni et al., 2023; Zawacki-Richter et al., 2019). From the perspective of Neurolinguistic Theory, these applications can be strategically employed to promote sensory and contextual learning, as ChatGPT enables the delivery of linguistic input within authentic contexts, with systematic, incremental repetition that engages learners' visual, auditory, and kinesthetic channels. Furthermore, ChatGPT can generate diverse linguistic examples, provide instant feedback, track learner progress, and support self-directed learning through ongoing clarification and realistic scenario simulations. This approach operationalizes the core principles of Neurolinguistic Theory to boost vocabulary retention, decrease learner anxiety, and enhance communicative fluency among non-native Arabic learners. (Costa et al., 2024; Elbanna & Armstrong, 2024; Fırat, 2023; Mogavi et al., 2023). Furthermore, studies have demonstrated that integrating platforms such as Google Sites with ChatGPT's intelligent conversational capabilities creates a flexible and interactive learning environment, facilitating personalized education adapted to learners' needs at any time and place, while maintaining repetitive practice and sensory-emotional engagement, in line with the principles of Neurolinguistic Theory (Al-Maroof et al., 2024; Alshahrani & Qureshi, 2024).

While educational technology offers advantages, it also introduces digital fatigue. It arises from cognitive load, multitasking, emotional pressure, and weak sensory and social interaction (Khalil & Said, 2023; Nazir, 2023). With increasing reliance on electronic media, it has become necessary to study this type of fatigue and understand its effects on language acquisition. Digital fatigue is defined as a feeling of physical and psychological exhaustion resulting from excessive use of digital environments, which may lead to poor concentration, reduced social interaction, and decreased learning efficiency (Argyriadi et al., 2025).

The research relies on multiple theoretical frameworks to understand this phenomenon and mitigate its effects, most notably the Limited Capacity Theory, which explains the limits of the mind's ability to process information, and Self-Determination Theory (SDT), which identifies three basic psychological needs for learners: competence, autonomy, and relatedness. These frameworks emphasize the importance of reducing digital fatigue to enhance motivation and achieve effective and sustainable learning (Deci & Ryan, 2000; Khalil & Said, 2023; Masrahi, 2023; Ryan & Deci, 2017; Sibanda, 2023).

Consequently, this research addresses digital fatigue across four main dimensions: physical exhaustion from intensive use, cognitive load from multitasking, emotional pressure, and weakened sensory and social interaction. This helps guide the design of the proposed strategy to enhance language learning while reducing the negative impacts of digital fatigue.

Therefore, it is clear that combining a strategy based on Neurolinguistic Theory with an AI-supported electronic environment to teach functional vocabulary—while reducing digital fatigue—may be a promising approach to teaching Arabic to non-native speakers. However, Neurolinguistic Programming (NLP) has faced criticisms and debate in the field of second language acquisition, particularly regarding the generalizability and empirical validation of its

techniques. Therefore, the effectiveness of this integration and its contribution to improving functional vocabulary acquisition need organized scientific research to test these hypotheses empirically, while considering the theoretical limitations of NLP. As a result, the research problem is clearly defined.

Research Problem

Despite rapid advancements in teaching Arabic to speakers of other languages, functional vocabulary—which is the main entry point for communication, is often taught using traditional methods that focus on memorization or translation. This approach impairs long-term retention and limits learners' ability to apply vocabulary in real-life situations. Furthermore, many electronic learning environments do not fully utilize the principles of Neurolinguistic Theory, which provides a scientific understanding of language acquisition mechanisms and enhances the Neuro-linguistic connection among learners. Given this issue, another challenge arises: digital fatigue caused by excessive use of educational applications. This calls for the creation of integrated digital learning environments that balance neural stimulation with reducing mental strain, thereby boosting learner motivation and maintaining ongoing engagement. Therefore, the current research aims to examine the effectiveness of an instructional strategy based on Neurolinguistic Theory and supported by Artificial Intelligence in helping novice-level non-native learners of Arabic develop functional vocabulary and reduce digital fatigue.

Research Questions

1. What is the functional vocabulary required for non-native Arabic learners at the novice level (A) from the perspective of experts and specialists?
2. What are the indicators for reducing digital fatigue associated with the e-learning process required for non-native Arabic learners at the novice level (A) from the perspective of experts and specialists?
3. What is the effectiveness of a strategy based on Neurolinguistic Theory within an electronic environment supported by AI applications in developing functional vocabulary among non-native learners of Arabic at the novice level (A)?
4. What is the effectiveness of a strategy based on Neurolinguistic Theory within an electronic environment supported by AI applications in reducing levels of digital fatigue associated with the e-learning process among non-native learners of Arabic at the novice level (A)?

Research Hypotheses

The research proceeded from the following hypotheses:

1. There is no statistically significant difference at the .05 level between the mean scores of the experimental and control groups on the post-test of the Functional Vocabulary Test.
2. There is no statistically significant difference at the .05 level between the mean scores of the experimental and control groups after administering the Digital Fatigue Reduction Scale.

Research Objectives

The current research sought to achieve a set of main objectives, as follows:

1. Developing an instructional strategy based on the principles of Neurolinguistic Theory, specifically designed to teach functional vocabulary to novice non-native Arabic learners.
2. Using an electronic environment supported by AI tools to present functional vocabulary in natural interactive contexts, thereby strengthening its retention in long-term memory and boosting its usefulness in real-life situations.
3. Assessing the effectiveness of the strategy based on Neurolinguistic Theory principles in developing functional vocabulary and reducing digital fatigue among novice non-native Arabic learners.
4. Providing a practical framework for developing innovative teaching strategies that apply brain-based learning principles in smart electronic environments.
5. Offering applicable models for teachers of Arabic to non-native speakers, as well as researchers, to design interactive activities that help develop learners' functional vocabulary.
6. Providing practical evidence for policymakers and curriculum developers in the field of Arabic as a second language on how to balance the use of digital technologies with reducing learners' cognitive fatigue.

METHOD

We adopted a two-group experimental design (experimental and control) to verify the research objectives, a design widely used in educational research to examine the effectiveness of instructional interventions (Creswell & Creswell, 2018). The study involved male participants aged between 13-16 years, from diverse linguistic and national backgrounds, all sharing the common goal of learning Arabic as a foreign language at the novice level (A). Participants were assigned to two groups: the experimental group studied functional vocabulary using the "Contextual Neuro-Learning" strategy in an AI-supported electronic environment. In contrast, the control group received instruction using the standard method. All participants possessed basic digital literacy skills, enabling them to interact effectively with the digital learning environment. The Functional Vocabulary Test and the Digital Fatigue Scale were used as primary research instruments and administered pre- and post-intervention to compare the two groups and to measure the impact of the proposed strategy.

Research Variables

In this study, the independent variable is the strategy based on the Neurolinguistic Theory within an AI-supported electronic environment. Conversely, the dependent variables include the development of functional vocabulary and the reduction of digital fatigue. The data collection tool was a questionnaire created to identify the functional vocabulary list. Meanwhile, the measurement tools comprised the Functional Vocabulary Test and the Digital Fatigue

Reduction Scale, both of which were used to systematically and accurately assess the impact of the proposed strategy on the dependent variables.

Data Tools

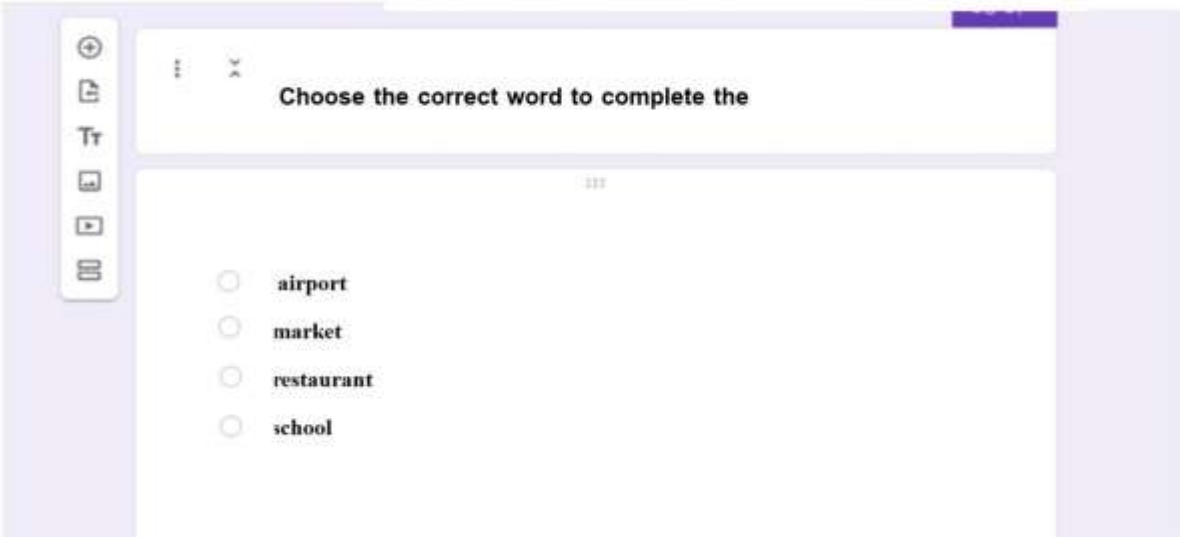
To address the research questions and determine whether to accept or reject its hypotheses, the following procedures were carried out. First, preparation and adjustment of research instruments were conducted, including the development of a questionnaire to identify the functional vocabulary list through several steps: defining the goal to create a list of functional vocabulary needed for non-native learners at the novice level (A) from the perspective of experts and specialists; designing the initial questionnaire, which covered 9 topics with 10 vocabulary items each, totaling 90 items; verifying validity by consulting experts in Arabic language and teaching methods to ensure the topics were comprehensive, the vocabulary suitable for novice learners, and relevant to the topics, followed by necessary adjustments; calculating reliability using the agreement coefficient (Abu Hatab et al., 2008), which reached .93; and reviewing expert feedback to finalize the list, resulting in a final set of 70 functional vocabulary items. Through these steps, the first research question was addressed: "What is the functional vocabulary required for non-native Arabic learners at the novice level (A) from the perspective of experts and specialists?"

Considering the overall and behavioral goals, as well as the cognitive content of the functional vocabulary, an achievement test was developed to be completed within the e-learning environment. The test underwent several stages, beginning with the definition of objectives to assess the acquisition of functional vocabulary among the target research sample. Next, a specification table was created, detailing the topics, the number of vocabulary items per topic, the number of questions, and their relative weights, divided into three levels: recognition (visual and auditory), comprehension (contextual and applied), and language production (Appendix 3). Clear instructions were provided to guide learners on the purpose and procedure for answering the test questions. Finally, the test items and scoring system were established, consisting of 30 questions divided into three sections: visual and auditory recognition, contextual comprehension and application, and language production. Each section had 10 questions; the first two sections featured multiple-choice questions, while the third included short-answer items. Each question was worth 1 point, for a total of 30 points.

We confirmed the test's validity through several steps. First, experts ensured face validity by reviewing in the Arabic language and teaching methods review the test for suitability, relevance to achievement levels, and clarity of instructions; the test was then revised based on their feedback and prepared for pilot testing. Second, content validity was verified with the table of specifications, which showed how questions were distributed across the three achievement levels for each topic. Lastly, the test was programmed electronically using Google Forms and integrated into the AI-supported learning environment, enabling automated responses and grading, as illustrated in the following figure.

Figure 1.

Designing and Programming the Test in the AI-Supported E-Learning Environment.



Source: compiled by the authors

A pilot test was conducted on a random sample of 20 non-native Arabic learners at the novice level (A) at the Sheik Zayed Center to calculate the difficulty, ease, and discrimination indices. The ease indices ranged from .50 to .70, the difficulty indices from .30 to .50, and the discrimination indices from .46 to .50, all of which are appropriate for the target level. The average response time was 40 minutes, which is suitable for the nature of the questions. The test reliability was also assessed using the split-half method, yielding a Spearman-Brown coefficient of .803 and Cronbach's alpha ranging from .744 to .779, indicating high reliability (see Table 1).

Table 1.

Reliability Coefficient of the Functional Vocabulary Test (Split-Half Method)

Test Items	Cronbach's Alpha	Adjusted Spearman-Brown Coefficient
Individual	.744	.803
Paired	.779	

Source: compiled by the authors

The internal consistency of the test was evaluated by calculating the correlation coefficients between the sub-dimensions and the total score, which ranged from .487 to .758 and were all statistically significant. This indicates high internal consistency and further supports the test's construct validity, as shown in the following table.

Table 2.

Correlation Coefficients of Test Dimensions with the Total Score

Dimensions	Visual & Auditory Recognition	Contextual Understanding & Usage	Language Production	Total Score

Visual & Auditory Recognition	–	.610**	*.487**	.694**
Contextual Understanding & Usage	.612**	–	.533**	.758**
Language Production	*.487**	.533**	–	.721**
Total Score	.694**	.758**	.721**	–

Source: compiled by the authors. Note. **Significant at .01; *Significant at .05

We prepared the final version of the test after completing all construction stages and verifying its validity and reliability, making it ready for administration to the research sample.

The Digital Fatigue Reduction Scale was created to measure digital fatigue among learners in an AI-supported learning environment and to track the effect of the Neurolinguistic Theory-based strategy in decreasing it. A table of specifications was developed, including four dimensions: Physical Comfort, Cognitive Comfort, Emotional Comfort, and Sensory/Social Interaction, each with two sub-dimensions and a set of indicators, resulting in a total of 20 items. The twenty items were drafted in short, clear phrases suitable for the digital learning environment and for novice non-native learners. The scale adopted a three-point Likert scoring system (Yes=3, Sometimes=2, No=1), with total scores ranging from 20 to 60 and three interpretation levels: Low (20–<34), Moderate (34–<47), and High (47–60). Content validity was verified by presenting the initial version to specialized arbitrators to ensure the suitability of items for the dimensions and their freedom from ambiguity, after which limited linguistic and scientific adjustments were made, making the scale ready for piloting.

Table 3.

Correlation Coefficients of Digital Fatigue Reduction Scale Dimensions with the Total Score

Scale Dimensions	**Physical Comfort**	**Cognitive Comfort**	**Emotional Comfort**	**Sensory & Social Interaction**	**Total Score**
Physical Comfort	–	**.564	*.431	**.502	**.672
Cognitive Comfort	**.564	–	**.598	**.623	**.741
Emotional Comfort	*.431	**.598	–	**.557	**.693
Sensory & Social Interaction	**.502	**.623	**.557	–	**.726
Total Score	**.672	**.741	**.693	**.726	–

Source: compiled by the authors

* Significant at .01 level

** Significant at .05 level

The scale was pilot-tested on 20 learners outside the main research sample to determine the response time, which averaged 20 minutes. The internal consistency of the scale was also

calculated, with correlation coefficients between the scale's dimensions and the total score ranging from .431 to .741, all statistically significant, indicating high internal consistency and supporting the scale's construct validity (see Table 3).

The reliability of the scale was calculated using the split-half method, with results showing a Spearman-Brown coefficient of .834 and Cronbach's Alpha ranging from .751 to .772, indicating high reliability (see Table 4).

Table 4.

Reliability Coefficient of the Digital Fatigue Reduction Scale (Split-Half Method)

Scale Items	Cronbach's Alpha	Adjusted Spearman-Brown
Odd Items	.751	.834
Even Items	.772	

Source: compiled by the authors

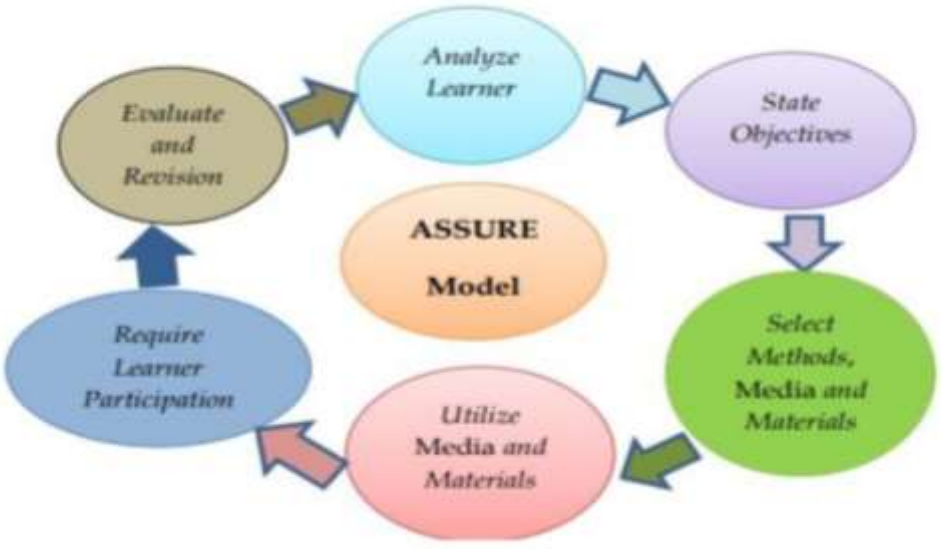
The final version of the scale was prepared after completing all validity and reliability procedures, making it ready for administration.

Construction and Design of the Experimental Treatment Material

The strategy, based on Neurolinguistic Theory, was designed using the ASSURE instructional design model, chosen for its suitability to the research variables and its effectiveness in planning educational activities and utilizing media in an AI-supported electronic environment.

Figure 2.

The Steps of the ASSURE Instructional Design Model (Heinich et al., 1996).



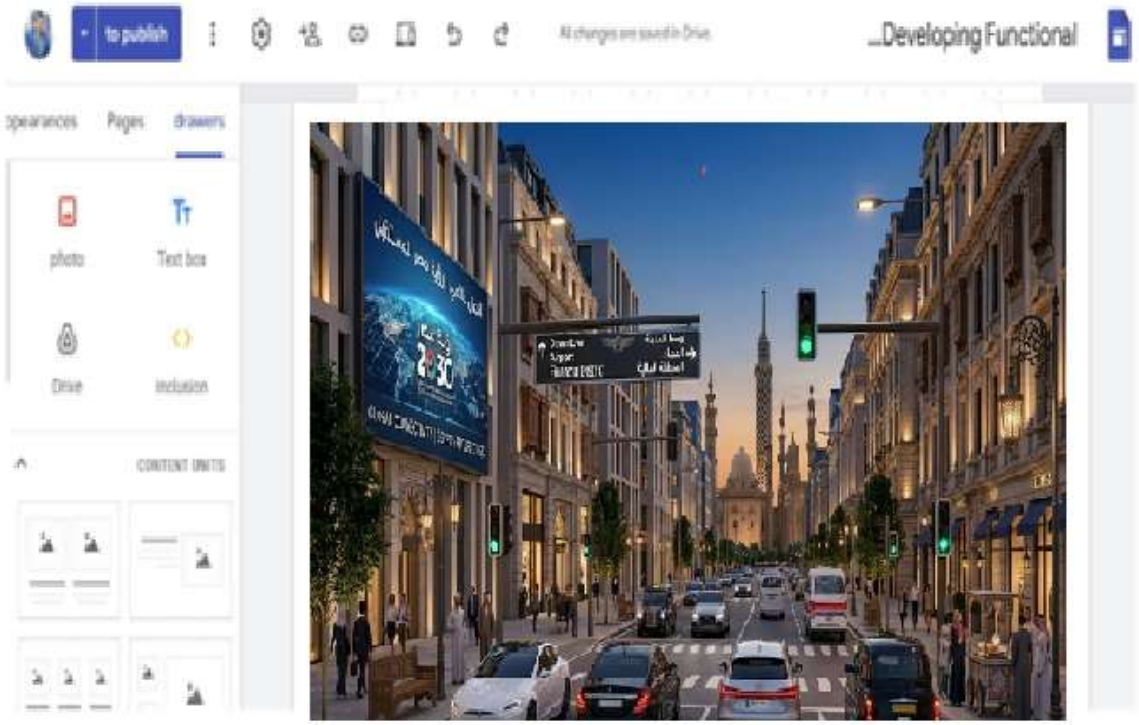
The stages of designing the experimental treatment material according to the ASSURE model were as follows: **Phase 1:** Analyze Learners, where the characteristics of non-native learners at the novice level (A) were identified in terms of age, cultural backgrounds, and linguistic needs, along with diagnosing the most prominent vocabulary learning difficulties they

face, such as weak structures, forgetfulness, and difficulty in recall. **Phase 2:** State Objectives, where general objectives aimed at developing functional vocabulary and reducing digital fatigue for novice learners (A) were established and formulated operationally in light of recognition, contextual comprehension, and linguistic production skills, and the content was distributed over seven thematic sessions after review by specialized arbitrators.

Phase Three: Designing Strategies, Materials, and Instructional Media included the following: The strategy based on Neurolinguistic Theory was titled "Contextual Neuro-Learning of Vocabulary" and relied on six steps: Brain Priming, Contextual Input, Repetition, Sensory Activation, Group Interaction, and Enhancing Meaning over Form. A set of videos, images, and situations appropriate for functional vocabulary was designed by preparing scripts for the videos and recording them in accordance with the research variables.

Figure 3.

Media and Educational Materials in the AI-supported E-learning Environment



Source: compiled by the authors

Phase Four: Utilizing Technology, Media, and Materials involved organizing digital content through an AI-supported e-learning environment designed in Google Sites, which includes interactive content for teaching Arabic to non-native learners at the novice level (A). It relies on ChatGPT to provide flexible, self-directed learning opportunities and to simulate real-life situations that support the acquisition and application of functional vocabulary. The environment also includes interactive activities such as multiple-choice, matching, and virtual situations, alongside diverse resources including images, sounds, videos, and intelligent conversation, with simplified instructions to ensure ease of access and use**.**

Phase Five (Learner Response and Participation) involved registering the experimental group members in the AI-supported e-learning environment after they were introduced to the user guide. They studied functional vocabulary using the ChatGPT tool and interactive media through activities such as vocal repetition, using vocabulary in virtual situations and in new sentences, alongside audio descriptions and collaborative work in short role-play dialogues.

Figure 4.

The Setup of the E-learning Environment according to the Neurolinguistic Theory-based Strategy

Source: compiled by the authors

Figure 5.

Learner Participation in Using ChatGPT within the E-learning Environment

Source: compiled by the authors

Phase Six: Evaluation and Revision involved assessing and improving the instructional process. The e-learning environment relied on a pre-assessment to measure learners' initial level, followed by formative assessment during sessions through short quizzes with immediate AI-supported feedback, and finally a post-assessment to measure growth in functional vocabulary and a reduction in digital fatigue. The analysis results and feedback were also used to conduct

continuous review and development of the content, with the measurement tools uploaded to the electronic environment.

Figure 6.

Adding Functional Vocabulary Test Questions via the Learning Environment

Source: compiled by the authors

Thus, the design and development of the strategy in the AI-supported e-learning environment were completed and made available via the link:

Figure 7.

The AI-supported E-learning Environment

Source: compiled by the authors

For pilot testing, we applied selected lessons to (10) learners at the novice level (A) to verify content clarity, suitability, and interaction with the electronic environment, and necessary adjustments were made before administering the lessons to the main sample.

Procedures of the Main Research Experiment

The main experiment aimed to reveal the impact of the independent variable on the dependent variables and included selecting sixty learners from the novice level (A) at the Sheik Zayed Center, distributed as (30) for the experimental group and (30) for the control group. To ensure group equivalence, the vocabulary test was administered beforehand via the electronic environment, and the t-test results indicated that the differences between the two groups were not statistically significant (t = .487, α = .05), demonstrating their equivalence (Table 5).

Table 5.

Results of the t-test to identify the Difference between the Experimental and Control Groups in the Functional Vocabulary Test

Group	N	Mean	SD	df	t	Significance (α=.05)
Experimental	30	16.8	3.2	58	.487	Not significant
Control	30	16.4	3.5			

Source: compiled by the authors

We ensured group equivalence through pre-measurement, where the scale was administered beforehand, and the t-test results showed no statistically significant differences (t = .19, α = .05), confirming the equivalence of the two groups (Table 6).

Table 6.

Results of the t-test to Identify the Difference between the Experimental and Control Groups in the Digital Fatigue Reduction Scale

Group	N	Mean	SD	df	t	Significance (α=.05)
Experimental	30	29.80	3.25	58	.19	Not significant
Control	30	29.55	3.10			

Source: Compiled by the authors

The researchers organized a training workshop for the experimental group to explain the registration procedures and the use of the AI-supported e-learning environment, and to introduce them to the user guide and the mechanism for following lessons and activities.

The field experiment was conducted from 2/8/2025 to 1/9/2025 via the AI-supported e-learning environment. Learners were notified of the start date through a WhatsApp group, and the link to the electronic environment was sent to them. After the experiment concluded, the post-administration of the research instruments was carried out for all participants using the same method as the pre-administration, aiming to measure the effectiveness of the strategy and to analyze the results statistically**.**

DISCUSSION

First: Presentation of Results – Result of the First Hypothesis. The first hypothesis posited that there is no statistically significant difference at the .05 level between the mean scores of the experimental and control groups after administering the Functional Vocabulary Test. The independent-samples t-test was used to compare mean scores between the two groups, and

the results showed statistically significant differences at the .05 level across all test dimensions (Auditory and Visual Recognition, Contextual and Functional Comprehension, Linguistic Production, and the Total Score) in favor of the experimental group. Furthermore, the effect size values (η^2) indicated a very large effect, reflecting the strong impact of the strategy based on Neurolinguistic Theory in developing functional vocabulary among non-native learners of Arabic at the novice level. Based on these results, the null hypothesis was rejected, and the alternative hypothesis was accepted (Table 7).

Table 7.

Results of the Independent Samples t-test to Identify the Difference between the Mean Scores of the Experimental and Control Groups in the Post-administration of the Functional Vocabulary Test and Its Dimensions

Sub-dimensions	Group	N	Mean	SD	t	df	Significance	η^2 Value	Effect Size
Auditory-visual recognition	Experimental	30	9.0	1.0	8.12	58	$p < .05$	.589	Very large
	Control	30	6.0	1.5					
Contextual-functional comprehension	Experimental	30	8.8	1.1	7.96	58		.599	Very large
	Control	30	5.5	1.6					
Linguistic production	Experimental	30	8.7	1.2	6.45	58		.424	Very large
	Control	30	6.5	1.4					
Total score	Experimental	30	26.5	3.0	9.20	58		.638	Very large
	Control	30	18.0	3.5					

Source: compiled by the authors

1. Cohen's indicators for effect size: $\eta^2 = .01$ (small), $\eta^2 = .06$ (medium), $\eta^2 = .14$ (large)

Result of the Second Hypothesis: The second hypothesis stated that there is no statistically significant difference at the .05 level between the mean scores of the experimental and control groups after administration of the Digital Fatigue Reduction Scale. An independent samples t-test was conducted to compare the mean scores between the two groups, and the results revealed statistically significant differences at the .05 level across all dimensions of the scale, including Physical Comfort, Cognitive Comfort, Emotional Comfort, Sensory and Social Interaction, and the Total Score, in favor of the experimental group. The very large effect sizes (η^2) confirmed the strategy's effectiveness in reducing digital fatigue among novice-level non-native Arabic learners (A). Accordingly, the null hypothesis was rejected, and the alternative hypothesis was accepted, as illustrated in Table 8.

Table 8.

Results of the Independent Samples t-test to Identify the Difference between the Mean Scores of the Experimental and Control Groups in the Post-administration of the Digital Fatigue Reduction Scale and Its Dimensions

Main Dimensions	Group	N	Mean	SD	t	df	Significance	η² Value	Effect Size
Physical comfort	Experimental	30	13.40	1.18	9.42	58	p < .05	.605	Very large
	Control	30	9.80	1.20					
Cognitive comfort	Experimental	30	14.20	1.10	11.16	58		.682	Very large
	Control	30	10.80	1.15					
Emotional comfort	Experimental	30	13.00	1.25	9.38	58		.603	Very large
	Control	30	9.60	1.22					
Sensory-social interaction	Experimental	30	12.80	1.22	9.99	58		.633	Very large
	Control	30	9.40	1.18					
Total score	Experimental	30	53.40	3.00	15.88	58		.813	Very large
	Control	30	39.60	3.10					

Source: compiled by the authors

1. *Cohen's indicators for effect size: $\eta^2 = .01$ (small), $\eta^2 = .06$ (medium), $\eta^2 = .14$ (large)*

Second: Discussion

Interpretation of Results Related to the Impact of the AI-Supported Neurolinguistic Strategy on Developing Functional Vocabulary: The research demonstrated the effectiveness of the strategy, based on Neurolinguistic Theory, in helping novice-level (A) non-native learners of Arabic develop functional vocabulary, as the experimental group outperformed the control group on the post-test. This superiority can be linked to several combined factors, including presenting vocabulary in real communicative contexts while focusing on pronunciation and meaning rather than the written form, using auditory and visual stimuli to activate long-term memory, promoting real social interaction through group and pair activities, utilizing Google Sites as a flexible platform for self-directed and interactive learning, and incorporating AI (ChatGPT) to offer immediate feedback and error correction.

These results stem not only from the content created following the procedures of the strategy based on Neurolinguistic theory, nor to artificial intelligence (ChatGPT) alone, but rather to the synergistic effect of both. ChatGPT allowed learners to receive immediate feedback and participate in flexible, self-directed learning, demonstrating its ability to support individual learning and encourage participation. Meanwhile, the content, designed according to the strategy's procedures based on the principles of Neurolinguistic theory, provided an organized framework that ensured comprehension of functional vocabulary and its use in real-life situations.

These results are consistent with Arab studies, including those of Abdel-Azim (2019), Abu Aida and Oukbar (2025), Ahmed (2019), and Al-Shahri (2019), which highlight the importance of context, collaborative learning, and phonetic priming. However, the results of this research go

beyond Nazir (2023) noted limitations of technology alone by integrating it into a comprehensive neural theoretical framework.

This study contributes by merging the principles of neural theory, interactive platforms, and AI applications, resulting in an effective educational model that enhances the acquisition of functional vocabulary in natural situations.

Studies have shown differing results regarding the role of AI tools, such as ChatGPT, in language learning. Research suggests that the effectiveness of AI-based tools depends on instructional design and contextual factors, and that they are not necessarily effective without a well-structured pedagogical framework (Alshahrani & Qureshi, 2024). Similarly, Al Mahrooqiyah (2024) found that using ChatGPT to enhance 10th-grade students' speaking skills could yield positive outcomes when used as a supportive tool. However, it requires educational supervision to ensure the quality of learning.

These conflicting findings imply that AI's role in vocabulary learning goes beyond merely providing technology; scientifically designed, pedagogically structured content is essential. This supports the results of the current study, which showed that synergistic effect between ChatGPT and content created using a strategy based on Neurolinguistic Theory significantly improved functional vocabulary learning and reduced digital fatigue. This effect was not fully observed in previous studies that examined each factor independently.

The research results demonstrated the effectiveness of the strategy based on the Neurolinguistic Theory in an AI-supported electronic environment in reducing digital fatigue among novice-level (A) non-native learners of Arabic, as the experimental group outperformed the control group in the post-administration. This can be attributed to the integration of the interactive platform (Google Sites) with ChatGPT, which created an engaging, user-friendly learning environment that alleviated tension and anxiety. The straightforward interface and appropriate audio-visual cues minimized the physical and mental effort required to engage with the content. Content was delivered gradually, with repetition and multisensory elements, reducing cognitive load and aiding vocabulary comprehension. Participation in group activities and realistic scenarios, like market or restaurant roles, improved social skills and reduced feelings of digital isolation. Additionally, allowing learners to control the pace and review materials fostered a sense of cognitive and emotional comfort, building confidence and easing emotional strain.

These results support the findings of previous studies (Argyriadi et al., 2025; Hall et al., 2021; Khalil & Said, 2023; Masrahi, 2023; Nazir, 2023; Nick et al., 2022), which confirmed that well-organized digital environments and the use of AI technologies help increase motivation and reduce digital anxiety.

The current research stands out because it combines two related areas: reducing digital fatigue and enhancing functional vocabulary within a unified framework based on Neurolinguistic Theory. This offers a valuable addition to the existing literature on teaching Arabic to non-native speakers.

Research Recommendations

Based on the results achieved by the research, it is recommended that educational institutions integrate strategies based on Neurolinguistic Theory into Arabic language programs for non-native speakers, especially at novice levels, and adopt AI-supported electronic learning environments to ensure the quality and sustainability of learning; that teachers of Arabic to non-native speakers participate in training programs to employ neural strategies and smart technologies in both physical and electronic classrooms and design interactive activities that consider the psychological and cognitive dimensions of learners to reduce digital pressure; that digital curriculum designers redesign courses to include audio-visual and contextual interactive activities supported by AI and prioritize functional vocabulary at novice levels as the primary entry point for communication; and that researchers in teaching Arabic to non-native speakers study the impact of integrating Neurolinguistic Theory with smart technologies on other linguistic skills and conduct comparative studies across different levels to measure the continuity of the impact and the effectiveness of the recommendations.

Research Suggestions for Further Research

Considering the research results and recommendations, the current research proposes conducting the following studies:

- The effectiveness of a strategy based on Neurolinguistic Theory within a Virtual Reality (VR) environment for developing speaking skills among non-native Arabic learners.
- The effectiveness of a strategy based on Neurolinguistic Theory within an Augmented Reality (AR) environment in enhancing listening skills among non-native Arabic learners.
- The effectiveness of a strategy based on Neurolinguistic Theory in an AI-supported electronic environment for developing functional and creative writing skills among non-native Arabic learners.
- The effectiveness of a strategy based on Neurolinguistic Theory in an AI-supported electronic environment for developing reading comprehension skills among non-native Arabic learners.
- The effectiveness of a strategy based on Neurolinguistic Theory in an AI-supported electronic environment for reducing linguistic anxiety and boosting learning motivation among non-native Arabic learners.
- The effectiveness of a strategy based on Neurolinguistic Theory in an AI-supported electronic environment for developing literary appreciation and rhetorical concepts among non-native learners of Arabic.

CONCLUSIONS

The study findings indicate the effectiveness of employing a strategy based on the principles of Neurolinguistic Theory, supported by Artificial Intelligence, to develop functional vocabulary and reduce digital fatigue among novice-level non-native learners of Arabic (A). The results highlight the importance of integrating this strategy into educational programs for these

learners, considering the interactive learning environments it offers, which help develop functional vocabulary and reduce digital fatigue. Additionally, the study stresses the need to improve Arabic teachers' skills in teaching non-native speakers with smart technologies and neural strategies through specialized training programs. It also underscores the need to redesign digital curricula to incorporate AI-supported contextual audiovisual activities, focusing on functional vocabulary as a key entry point for communication. Finally, the findings emphasize the importance of expanding research on the application of Neurolinguistic Theory combined with smart technologies to other language skills, as well as conducting comparative studies across different learning levels.

The Limitations of the Study

After discussing the results and their interpretation, some limitations can be noted that may affect the applicability of the findings to other contexts. First, the study focused on novice-level (A) non-native learners of Arabic, and the relatively small sample size may limit the generalizability of the results to other proficiency levels or to all non-native learners of Arabic. Second, the implementation period was limited (one month), which may restrict the observation of the long-term effects of the Neurolinguistic theory–based strategy.

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