**International Journal of Global Research Innovations & Technology (IJGRIT)**
An International Multidisciplinary Quarterly Double Blind Open Access Peer Reviewed Refereed Journal
e-ISSN : 2583-8717, Impact Factor: (Cosmos: 6.972 & I2OR: 5.002), Volume 04, No. 02(II), April-June, 2026, pp 31-34

# Adaptive Neuro-Pedagogical Models for AI-Supported English Language Learning: NeuroAdaptive ELT

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*Citation: Jenifer, R. & Yamini, G. (2026). Adaptive Neuro-Pedagogical Models for AI-Supported English Language Learning: NeuroAdaptive ELT. International Journal of Global Research Innovations & Technology, 04(02(II)), 31–34. https://doi.org/10.62823/IJGRIT/4.2(II).9086*

## ABSTRACT

*The emergence of Artificial Intelligence (AI) has significantly transformed educational methodologies across the globe, particularly in the field of English Language Teaching (ELT). Traditional approaches to language learning often adopt uniform instructional methods that fail to address the cognitive diversity, emotional variations, and neurological learning patterns of individual learners. In response to these limitations, the concept of NeuroAdaptive ELT has emerged as an innovative interdisciplinary framework integrating neuro-pedagogy, cognitive science, and AI-supported adaptive learning technologies. This study explores how AI-driven systems can analyze learners' cognitive responses, emotional engagement, memory retention, attention span, and linguistic behaviors to create personalized English learning environments. The research adopts a mixed-method approach involving experimental learning sessions, AI-assisted language assessment tools, learner analytics, and qualitative feedback from participants. Findings indicate that neuro-adaptive AI systems enhance vocabulary acquisition, pronunciation accuracy, communicative competence, learner engagement, and emotional confidence. The study concludes that NeuroAdaptive ELT has the potential to redefine future English education by creating intelligent, emotionally responsive, and cognitively adaptive learning ecosystems capable of supporting individualized language acquisition.*

***Keywords**: NeuroAdaptive ELT, Artificial Intelligence, Neuro-Pedagogy, Cognitive Learning, Adaptive Learning Systems, English Language Teaching, Generative AI.*

## Introduction

The rapid growth of digital technologies and Artificial Intelligence has transformed educational systems, especially in English Language Teaching (ELT). Traditional language teaching methods often follow standardized approaches that fail to address the cognitive and emotional diversity of learners. Since learners differ in memory retention, attention span, emotional state, and neurological functioning, conventional ELT methods frequently struggle to provide personalized and effective instruction.

Neuro-pedagogy, which combines neuroscience and educational psychology, explains how the brain acquires and retains language through neural stimulation, emotional engagement, and cognitive interaction. At the same time, AI technologies such as machine learning, speech recognition, natural language processing, and generative AI have enabled intelligent educational systems capable of analyzing learner behavior and adapting instructional content dynamically.

Neuro Adaptive ELT emerges from the integration of neuro-pedagogy and AI-supported learning technologies. This framework continuously adapts learning materials, assessments, and feedback according to learners' cognitive and emotional responses. By integrating cognitive monitoring, emotional analytics, adaptive AI systems, and real-time feedback mechanisms, Neuro Adaptive ELT creates

personalized, interactive, and emotionally supportive language learning environments that improve learner engagement, communicative competence, and language proficiency.

**Objectives**

The primary objective of this study is to examine the role of neuro-pedagogy in AI-supported English language learning. The research also aims to analyze how Artificial Intelligence contributes to adaptive learning systems in ELT. Another important objective is to explore the role of cognitive and emotional analytics in improving language acquisition and learner engagement. Furthermore, the study seeks to develop a conceptual NeuroAdaptive ELT framework capable of supporting personalized learning environments. Finally, the research evaluates the effectiveness of adaptive neuro-pedagogical models in enhancing learners' communicative competence, vocabulary acquisition, pronunciation accuracy, and emotional confidence.

**Theoretical Framework**

The theoretical foundation of this study is based on neuro-pedagogical theory, constructivist learning theory, and adaptive learning theory. Neuro-pedagogy explains how the brain learns through cognitive stimulation, neural plasticity, emotional engagement, and sensory interaction. It highlights the importance of individualized learning experiences based on learners' neurological patterns and cognitive diversity.

Constructivist learning theory suggests that learners actively construct knowledge through interaction, communication, and experiential learning activities. AI-supported adaptive systems enhance this process by creating personalized learning pathways and interactive educational environments.

Adaptive learning theory focuses on modifying instructional materials according to learners' performance, pace, strengths, weaknesses, and emotional responses. AI technologies make adaptive learning more effective through real-time learner analytics, intelligent automation, and continuous feedback systems.

**Methodology**

This research adopts a mixed-method approach combining both quantitative and qualitative research methodologies. The study was conducted among undergraduate learners studying English language courses in higher educational institutions. Participants were divided into experimental and control groups for comparative analysis.

The experimental group was exposed to AI-supported NeuroAdaptive ELT systems integrating cognitive analytics, emotional monitoring, adaptive learning modules, and generative AI communication tools. The control group followed conventional English language teaching methods. The study was conducted over a period of twelve weeks focusing on vocabulary acquisition, pronunciation accuracy, listening comprehension, speaking fluency, writing performance, and learner engagement.

Data collection methods included AI-assisted language assessment tools, cognitive performance tracking systems, pronunciation analysis software, learner engagement surveys, classroom observations, and qualitative interviews. Quantitative data were analyzed using comparative statistical methods, while qualitative responses were interpreted through thematic analysis to understand learner experiences and emotional engagement patterns.

**Conceptual Neuroadaptive ELT Framework**

The proposed NeuroAdaptive ELT framework consists of interconnected components designed to create personalized and cognitively adaptive learning environments. The first component is the cognitive monitoring system, which tracks learners' attention span, memory retention, response speed, and comprehension performance during language learning activities. This system enables AI technologies to identify individual learning patterns and cognitive strengths.

The second component is the emotional analytics engine. This module analyzes learners' emotional states such as stress, motivation, confidence, frustration, and engagement levels through interaction patterns and behavioral analytics. Emotion-sensitive AI systems help create emotionally supportive learning environments that reduce anxiety and improve participation.

The adaptive AI learning engine forms the third component of the framework. This system continuously modifies instructional content, learning pace, activities, assessments, and feedback according to learners' cognitive responses and linguistic performance. Personalized learning pathways improve learner engagement and educational effectiveness.

The fourth component is the generative AI communication module, which provides conversational practice, intelligent tutoring, automated writing support, pronunciation correction, and interactive language activities. This module enhances communicative competence and practical language application.

Finally, the real-time feedback mechanism delivers immediate corrective feedback and performance analysis. Continuous feedback helps learners identify errors, improve accuracy, and develop confidence in language communication.

**Findings and Discussion**

The findings of the study indicate significant improvements among learners exposed to NeuroAdaptive ELT systems compared to traditional teaching environments. AI-supported adaptive repetition and contextual learning activities improved vocabulary acquisition and retention. Learners demonstrated better understanding and usage of vocabulary in communication tasks.

Speech recognition and pronunciation analysis technologies significantly improved learners' articulation, pronunciation accuracy, and speaking fluency. The use of conversational AI systems increased learner confidence and communicative competence during oral activities.

The study also revealed increased learner engagement and motivation within adaptive learning environments. Personalized instructional content and emotionally responsive feedback mechanisms encouraged active participation and sustained learner attention throughout the learning process.

Furthermore, learners demonstrated improved cognitive performance, including higher memory retention, faster comprehension, and better concentration levels. Emotion-sensitive AI systems reduced communication anxiety and created supportive learning environments that enhanced emotional confidence.

These findings confirm that NeuroAdaptive ELT provides a more effective, inclusive, and learner-centered approach to English language education by integrating cognitive science, emotional intelligence, and adaptive AI technologies.

**Advantages of Neuroadaptive ELT**

NeuroAdaptive ELT offers numerous advantages in modern language education. The framework supports personalized learning experiences tailored to individual cognitive and emotional needs. Real-time adaptive instruction allows learners to progress according to their own pace and abilities. Emotionally responsive learning environments enhance learner confidence, motivation, and participation.

The integration of generative AI tools improves communication skills, pronunciation accuracy, and writing proficiency through continuous practice and automated feedback. Additionally, AI-driven learner analytics enable teachers to monitor performance effectively and design targeted instructional interventions. NeuroAdaptive ELT also promotes flexible and inclusive education capable of supporting diverse learning styles and educational backgrounds.

**Challenges and Limitations**

Despite its advantages, NeuroAdaptive ELT faces several challenges and limitations. The implementation of advanced AI technologies requires strong technological infrastructure and financial investment. Many educational institutions, especially in developing regions, may lack access to such resources.

Data privacy and ethical concerns also represent major challenges because AI systems collect large amounts of learner information, including cognitive and emotional data. Additionally, excessive dependence on technology may reduce human interaction and emotional connection between teachers and learners.

Another limitation involves digital literacy, as both educators and learners require technical skills to effectively use adaptive learning systems. Therefore, balanced integration between AI technologies and human-centered pedagogy remains essential for successful implementation.

**Future Implications**

The future of English Language Teaching may increasingly depend on intelligent adaptive systems capable of understanding learners cognitively and emotionally. Emerging technologies such as affective computing, brain-computer interfaces, immersive virtual learning environments, and advanced generative AI systems could further strengthen NeuroAdaptive ELT frameworks.

Educational institutions may adopt AI-driven cognitive learning ecosystems that support multilingual communication, inclusive education, and lifelong learning. Teachers may gradually transition into facilitators, mentors, and cognitive learning designers within AI-supported educational environments. NeuroAdaptive ELT may therefore redefine future educational systems by creating highly personalized, emotionally intelligent, and technologically advanced learning experiences.

**Conclusion**

The integration of Artificial Intelligence, neuro-pedagogy, and adaptive learning technologies has introduced a transformative direction in English Language Teaching. NeuroAdaptive ELT represents an innovative educational framework capable of addressing cognitive diversity, emotional engagement, and individualized learning needs. By combining adaptive AI systems with brain-based pedagogical principles, language learning becomes more personalized, interactive, efficient, and emotionally supportive.

The study demonstrates that NeuroAdaptive ELT significantly improves vocabulary acquisition, pronunciation accuracy, learner engagement, communicative competence, memory retention, and emotional confidence. Although technological, ethical, and infrastructural challenges remain, the potential of neuro-adaptive learning systems to redefine future English education is substantial.

Ultimately, NeuroAdaptive ELT offers a vision for intelligent, emotionally responsive, and cognitively adaptive educational ecosystems that support meaningful and personalized language acquisition in the digital era.

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