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# Roles of the Peripheral and Autonomic Nervous Systems in Learning: A Systematic Review Bridging Neuroeducation and Islamic Education

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**ABSTRACT**

This study aims to analyze the functions of the peripheral nervous system and autonomic nervous system as the neurobiological foundation of learning and to examine their relevance in strengthening the theoretical framework of neuroscience-based Islamic education. The study employed a Systematic Literature Review method involving 30 scholarly articles covering health neuroscience, autonomic nervous system research, neuroeducation, neuromyths, and neuroscience-based Islamic education. Data were analyzed using thematic analysis and narrative synthesis to identify relationships among nervous system functions, learning processes, and Islamic educational concepts. The findings indicate that the autonomic nervous system plays a significant role in regulating attention, memory, emotions, motivation, decision-making, and learning behaviors. Neuroeducation literature explains that the balance between sympathetic and parasympathetic nervous system activities contributes to cognitive, affective, and behavioral processes that support effective learning. Furthermore, the synthesis reveals that Islamic educational concepts such as intellect *'aql*, *dhikr*, *tafakkur*, *muhasabah*, and character development are closely related to neurological mechanisms described in contemporary neuroscience. This study concludes that the autonomic nervous system serves as a neurobiological foundation linking neuroscience, neuroeducation, and Islamic education within a holistic and integrative learning framework.

**Keyword**
Autonomic Nervous System, Peripheral Nervous System, Neuroeducation, Learning, Islamic Education, Neuroscience.

**Abstrak**

Penelitian ini bertujuan untuk menganalisis fungsi sistem saraf tepi dan sistem saraf otonom sebagai dasar neurobiologis pembelajaran serta mengkaji relevansinya dalam penguatan landasan teoritis pendidikan Islam berbasis neurosains. Penelitian menggunakan metode Systematic Literature Review (SLR) terhadap 30 artikel ilmiah yang mencakup bidang neuroscience kesehatan, sistem saraf otonom, neuroeducation, neuromyths, dan pendidikan Islam berbasis neurosains. Data dianalisis melalui teknik analisis tematik dan sintesis naratif untuk mengidentifikasi hubungan antara fungsi sistem saraf, proses pembelajaran, dan konsep-konsep pendidikan Islam. Hasil penelitian menunjukkan bahwa sistem saraf

otonom berperan penting dalam regulasi perhatian, memori, emosi, motivasi, pengambilan keputusan, dan perilaku belajar. Literatur neuroeducation menjelaskan bahwa keseimbangan aktivitas saraf simpatis dan parasimpatis berkontribusi terhadap proses kognitif, afektif, dan perilaku yang mendukung keberhasilan pembelajaran. Selain itu, sintesis literatur menunjukkan bahwa konsep-konsep pendidikan Islam seperti akal, dzikir, tafakkur, muhasabah, dan pembentukan karakter memiliki relevansi dengan mekanisme neurologis yang dijelaskan dalam neuroscience modern. Penelitian ini menyimpulkan bahwa sistem saraf otonom merupakan fondasi neurobiologis yang menghubungkan neuroscience, neuroeducation, dan pendidikan Islam dalam kerangka pembelajaran yang holistik dan integratif.

**Kata Kunci** Sistem Saraf Otonom, Sistem Saraf Tepi, Neuroeducation, Pembelajaran, Pendidikan Islam, Neurosains

## INTRODUCTION

Developments in neuroscience over the past two decades have brought fundamental changes in the understanding of human learning processes. Whereas learning was previously viewed primarily as a psychological and pedagogical activity centered on the transfer of knowledge, neuroscience research has demonstrated that learning is fundamentally a biological phenomenon involving complex interactions among the brain, nervous system, body, emotions, and environment.

Within this context, the Peripheral Nervous System (PNS) and the Autonomic Nervous System (ANS) have received increasing attention because they play crucial roles in connecting physiological bodily activities with cognitive functions that support learning. Numerous studies have shown that autonomic nervous system activity is closely associated with attention, memory, emotional regulation, motivation, decision-making, and individuals' ability to respond to challenges in learning environments. The autonomic nervous system, consisting of the sympathetic and parasympathetic divisions, functions to maintain physiological homeostasis, enabling individuals to achieve optimal conditions for learning. Through physiological indicators such as Heart Rate Variability (HRV)**,** Electrocardiography (ECG)**,** Electrodermal Activity (EDA)**,** and various other biomarkers, researchers have demonstrated that the quality of autonomic nervous system regulation directly influences cognitive performance and mental well-being. These findings emphasize that learning is shaped not only by intellectual factors but also by the underlying neurobiological conditions that support cognitive functioning (Shaffer & Ginsberg, 2017).

The significance of the autonomic nervous system in learning becomes increasingly evident through studies linking physiological activity to academic performance and student mental health. The literature indicates that imbalances between sympathetic and parasympathetic nervous system activity are associated with increased levels of stress, anxiety, depression, mental fatigue, and attention disorders such as ADHD. Conversely, effective autonomic regulation, often reflected by higher HRV levels, is associated with greater psychological flexibility, enhanced adaptive capacity, and improved learning performance. These findings suggest that the autonomic nervous system serves as a biological foundation enabling learners to sustain attention, regulate emotions, and process information effectively. From the perspective of contemporary neuroscience, learning success is no longer understood merely as a product of intellectual ability but rather as the result of interactions among brain function, physiological regulation, and environmental experiences. Therefore, understanding the anatomy and functions of the peripheral and autonomic nervous systems has become

increasingly important for developing more comprehensive theories and practices of learning. Nevertheless, most existing studies remain focused on clinical and health-related aspects, while investigations specifically linking autonomic nervous system functions to learning processes remain relatively limited. This situation highlights the need for a more systematic synthesis regarding the role of the autonomic nervous system as a neurobiological foundation of learning (Burlacu et al., 2026; Gedam et al., 2026; Jhon et al., 2026; Trujillo et al., 2026; Camacho-Navas et al., 2026).

Alongside advances in neuroscience, a new field known as neuroeducation or educational neuroscience has emerged. This field seeks to bridge neuroscience findings with educational theories and practices through a deeper understanding of how the brain and nervous system function during learning processes. Neuroeducation conceptualizes learning as a biological activity involving attention, memory, emotion, motivation, and executive functions, all of which are influenced by learners' neurological conditions. Research in neuroeducation has demonstrated that learning environments supporting emotional regulation and physiological balance can enhance motivation, learning engagement, psychological well-being, and academic achievement.

Neurodidactic programs developed based on neuroscience principles have been shown to improve psychological capital, thinking skills, and the quality of learning interactions. At the same time, scholars have emphasized the importance of caution when translating neuroscience findings into educational practice to avoid neuromyths and oversimplifications. Therefore, neuroeducation serves not only as a bridge between neuroscience and education but also as a conceptual framework for understanding how the peripheral and autonomic nervous systems contribute scientifically to learning processes (Brick et al., 2021; Schmitt et al., 2023; Qafa et al., 2025; Shukla et al., 2025).

Within the context of Islamic education, developments in neuroscience have generated new discussions concerning the integration of neuroscience with educational concepts derived from the Qur'an and the Islamic intellectual tradition. Various studies indicate that concepts such as '*aql* (intellect), *dhikr* (remembrance of God), *tafakkur* (reflection), *tadabbur* (contemplation), *nazhar* (observation), *muhasabah* (self-evaluation), and *ijtihad* (independent reasoning) possess relevance to neurological mechanisms occurring within the human brain and nervous system. This integration has developed through approaches such as Islamic neuroeducation**,** neurotheology**,** and spiritual neuroscience**,** which seek to explain the relationship between biological activity and human spiritual experiences. These studies suggest that Islamic education holds significant potential for developing learning paradigms that extend beyond cognitive dimensions to include affective, moral, and spiritual development. Neuroscience-based taxonomies of Islamic learning developed in recent studies indicate that processes of thinking, remembering, understanding, evaluating, and creating can be explained through the involvement of interconnected brain regions and nervous system networks. Consequently, the integration of neuroscience and Islamic education offers opportunities to establish a stronger theoretical foundation for understanding learning processes holistically (Suyadi, 2022; Mujiburrahman et al., 2025; Asman et al., 2021; Putra & Suyadi, 2022).

Despite the rapid development of neuroeducation and Islamic neuroscience studies, the examination of the peripheral and autonomic nervous systems as neurobiological foundations of learning has not received sufficient attention. Most studies focus on brain functions, neuroplasticity, executive functions, or cognitive aspects of learning, whereas the roles of the peripheral and autonomic nervous systems

are often discussed only partially. However, numerous studies indicate that physiological regulation mediated by the autonomic nervous system is a critical prerequisite for attention, memory, motivation, self-regulation, and learning engagement (Ritonga et al, 2022).

Furthermore, neuroscience-based Islamic education research has largely concentrated on intellect, character formation, spirituality, and moral values, while the relationships between autonomic nervous system functions and Islamic educational concepts such as dhikr, tafakkur, muhasabah, and character development have not been systematically synthesized. This gap demonstrates the need for research that specifically examines the functions of the peripheral and autonomic nervous systems from integrated perspectives of neuroscience, neuroeducation, and Islamic education. Such research is expected to contribute conceptually to expanding understanding of the neurobiological foundations of learning while strengthening the integration of neuroscience and Islamic education (Suyadi, 2022; Asman et al., 2021; Putra & Suyadi, 2022; Mujiburrahman et al., 2025; Qafa et al., 2025).

Based on these considerations, this study aims to conduct a systematic review of the literature addressing the anatomical characteristics and functions of the peripheral and autonomic nervous systems in relation to learning, explain their contributions to cognitive, affective, and behavioral learning processes from a neuroeducational perspective, and synthesize relevant neuroscience concepts to strengthen the theoretical foundations of Islamic education. This study is significant because it offers a perspective that connects three fields that have traditionally developed separately: neuroscience, neuroeducation, and Islamic education. Through a comprehensive synthesis of the literature, this study seeks to demonstrate that the autonomic nervous system functions not only as a physiological mechanism regulating bodily organs but also as a neurobiological foundation supporting successful learning processes. Furthermore, this study is expected to enrich neuroscience-based Islamic educational discourse by highlighting the relevance of nervous system functions to Islamic educational concepts aimed at developing human intellect, character, emotions, and spirituality in an integrated manner.

Accordingly, this study is guided by three primary research questions: (1) How are the anatomical characteristics and functions of the peripheral and autonomic nervous systems explained in neuroscience literature related to learning? (2) How does neuroeducation literature explain the contributions of the peripheral and autonomic nervous systems to cognitive, affective, and behavioral learning processes? (3) How can the synthesis of neuroscience concepts concerning the peripheral and autonomic nervous systems be utilized to strengthen the theoretical foundations of Islamic education? By addressing these questions, this study aims to contribute theoretically to the development of a more integrative and contextual neuroscience-based paradigm of Islamic education.

## METHOD

This study employed a Systematic Literature Review (SLR**)** approach to identify, analyze, evaluate, and synthesize previous research findings concerning the functions of the Peripheral Nervous System (PNS) and the Autonomic Nervous System (ANS) as neurobiological foundations of learning and their relevance to the

development of neuroscience-based Islamic education. The SLR approach was selected because it enables researchers to obtain a comprehensive understanding of conceptual developments, empirical findings, and research trends within the fields of neuroscience, neuroeducation, and Islamic education. Rather than collecting primary field data, this study focused on integrating findings from previously published research to construct a more comprehensive conceptual framework explaining the relationships among the autonomic nervous system, learning processes, and Islamic education. Through this approach, the study sought to address three research questions concerning the anatomical characteristics and functions of the peripheral and autonomic nervous systems, their contributions to learning from a neuroeducational perspective, and the synthesis of neuroscience concepts to strengthen the theoretical foundations of Islamic education (Suyadi, 2022; Qafa et al., 2025; Mujiburrahman et al., 2025).

The data sources consisted of 30 scientific articles selected based on their relevance to the research topic. These articles were drawn from reputable international journals and accredited national journals covering four major thematic areas: health neuroscience and the autonomic nervous system, neuroeducation and neurodidactics, neuromyths in education, and neuroscience and Islamic education**.** The first group included studies examining Heart Rate Variability (HRV), wearable biosensors, depression, ADHD, mental stress, and the autonomic nervous system as digital biomarkers of learning and mental health. The second group comprised neuroeducation studies focusing on neurodidactics, neuroplasticity, executive functions, learning engagement, and neuroscience-based teacher training. The third group addressed neuromyths and the validity of applying neuroscience findings in educational contexts. The fourth group consisted of studies specifically discussing the integration of neuroscience and Islamic education, including neuroscience-based Islamic learning taxonomies, character education, inclusive education, anti-corruption education, Islamic neuro-pedagogy, and the repositioning of Islamic education in the neuroscience era. All selected articles served as units of analysis because of their direct relevance to the research objectives. Therefore, instead of statistical sampling procedures commonly used in quantitative research, this study employed purposive sampling based on thematic relevance (Brick et al., 2021; Schmitt et al., 2023; Suyadi, 2022; Mujiburrahman et al., 2025).

The primary research instrument was a data extraction sheet developed according to the study objectives and research questions. The data extraction sheet was used to identify and record essential information from each article, including publication details, research objectives, research design, key concepts, findings related to the peripheral and autonomic nervous systems, contributions to learning processes, and relevance to Islamic education. In addition, a literature synthesis matrix was utilized to map relationships among studies based on emerging themes. This instrument enabled systematic categorization of data, allowing findings dispersed across the literature to be compared, contrasted, and integrated into a coherent conceptual framework. The synthesis matrix also facilitated the identification of patterns, trends, similarities, differences, and research gaps that warrant further investigation (Shukla et al., 2025; Qafa et al., 2025; Suyadi et al., 2021).

Data collection was conducted through several systematic stages. The first stage involved identifying all available articles relevant to the research topic. The second stage consisted of an in-depth review of the selected articles to understand their contexts, concepts, methodologies, and findings. The third stage involved data

extraction using the previously developed extraction sheet. During this phase, each article was analyzed according to its contribution to the study's three primary areas of focus: the functions of the peripheral and autonomic nervous systems, their contributions to learning from a neuroeducational perspective, and their implications for Islamic education. The fourth stage involved categorizing the articles into four major clusters: health neuroscience and the autonomic nervous system, neuroeducation, neuromyths, and neuroscience and Islamic education. This categorization facilitated interdisciplinary synthesis and enabled a more systematic explanation of relationships among concepts originating from different fields. The final stage consisted of conceptual validation through cross-study comparisons to ensure the consistency, relevance, and coherence of the arguments developed throughout the review (Putra & Suyadi, 2022; Asman et al., 2021; Brick et al., 2021).

Data analysis was conducted using thematic analysis and narrative synthesis. Thematic analysis was employed to identify recurring themes across the literature, including the physiological functions of the autonomic nervous system, emotional regulation, attention, memory, motivation, neuroeducation, neuro-pedagogy, character development, spirituality, and neuroscience-based Islamic education. Once the major themes had been identified, narrative synthesis was applied to integrate the findings into a coherent explanatory framework. Through this process, evidence from health sciences, neuroscience, education, and Islamic education was connected to explain how the autonomic nervous system functions as a neurobiological foundation of learning. The synthesized findings were subsequently used to address the three research questions sequentially, beginning with the anatomical characteristics and functions of the peripheral and autonomic nervous systems, followed by their contributions to cognitive, affective, and behavioral learning processes from a neuroeducational perspective, and concluding with the development of a theoretical framework for neuroscience-based Islamic education. By following these procedures, the study provides a replicable framework for future researchers interested in investigating the integration of neuroscience, neuroeducation, and Islamic education through a systematic literature review approach (Suyadi, 2022; Mujiburrahman et al., 2025; Qafa et al., 2025; Shukla et al., 2025).

## RESULTS&DISCUSSION

### 1. Distribution of Articles by Research Cluster

The identification and analysis of the 30 selected articles revealed that the literature included in this study could be categorized into four major research clusters. The first cluster, Health Neuroscience and the Autonomic Nervous System, comprised studies on Heart Rate Variability (HRV), wearable biosensors, stress detection, depression, ADHD, autonomic dysreflexia, and physiological biomarkers, accounting for ten articles. The second cluster, Neuroeducation and Neurodidactics, included studies focusing on neuroeducation, neurodidactics, neuroplasticity, executive functions, teacher training, mental health literacy, and the implementation of neuroscience in educational settings, comprising eleven articles. The third cluster, Neuromyths and the Validation of Neuroscience Concepts in Education, consisted of two articles. The fourth cluster, Neuroscience and Islamic Education, included studies on neuroscience-based character education, Islamic learning taxonomies, inclusive education, anti-corruption education, Islamic neuro-pedagogy, neuroscience-based creativity, and the repositioning of Islamic education in the era of neuroscience, totaling seven articles (Suyadi, 2022; Asman et al., 2021; Putra & Suyadi, 2022; Mujiburrahman et al., 2025).

**Table 1.** Distribution of Articles by Research Cluster

| No | Klaster Penelitian | Jumlah Artikel |
|---|---|---|
| **1** | Health Neuroscience and the Autonomic Nervous System | 10 |
| **2** | Neuroeducation and Neurodidactics | 11 |
| **3** | Neuromyths in Education | 2 |
| **4** | Neuroscience and Islamic Education | 7 |
| Total | | **30** |

**2. Findings on the Peripheral and Autonomic Nervous Systems**

The synthesis results indicate that all articles within the health neuroscience cluster identified the autonomic nervous system as a critical component of human physiological regulation. The primary findings highlighted relationships between autonomic nervous system activity and Heart Rate Variability (HRV), stress regulation, depression, ADHD, decision-making, pain perception, and mental health. Most studies employed physiological indicators such as ECG, HRV, EDA, EEG, GSR, and wearable sensors to assess autonomic nervous system activity. The literature consistently identifies the sympathetic and parasympathetic nervous systems as the two principal components involved in emotional regulation, physiological readiness, and environmental adaptation. Several studies applied Artificial Intelligence (AI) and Machine Learning techniques to identify autonomic nervous system activity patterns as biomarkers of specific psychological conditions. Furthermore, HRV emerged as the most frequently utilized indicator in autonomic nervous system research. These findings demonstrate that the autonomic nervous system has become a central focus of contemporary neuroscience research concerning human physiological functioning.

**Table 2.** Research Focuses on the Autonomic Nervous System

| **Fokus Kajian** | **Jumlah Artikel** |
|---|---|
| HRV and Digital Biomarkers | 4 |
| Mental Stress | 2 |
| Depression | 1 |
| ADHD | 1 |
| Pain and Physiological Responses | 1 |
| Decision-Making and Autonomic Regulation | 1 |

**3. Findings on Neuroeducation and Learning**

Analysis of neuroeducation studies revealed a strong focus on the relationship between neuroscience and learning processes. The most frequently discussed themes included neuroplasticity, executive functions, emotional regulation, engagement, motivation, teacher training, and mental health literacy. Several studies characterized neuroeducation as an interdisciplinary field integrating neuroscience, psychology, and education. The findings further indicated that understanding brain and nervous system functions is essential for enhancing educational quality. Neurodidactic programs examined in the literature were found to support learning motivation, psychological capital, executive function development, and students' higher-order thinking skills. Several studies also highlighted the importance of neuroscience-based teacher training in improving educators' understanding of students' behavior, emotional development, and mental health. Overall, the literature suggests that neuroeducation extends beyond cognitive dimensions and encompasses affective and social aspects of learning.

**Table 3.** Major Themes in Neuroeducation Literature

| Tema Neuroeducation | Jumlah Artikel |
|---|---|
| Neuroplasticity dan Learning | 3 |
| Executive Function | 2 |
| Motivation dan Engagement | 2 |
| Teacher Training | 2 |
| Mental Health Literacy | 1 |
| Neurodidactics | 1 |

**4. Findings on Neuroscience and Islamic Education**

The synthesis revealed that neuroscience-based Islamic education literature has developed around several major themes. The first theme concerns the development of neuroscience-based Islamic learning taxonomies that connect concepts such as *dhikr* (remembrance), *nazhar* (observation), *fikr* (reflection), *muhasabah* (self-evaluation), and *ijtihad* (independent reasoning) with specific neurological functions. The second theme focuses on neuroscience-based character education, emphasizing character formation as a process involving brain and nervous system functions. The third theme addresses neuroscience-based inclusive Islamic education, highlighting the development of cognitive abilities, emotional maturity, and social awareness. The fourth theme concerns neuroscience-based anti-corruption education, integrating integrity values into Islamic educational practices. Additional themes include neuroscience-based creativity, disaster jurisprudence (*fiqh al-kawārith*) from an Islamic neuroscience perspective, and the integration of neuro-pedagogy, spiritual intelligence, and Artificial Intelligence in digital Islamic education. Overall, the literature demonstrates a strong tendency toward integrating neuroscience concepts into various dimensions of Islamic education.

**Table 4.** Neuroscience Themes in Islamic Education

| Theme | Number of Articles |
|---|---|
| Islamic Learning Taxonomy | 1 |
| Character Education | 1 |
| Inclusive Education | 1 |
| Anti-Corruption Education | 1 |
| Neuroscience-Based Creativity | 1 |
| Repositioning Islamic Education | 1 |
| Neuro-Pedagogy and AI | 1 |

**5. Synthesis of Relationships Among Research Clusters**

The final synthesis demonstrated significant interconnections among the four research clusters. Health neuroscience literature positions the autonomic nervous system as a physiological foundation associated with emotional regulation, stress management, attention, and mental health. Neuroeducation literature connects these functions to learning processes through concepts such as neuroplasticity, executive functions, motivation, and engagement. Meanwhile, neuromyth literature focuses on validating the application of neuroscience findings in educational practice. Neuroscience-based Islamic education literature integrates findings from neuroscience and neuroeducation into Islamic educational concepts such as intellect (*'aql*), *dhikr*, character development, integrity, creativity, and spirituality. The synthesis revealed that the autonomic nervous system serves as a common conceptual thread across all four research clusters. Emotional regulation, learning, mental health, and character development emerged as the most prominent cross-cutting themes. These findings indicate a substantial

conceptual relationship among the autonomic nervous system, neuroeducation, and Islamic education.

**Table 5.** Summary of Research Clusters

| Cluster | Number of Articles |
|---|---|
| Health Neuroscience | 10 |
| Neuroeducation | 11 |
| Neuromyths | 2 |
| Islamic Education | 7 |

## Discussion

### 1. Anatomical Characteristics and Functions of the Peripheral and Autonomic Nervous Systems in Learning

The literature synthesis demonstrates that the Peripheral Nervous System (PNS) and the Autonomic Nervous System (ANS) occupy a crucial position in explaining the biological foundations of learning. Learning has traditionally been understood as a mental activity centered on the brain; however, the studies analyzed in this review indicate that cognitive functions cannot be separated from physiological mechanisms mediated through the peripheral and autonomic nervous systems. Research on Heart Rate Variability (HRV), stress detection, depression, ADHD, and various physiological biomarkers consistently shows that the autonomic nervous system regulates an individual's biological readiness to receive, process, and respond to environmental information. The sympathetic nervous system enhances alertness when individuals encounter challenges or environmental demands, whereas the parasympathetic nervous system restores physiological balance following stressful conditions. These findings suggest that learning is influenced not only by intellectual abilities but also by the body's capacity to maintain physiological equilibrium throughout the learning process. In other words, the autonomic nervous system serves as a bridge between biological conditions and learning performance. This conclusion is consistent with studies identifying HRV as an important indicator of adaptive capacity, emotional regulation, and psychological flexibility (Burlacu et al., 2026; Gedam et al., 2026; Jhon et al., 2026; Trujillo et al., 2026).

The findings further reveal that contemporary neuroscience literature no longer views the autonomic nervous system merely as a regulator of bodily organs but rather as an integral regulatory system influencing attention, memory, emotion, and behavior. Research involving the orbitofrontal cortex (OFC) and anterior cingulate cortex (ACC) indicates that physiological activity mediated by the autonomic nervous system is associated with decision-making and behavioral control. Stable physiological conditions enable individuals to evaluate information more rationally and effectively, whereas physiological dysregulation may impair thinking processes and decision-making. These findings strengthen the argument that the autonomic nervous system is closely related to learning because nearly all learning activities involve attention, information evaluation, problem-solving, and decision-making. Therefore, this study expands the understanding of learning by highlighting its strong neurobiological dimension in addition to its psychological aspects. The primary contribution of these findings is the demonstration that the autonomic nervous system serves as a physiological foundation that enables

cognitive functions to develop and operate optimally during learning processes (Burlacu et al., 2026).

## 2. Contributions of the Peripheral and Autonomic Nervous Systems to Cognitive, Affective, and Behavioral Learning Processes

The synthesis indicates that neuroeducation literature consistently conceptualizes learning as the result of interactions among the brain, the nervous system, emotions, and the environment. From a neuroeducational perspective, the autonomic nervous system contributes directly to cognitive processes by influencing attention, working memory, executive functions, and information-processing abilities. The reviewed studies demonstrate that students' physiological conditions play a significant role in determining learning effectiveness. Individuals experiencing physiological stability tend to exhibit greater attentional capacity, enhanced memory performance, and more effective problem-solving skills. In contrast, prolonged stress may impair these functions because excessive sympathetic nervous system activation reduces the cognitive resources available for learning. These findings suggest that the autonomic nervous system not only supports fundamental biological functions but also constitutes a critical mechanism underlying effective cognitive performance. This conclusion aligns with neuroeducation research emphasizing physiological regulation as a prerequisite for successful learning (Qafa et al., 2025; Gkintoni et al., 2023; Pradeep et al., 2024).

From an affective perspective, the findings demonstrate that the autonomic nervous system plays a vital role in emotional regulation, motivation, and learning engagement. The neurodidactic literature analyzed in this review indicates that emotions are not separate from learning but rather directly influence the quality of learning experiences. Neurodidactic programs examined across the literature have been shown to enhance psychological capital, engagement, and learning motivation among students. These findings suggest that maintaining a balance between sympathetic and parasympathetic nervous system activity contributes significantly to individuals' ability to regulate emotions during learning processes. When students successfully manage anxiety, academic pressure, and stress, they are better able to sustain attention and maintain long-term engagement in learning activities. Consequently, the autonomic nervous system functions as a biological mechanism linking emotional regulation to academic performance. These findings reinforce neuroeducation literature advocating the creation of learning environments that support students' emotional well-being (Ventura et al., 2024; Erick et al., 2021).

Regarding learning behavior, the synthesis reveals that the autonomic nervous system contributes to habit formation, self-regulation, and adaptation to educational environments. Neuroscience-based character education literature suggests that positive learning behaviors are not formed solely through external reinforcement but also through gradual changes in neural structures and functions associated with neuroplasticity. These findings indicate that effective learning requires neurobiological mechanisms supporting behavioral regulation and self-control. The autonomic nervous system assists individuals in maintaining physiological stability, thereby enabling impulse control, sustained attention, and the development of consistent learning behaviors. Consequently, this study contributes to the field of neuroeducation by demonstrating that cognitive, affective, and behavioral dimensions of learning possess

strong physiological foundations through the involvement of the autonomic nervous system (Hakim et al., 2022; Asman et al., 2021).

### 3. Strengthening the Theoretical Foundations of Islamic Education Through Neuroscience Concepts

The findings indicate that concepts related to the peripheral and autonomic nervous systems can strengthen the theoretical foundations of Islamic education through an integrative approach combining neuroscience and Islamic values. The reviewed literature suggests that neuroscience-based Islamic education has emerged from the recognition that human learning encompasses not only cognitive processes but also emotional, moral, social, and spiritual dimensions. Studies discussing the repositioning of Islamic education in the era of neuroscience emphasize the need for Islamic education to respond to developments in cognitive science and neuroscience while maintaining its grounding in the principle of *tawhid* (Islamic monotheism). Within this framework, the autonomic nervous system provides a valuable concept for explaining the relationship between human biological conditions and educational activities aimed at developing morality, character, and spirituality.

The findings further suggest that concepts such as *dhikr* (remembrance of God), *tafakkur* (reflection), *nazhar* (observation), *muhasabah* (self-evaluation), and *ijtihad* (independent reasoning) may be understood not only as spiritual practices but also as activities involving physiological and neurological regulation. Consequently, the integration of neuroscience and Islamic education creates new opportunities for understanding educational processes in a more holistic manner (Mujiburrahman et al., 2025; Suyadi, 2022).

The synthesis also indicates that Islamic character education gains a stronger theoretical foundation when linked to neuroscience findings concerning the autonomic nervous system. Neuroscience-based character education literature explains that character formation depends not only on teaching values and norms but also on biological changes occurring through neuroplastic processes. This perspective provides a new understanding of how morality, integrity, and self-control in Islamic education may be interpreted through biological mechanisms supporting habit formation and behavioral development. Research on neuroscience-based anti-corruption education further demonstrates that honesty and integrity can be cultivated through approaches that simultaneously develop rational and spiritual awareness. Therefore, the autonomic nervous system may be positioned as one of the neurobiological foundations explaining how Islamic values become internalized within learners (Asman et al., 2021; Suyadi et al., 2021).

Furthermore, the findings reveal that neuroscience-based Islamic education contributes not only to spiritual development but also to the enhancement of critical thinking, social awareness, and tolerance. Studies on neuroscience-based inclusive Islamic education suggest that the ability to understand others, regulate social emotions, and establish harmonious relationships is associated with nervous system functions supporting empathy and emotional regulation. These findings indicate that the autonomic nervous system is highly relevant to the objectives of Islamic education in developing morally upright, tolerant, and socially responsible individuals. Thus, the synthesis of neuroscience concepts concerning the autonomic nervous system contributes significantly to expanding the theoretical foundations of Islamic education

from a predominantly normative framework toward a more integrative and evidence-based approach (Putra & Suyadi, 2022; Afdhal et al., 2025).

**Significance of the Findings**

The significance of this study lies in its demonstration that the autonomic nervous system represents an educational component that has received relatively limited attention, particularly within the field of Islamic education. The findings reveal that physiological regulation mediated by the autonomic nervous system is directly associated with attention, memory, emotion, motivation, self-regulation, and learning behavior. Consequently, this study expands the scope of neuroeducation by positioning the autonomic nervous system as a neurobiological foundation of learning. Furthermore, the study contributes conceptually to the development of neuroscience-based Islamic education by demonstrating that Islamic concepts such as *dhikr*, *tafakkur*, *muhasabah*, and character formation can be understood through scientific approaches without diminishing their spiritual dimensions. This contribution is particularly important because it fosters a more productive dialogue between modern neuroscience and the Islamic educational tradition.

**Research Implications**

The theoretical implication of this study is the development of a conceptual framework that integrates the autonomic nervous system, neuroeducation, and Islamic education within a unified model. Practically, the findings suggest that educators should recognize that learning success is determined not only by instructional methods but also by students' physiological and emotional conditions. The study further highlights opportunities for developing educational strategies that emphasize emotional regulation, mental health, and psychological well-being. Within the context of Islamic education, these findings may serve as a foundation for designing learning models that simultaneously integrate spiritual practices, character development, and neuroscience principles.

**Research Limitations**

This study has several limitations. First, it employed a systematic literature review approach; therefore, all findings were derived from literature analysis rather than direct empirical data collection. Second, the reviewed studies varied considerably in research design, population characteristics, and research focus, making the synthesis primarily conceptual rather than quantitative. Third, most neuroscience studies analyzed originated from health sciences and general neuroeducation contexts, while research specifically examining the autonomic nervous system within Islamic educational settings remains relatively limited. Finally, because this study focused on literature synthesis, it cannot empirically establish causal relationships between autonomic nervous system activity and students' learning outcomes in Islamic educational contexts. Future research should therefore develop empirical studies that directly examine the relationships among autonomic nervous system regulation, learning processes, and character development within neuroscience-based Islamic education.

## CONCLUSIONS

Based on the systematic review of 30 articles concerning health neuroscience, the autonomic nervous system, neuroeducation, and neuroscience-based Islamic education, it can be concluded that the Peripheral Nervous System (PNS), particularly the Autonomic Nervous System (ANS), serves as an essential neurobiological foundation for learning. The reviewed literature consistently indicates that the ANS not only regulates involuntary physiological functions but also influences attention, memory, emotional regulation, motivation, decision-making, and learning behavior. The balance between sympathetic and parasympathetic activity affects learners' readiness to receive, process, and respond to information. Evidence from studies employing Heart Rate Variability (HRV), Electrocardiography (ECG), Electrodermal Activity (EDA), and wearable biosensors further demonstrates that autonomic regulation is closely associated with mental well-being, adaptability, and academic performance. These findings suggest that learning should be viewed as an integrated process involving neurological, physiological, psychological, and environmental interactions rather than solely a cognitive function of the brain.

The review also highlights the significant contribution of neuroeducation in explaining how autonomic nervous system activity supports learning. Neuroeducation research shows that attention, working memory, executive functioning, motivation, engagement, and self-regulation are strongly influenced by physiological conditions mediated through the ANS. Consequently, successful learning depends not only on instructional quality and teaching strategies but also on learners' physiological and emotional stability. Several neurodidactic approaches identified in the literature indicate that educational practices attentive to neurological and emotional dimensions can improve both learning outcomes and student well-being. Therefore, the ANS can be regarded as a critical link between biological processes and educational achievement.

From the perspective of Islamic education, the findings demonstrate that neuroscience can enrich the theoretical foundations of educational practice. Concepts such as *'aql*, *dhikr*, *tafakkur*, *tadabbur*, *muhasabah*, self-control, and character development can be meaningfully related to neurological mechanisms underlying cognition, emotion, and behavior. Integrating neuroscience with Islamic education offers a broader educational framework that encompasses intellectual, emotional, moral, social, and spiritual development. In this regard, the autonomic nervous system may function as a conceptual bridge connecting contemporary neuroscience with the objectives of Islamic education in developing knowledgeable, ethical, spiritually aware, and adaptable individuals.

The main contribution of this study lies in synthesizing three fields that are often examined separately: neuroscience, neuroeducation, and Islamic education. The findings demonstrate that the autonomic nervous system occupies a strategic position in explaining the relationship between physiological regulation, learning processes, and Islamic educational values. This synthesis expands the scope of neuroeducation while providing a foundation for a more holistic and evidence-based model of Islamic education. Future research should focus on empirical investigations examining ANS activity during learning through technologies such as HRV, EEG, EDA, and wearable biosensors. In addition, further studies should explore neuroscience-informed learning models that support emotional regulation, stress management, and student well-being. Research examining the effects of spiritual practices, including *dhikr*, reflection, prayer, and self-regulation, on autonomic functioning would also contribute to the advancement of neuroscience-based Islamic education. Furthermore, integrating developments in

Artificial Intelligence (AI), neuro-pedagogy, and digital learning technologies may support the creation of more adaptive and personalized educational approaches. Such efforts are expected to strengthen both the theoretical and practical development of Islamic education in the era of neuroscience and digital transformation.

## BIBILIOGRAPHY

Afdhal, S., Ritonga, M., Nasution, A. J., & Salonen, E. (2025). Dysfunction of Islamic Religious Education in the SDGs Era: Challenges in Internalizing Islamic Values for Youth Responsibility. *Profetika: Jurnal Studi Islam*, *26*(03), 867-882.

Aktaş, N., & Sazak, Y. (2025). The use of an escape room-based learning strategy to enhance pharmacology knowledge among nursing students. *BMC Nursing*. https://doi.org/10.1186/s12912-025-04270-8

Asman, A., Suyadi, S., & Huda, M. (2021). Character Education as Brain Education: Spiritual Neuroscience Studies in Islamic Education. *Jurnal Tarbiyatuna*, *12*(2), 77–86. https://doi.org/10.31603/tarbiyatuna.v12i2.4278

Borst, G. (2023). Neuroeducation _ LaPsyDÉ (UMR CNRS 8240). *Annee Psychologique*, *123*(2), 387–392. https://doi.org/10.3917/anpsy1.232.0387

Brick, K., Cooper, J. L., Mason, L., Faeflen, S., Monmia, J., & Dubinsky, J. M. (2021). Training-of-Trainers Neuroscience and Mental Health Teacher Education in Liberia Improves Self-Reported Support for Students. *Frontiers in Human Neuroscience*, *15*. https://doi.org/10.3389/fnhum.2021.653069

Burlacu, A., Brinza, C., Geman, O., Karppa, M., & Hemanth, D. J. (2026). Heart rate variability as a dual-use digital biomarker: integrating clinical, AI, and operational perspectives on human performance and resilience. In *BMC Cardiovascular Disorders* (Vol. 26, Number 1). BioMed Central Ltd. https://doi.org/10.1186/s12872-026-05543-z

Camacho-Navas, C., Li, L., Poply, K., Mehta, V., & Kyriacou, P. (2026). Pain assessment using physiological responses/markers in different types of pain: a scoping review. *Npj Digital Medicine*. https://doi.org/10.1038/s41746-025-02241-6

Cubelli, R., & Sala, S. Della. (2022). Neuroscience in education: Not a recipe book. *Italian Journal of Educational Technology*, *30*(3), 6–15. https://doi.org/10.17471/2499-4324/1274

Fuchs, B., Ejtehadi, M., Cisnal, A., Pannek, J., Scheel-Sailer, A., Riener, R., Eriks-Hoogland, I., & Paez-Granados, D. (2026). Robust learning framework for a scalable remote monitoring of autonomic dysreflexia: use-case in spinal cord injury. *Scientific Reports*, *16*(1). https://doi.org/10.1038/s41598-025-33797-8

Gedam, S., Pranav, P., Dutta, S., & Jha, R. (2026). A deep learning approach with wearable physiological sensors and feature selection methods to detect mental stress in Indian housewives. *Discover Artificial Intelligence*. https://doi.org/10.1007/s44163-026-00837-9

Gkintoni, E., Dimakos, I., Halkiopoulos, C., & Antonopoulou, H. (2023). Contributions of Neuroscience to Educational Praxis: A Systematic Review. In *Emerging*

*Science Journal* (Vol. 7, Number Special Issue 2, pp. 146–158). Ital Publication. https://doi.org/10.28991/ESJ-2023-SIED2-012

Grospietsch, F., & Lins, I. (2021). Review on the Prevalence and Persistence of Neuromyths in Education – Where We Stand and What Is Still Needed. In *Frontiers in Education* (Vol. 6). Frontiers Media S.A. https://doi.org/10.3389/feduc.2021.665752

Hakim, R., Ritonga, M., Khodijah, K., Zulmuqim, Z., Remiswal, R., & Jamalyar, A. R. (2022). Learning strategies for reading and writing the quran: improving student competence as preservice teachers at the faculty of tarbiyah and teacher training. *Education Research International*, *2022*(1), 3464265.

Hosney, M. E., Emam, M. M., Saad, M. R., Samee, N. A., & Houssein, E. H. (2026). Heart rate optimizer: a novel bio-inspired metaheuristic algorithm. *Scientific Reports*, *16*(1). https://doi.org/10.1038/s41598-026-44516-2

Jhon, M., Kim, J. W., Lee, K., Kim, D., Park, S. H., Kim, C., Lim, B., Kim, S. Y., Kim, S. W., Kim, J. M., Shin, I. S., & Choi, Y. (2026). Contactless depression screening via facial video-derived heart rate variability. *Translational Psychiatry*, *16*(1). https://doi.org/10.1038/s41398-026-03831-y

Mujiburrahman, M., Zulfikar, T., Ibrahim, I., & Zulfatmi, Z. (2025). Academic Discourses on the Cognitive Revolution and the Repositioning of Islamic Education in the Era of Neurosciences. *Jurnal Ilmiah Islam Futura*, *25*(2), 305–330. https://doi.org/10.22373/jiif.v25i2.25997

Pradeep, K., Sulur Anbalagan, R., Thangavelu, A. P., Aswathy, S., Jisha, V. G., & Vaisakhi, V. S. (2024). Neuroeducation: understanding neural dynamics in learning and teaching. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1437418

Putra, A. F. M., & Suyadi, S. (2022). The Concept of Neuroscience-Based Inclusive Islamic Education for Millennial Generation: A Literature Review. *Jurnal Penelitian Pendidikan Islam*, *10*(1), 41. https://doi.org/10.36667/jppi.v10i1.933

Qafa, A., Treska, T., Sina, Z., Kosova, R., & Shahini, M. (2025). Neuroeducation in the Classroom: From Theoretical Foundations to Practical Challenges. *Journal of Educational and Social Research*, *15*(4), 343–357. https://doi.org/10.36941/jesr-2025-0142

Ritonga, M., Tazik, K., Omar, A., & Saberi Dehkordi, E. (2022). Assessment and language improvement: the effect of peer assessment (PA) on reading comprehension, reading motivation, and vocabulary learning among EFL learners. *Language testing in Asia*, *12*(1), 36.

Schmitt, A., Wollschläger, R., Blanchette Sarrasin, J., Masson, S., Fischbach, A., & Schiltz, C. (2023). Neuromyths and knowledge about intellectual giftedness in a highly educated multilingual country. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1252239

Shukla, S., Shukla, P., Gore, R., Mishra, B. N., Katiyar, A. K., & Singh, V. (2025). Mapping the Neuroeducation Landscape: A Bibliometric Analysis (2020–2025).

In *Annals of Neurosciences*. SAGE Publications Inc. https://doi.org/10.1177/09727531251355822

Suyadi, Nuryana, Z., & Asmorojati, A. W. (2021). The insertion of anti-corruption education into Islamic education learning based on neuroscience. *International Journal of Evaluation and Research in Education*, *10*(4), 1417–1425. https://doi.org/10.11591/IJERE.V10I4.21881

Suyadi, Nuryana, Z., & Fauzi, N. A. F. (2020). The fiqh of disaster: The mitigation of Covid-19 in the perspective of Islamic education-neuroscience. *International Journal of Disaster Risk Reduction*, *51*. https://doi.org/10.1016/j.ijdrr.2020.101848

Suyadi. (2022). Learning Taxonomy of Islamic Education: The Development of Aql and the Brain in Quran from a Neuroscience Perspective. *Millah: Journal of Religious Studies*, *21*(2), 361–410. https://doi.org/10.20885/millah.vol21.iss2.art3

Trujillo, J., Ferrer-Cascales, R., Teruel, M. A., Ruiz-Robledillo, N., Sanchis, J., García-Ponsoda, S., Panagiotidis-Arrizabalaga, A., Albaladejo-Blázquez, N., Martínez-Nicolás, Á., García-Carrasco, J., Reina, A., Lavalle, A., Maté, A., & Costa-López, B. (2026). A Multimodal Dataset for Neurophysiological and AI Applications. *Scientific Data*, *13*(1), 436. https://doi.org/10.1038/s41597-026-06758-7

Tumiran, M. A., Saat, R. M., Rahman, N. N. A., & Adli, D. S. H. (2010). Sleep from neuroscience and Islamic perspectives: Comprehension and practices of Muslims with science background in Malaysian education system. *Procedia - Social and Behavioral Sciences*, *9*, 560–564. https://doi.org/10.1016/j.sbspro.2010.12.197

Tumiran, Siregar, B., Lubis, S., Harahap, M. Y., & Rahman, M. H. (2026). AI-Driven Islamic Classroom Management in the Digital Era: The Roles of Neuro-Pedagogy, Spiritual Intelligence, and Innovative Teaching Performance. *Qubahan Academic Journal*, *6*(2), 191–205. https://doi.org/10.48161/qaj.v6n2a2072

Ventura, M., Ventura-Campos, N., & Moreno-Rus, A. (2024). Impact of a neurodidactics training program on psychological capital: influence on academic motivation and engagement. *European Public and Social Innovation Review*, *9*. https://doi.org/10.31637/epsir-2024-565

Wang, X., Zhang, Y., Zhao, S., Hui, H., He, B., Jiang, C., Y.R. Stainier, D., & Yang, H. (2026). Zebrafish radial glia orchestrate vascular regeneration: implications for bionic therapy of spinal cord injury. *Stem Cell Research & Therapy*. https://doi.org/10.1186/s13287-026-04898-6

Yusmaliana, D., Suyadi, Widodo, H., & Suryadin, A. (2020). Creative imagination base on neuroscience: A development and validation of teacher's module in covid-19 affected schools. *Universal Journal of Educational Research*, *8*(11), 5849–5858. https://doi.org/10.13189/ujer.2020.082218

Zhumabayeva, Z., Bazarbekova, R., Nurzhanova, S., Stambekova, A., & Kalbergenova, S. B. (2025). Development of neuro-didactic content aimed at developing the intelligence of younger schoolchildren. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1584490