International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 10, October 2026)

Neuro-Informed Pedagogy: Bridging Brain Science, Teaching, and Human-Centred Learning in the 21st Century

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***Abstract*-- Neuro-informed pedagogy is an emerging interdisciplinary approach that uses credible findings from neuroscience, cognitive psychology, and learning sciences to inform teaching, curriculum design, assessment, and educational decision-making. It recognises that learning is influenced by attention, memory, emotion, motivation, prior knowledge, cognitive load, sleep, and social interaction. Rather than prescribing a single teaching method, neuro-informed pedagogy encourages educators to design learning experiences that are cognitively appropriate, emotionally supportive, inclusive, and responsive to learners' individual needs. In the context of 21st-century education, digital technologies and artificial intelligence (AI) create new opportunities for personalisation but also raise questions about cognitive engagement, learner autonomy, critical thinking, and human agency. This article examines the conceptual foundations of neuro-informed pedagogy, explains its key principles in accessible paragraphs, and discusses practical strategies for classroom implementation. It also highlights the importance of scientific evidence, ethical practice, and teacher professional development in translating brain research into meaningful educational outcomes.**

***Keywords*-- Neuro-informed pedagogy, neuroscience, cognitive psychology, memory, cognitive load, emotional learning, metacognition, inclusive education, artificial intelligence, teacher professional development.**

I. Introduction

Education is fundamentally concerned with how human beings learn, understand, remember, apply, and transfer knowledge. However, traditional instructional practices sometimes emphasise the delivery of content more than the cognitive and emotional processes through which learners make sense of it. A student may listen to a lesson without understanding it, memorise information without retaining it, or perform well in an examination without being able to apply the knowledge in a new context. These challenges suggest that effective teaching requires more than subject expertise and curriculum coverage; it requires an understanding of the learner.

Neuroscience and cognitive psychology have expanded our understanding of the mechanisms associated with learning. Research indicates that attention, working memory, long-term memory, emotion, motivation, and prior knowledge influence how learners process information. These findings provide useful foundations for developing teaching practices that are more responsive to the needs of learners (Dehaene, 2020; National Academies of Sciences, Engineering, and Medicine, 2018).

Neuro-informed pedagogy can therefore be understood as the thoughtful application of well-supported findings from neuroscience and the learning sciences to educational practice. The term neuro-informed is important: it does not suggest that brain scans can prescribe the perfect lesson or that every educational problem has a neurological solution. Instead, it encourages educators to use scientific evidence alongside professional judgement, classroom observation, cultural understanding, and knowledge of individual learners.

In contemporary education, this approach is particularly relevant because teachers must support not only academic achievement but also critical thinking, creativity, collaboration, emotional regulation, digital literacy, and responsible engagement with AI. The central question is no longer simply, "How much content has the teacher covered?" It is also, "What has the learner understood, retained, applied, and become capable of doing independently?"

II. Understanding The Foundations Of Neuro-Informed Pedagogy

Neuro-informed pedagogy rests on the principle that learning is an active process of constructing, strengthening, and applying knowledge. The brain does not function as a passive container into which information is deposited. Learners interpret new information through their existing knowledge, experiences, expectations, and social environments. Consequently, effective teaching must connect new concepts with what students already know, provide opportunities to practise, and help learners develop meaningful relationships between ideas. The National Academies of Sciences, Engineering, and Medicine (2018) emphasises that learning is shaped by the interaction of cognitive, social, emotional, cultural, and biological factors. This perspective encourages teachers to consider the whole learner rather than focusing exclusively on academic performance.

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A second foundation is the relationship between neuroscience and educational psychology. Neuroscience investigates the brain and nervous system, while cognitive psychology examines processes such as attention, reasoning, memory, and problem-solving. Educational research investigates how these processes interact with instructional methods, classroom environments, assessment, and learning outcomes. Neuro-informed pedagogy brings these perspectives together, while recognising that evidence from brain research cannot automatically be translated into a classroom prescription. A teaching strategy should be evaluated by whether it improves meaningful learning, not merely by whether it can be associated with a particular brain region.

III. Key Principles of Neuro-Informed Pedagogy: Explained in Simple Paragraphs

3.1 Attention is the gateway to learning

Attention determines which aspects of the information available in the environment receive priority for processing. Students may struggle to learn when a lesson contains excessive distractions, lengthy explanations, unclear instructions, or too many competing demands. Teachers can support attention by communicating clear learning objectives, using meaningful examples, asking focused questions, and dividing complex explanations into manageable segments. For instance, instead of presenting an entire chapter on photosynthesis in one uninterrupted lecture, a teacher might introduce the central concept, demonstrate the process, ask students to interpret a diagram, and then invite them to explain what they have understood. The objective is not to assume that attention always lasts for a fixed number of minutes, but to design lessons that repeatedly reconnect students with the learning task.

Key pointer: Capture attention through relevance, clarity, curiosity, purposeful questioning, and active participation rather than relying exclusively on entertainment or novelty.

3.2 Working memory and cognitive load must be managed

Working memory allows learners to hold and manipulate information temporarily while completing a task. Its capacity is limited, especially when learners encounter unfamiliar or complex material. When teachers introduce too many new concepts, unfamiliar terms, instructions, and visual elements simultaneously, students may become cognitively overloaded. Cognitive load theory explains why instructional design should minimise unnecessary mental demands and provide appropriate guidance when learners are developing new knowledge (Sweller, 1988).

For example, when teaching algebra, a teacher can demonstrate one worked example, explain each step, and gradually move towards independent problem-solving. Providing a labelled diagram alongside an explanation may help students understand a complicated scientific process, whereas displaying excessive decorative images or repeating identical information across multiple formats may distract them. As students gain expertise, the teacher can gradually reduce support and increase task complexity.

Key pointer: Simplify the presentation of information without oversimplifying the subject. Introduce unfamiliar concepts progressively, model complex tasks, and provide scaffolding before expecting independent performance.

3.3 Learning requires memory formation and retrieval

Understanding a concept during a lesson does not guarantee that a student will remember it a week later. Durable learning depends on the development and strengthening of memory through meaningful processing, practice, and retrieval. Retrieval practice requires students to recall information from memory rather than merely reread it. Spaced practice involves revisiting knowledge across multiple sessions instead of concentrating all practice into one period. Research reviews identify both approaches as effective strategies for supporting long-term retention (Dunlosky et al., 2013).

A teacher can apply these principles by beginning a lesson with three questions from the previous class, revisiting the same concepts after several days, and asking students to explain an idea without looking at their notes. Short, low-stakes quizzes can reveal misconceptions while strengthening recall. Students should receive feedback so that incorrect understandings can be corrected. Retrieval is therefore not simply an examination technique; it is also a learning activity.

Key pointer: Teach, retrieve, receive feedback, revisit, and apply. Repeated exposure is useful, but students also need opportunities to recall and use what they have learned.

3.4 Emotion and cognition are interconnected

Learning is influenced by emotional experiences, perceived safety, motivation, belonging, and expectations of success. A student who fears ridicule may hesitate to ask questions, while a learner who feels respected may be more willing to participate, make mistakes, and reconsider an incorrect answer. This does not mean that learning must always be enjoyable or free from challenge. Rather, productive learning requires an environment in which intellectual difficulty can be experienced without unnecessary humiliation or threat.

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Immordino-Yang and Damasio (2007) explain why emotion and cognition should not be treated as entirely separate processes in education. Teachers can apply this insight by establishing respectful classroom routines, acknowledging effort and progress, responding constructively to mistakes, and connecting lessons with meaningful human experiences. When students encounter frustration, educators can help them identify the problem, select a strategy, and persist without interpreting temporary difficulty as evidence of low ability.

Key pointer: Build psychological safety and belonging while maintaining high expectations. Emotional support should help students engage with challenging work, not remove the challenge itself.

3.5 Motivation grows through purpose, competence, and autonomy

Motivation influences whether students initiate learning, sustain effort, and continue working when tasks become difficult. Learners are more likely to engage when they understand the purpose of an activity, experience progress, and have appropriate opportunities to make choices. Motivation is not produced by praise or rewards alone; it is shaped by students' beliefs about their abilities, the value of the task, their relationships with teachers, and the learning environment (National Academies of Sciences, Engineering, and Medicine, 2018).

A mathematics teacher, for example, may connect percentages with shopping discounts, budgeting, or interpreting survey results. Students might then select one of several problems to solve, explain their reasoning, and reflect on their progress. Such practices make learning relevant while allowing the teacher to maintain curricular objectives and standards.

Key pointer: Make learning purposeful, provide achievable but meaningful challenges, recognise progress, and give students structured opportunities to exercise choice and responsibility.

3.6 Prior knowledge provides the foundation for new learning

Learners do not enter a classroom as blank slates. They bring previous knowledge, everyday experiences, cultural understandings, assumptions, and misconceptions. New information is easier to interpret when students can connect it with relevant existing knowledge. However, prior knowledge can also interfere with learning when an inaccurate explanation has become firmly established.

Teachers should therefore assess what students already understand before introducing a new topic. Concept maps, diagnostic questions, classroom discussions, demonstrations, and prediction activities can reveal students' initial thinking. In a science lesson about gravity, for example, some students may assume that heavier objects always fall faster than lighter objects. A carefully designed demonstration, followed by an explanation of the relevant conditions, can help students reconsider this belief and develop a more accurate scientific model.

Key pointer: Begin with what learners know, identify misconceptions, and explicitly connect new knowledge with existing mental models.

3.7 Feedback and metacognition support self-regulated learning

Metacognition refers to the ability to monitor and regulate one's own thinking and learning. Metacognitive learners plan how to approach a task, monitor their understanding, recognise difficulties, and evaluate the effectiveness of their strategies. These abilities are especially important when students move from teacher-guided activities towards independent learning.

Feedback should explain not only whether an answer is correct but also what the learner has done well, what needs improvement, and what the next step should be. For example, instead of writing "poor answer" on an assignment, a teacher might explain that the student has identified the main idea but needs evidence to support the conclusion. Students can then use a reflection journal or checklist to identify the strategy they will apply in their next attempt.

Key pointer: Encourage learners to ask themselves: What am I trying to learn? What do I understand? Where am I confused? Which strategy should I try next?

3.8 Social interaction contributes to learning

Learning takes place within social and cultural contexts. Discussion, collaborative problem-solving, peer explanation, and dialogue with teachers can help students articulate their thinking, encounter alternative perspectives, and refine their understanding. However, group work is not automatically effective. It requires a clear purpose, appropriate task design, individual accountability, and opportunities for every student to contribute.

For example, a teacher may ask groups to investigate a local environmental problem, evaluate evidence, propose solutions, and present their reasoning. Each student can be assigned a meaningful responsibility, while the teacher monitors participation and addresses misconceptions.

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This approach connects knowledge with communication, collaboration, critical thinking, and civic responsibility.

Key pointer: Use collaboration to deepen understanding, not simply to divide tasks. Ensure that every learner explains, questions, evaluates, or applies knowledge.

3.9 Individual differences require flexible teaching

Students differ in their prior knowledge, language proficiency, developmental stage, interests, learning difficulties, cultural experiences, and access to resources. Neuro-informed pedagogy does not suggest that every student needs an entirely separate curriculum. It encourages teachers to offer appropriate support, multiple ways of engaging with content, and varied opportunities to demonstrate learning.

For example, a teacher may explain a concept verbally, represent it through a diagram, provide a worked example, and ask students to apply it to a practical problem. Students may receive additional guided practice when necessary, while those who have mastered the foundational material move towards more complex applications. These adaptations should be based on learning objectives, evidence of student understanding, and accessibility needs—not assumptions about fixed neurological categories.

Key pointer: Adapt instruction to learners' demonstrated needs, while maintaining meaningful expectations and access to challenging learning opportunities.

3.10 Sleep, movement, and well-being matter

Learning is affected by conditions beyond the immediate lesson. Sleep supports memory consolidation and cognitive functioning, while physical activity can contribute to health, attention, and aspects of executive functioning. Fatigue, hunger, chronic stress, and inadequate opportunities for movement may make learning more difficult. These factors should be understood as part of the wider conditions supporting education, rather than as simple explanations for every instance of poor performance.

Schools can support well-being through reasonable workloads, movement breaks, age-appropriate physical activity, supportive relationships, and education about healthy routines. Teachers should not diagnose neurological or medical problems based on classroom behaviour; persistent concerns should be addressed through appropriate school support systems and qualified professionals.

Key pointer: Recognise that learning depends on the learner's broader physical and social environment. Support healthy routines without reducing educational challenges to biology alone.

IV. Neuro-Informed Pedagogy In The Age Of Artificial Intelligence

Artificial intelligence is changing how educational content is created, presented, assessed, and personalised. AI-powered systems can provide explanations, generate practice questions, offer immediate feedback, and help teachers identify learning gaps. Nevertheless, technological efficiency should not be confused with educational effectiveness. If learners routinely ask AI to generate answers without analysing the problem, explaining their reasoning, or evaluating the evidence, they may complete tasks while missing opportunities to develop independent understanding.

A neuro-informed approach to AI integration begins by identifying the cognitive purpose of a learning activity. AI may be used to generate alternative explanations, offer graduated hints, provide practice questions, or simulate a dialogue in which students defend their arguments. However, students should still be expected to retrieve knowledge, evaluate claims, explain their reasoning, and apply ideas independently. Teachers remain essential in designing learning experiences, interpreting student needs, building relationships, and exercising professional judgement.

This perspective is particularly relevant to human-centred AI in education. The objective should be to develop systems that support human cognition, agency, creativity, and social development rather than simply automate the completion of academic tasks. AI should extend the teacher's capacity to support learning without replacing the learner's responsibility to think. This is a central principle for developing a neuro-informed, human-oriented AI pedagogical framework.

For example, in a secondary-school science lesson, students could first attempt to explain a phenomenon independently. They could then use an AI tool to compare their explanation with an alternative account, identify discrepancies, verify the evidence, and revise their understanding. Finally, they could explain the concept without AI assistance. This sequence makes technology a resource for thinking rather than a substitute for it.

Key pointer: Use AI to scaffold thinking, personalise practice, and support feedback, but preserve opportunities for independent retrieval, reasoning, decision-making, and reflection. Protect student privacy, verify AI-generated information, and ensure that access to learning support is equitable.

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V. Translating Neuro-Informed Pedagogy Into Classroom Practice

The effectiveness of neuro-informed pedagogy depends on how well its principles are translated into lesson planning, instructional routines, assessment, and teacher development. The following practical pointers offer a manageable starting point.

VI. A Practical Neuro-Informed Lesson Sequence

1. Activate prior knowledge

Begin with a short question, prediction, demonstration, or retrieval activity that connects the new topic with previously learned material.

2. Introduce concepts in manageable steps

Explain one central idea at a time, model unfamiliar processes, use purposeful visuals, and check understanding before increasing complexity.

3. Engage learners actively

Include questioning, discussion, problem-solving, demonstrations, and opportunities for students to explain concepts in their own words.

4. Practise retrieval and application

Ask students to recall the main ideas without notes, correct misunderstandings, and apply their knowledge to a new example or problem.

5. Provide constructive feedback

Identify what the student understands, explain the next step, and allow time for revision rather than treating assessment only as a final score.

6. Revisit and reflect

Return to important ideas in later lessons and ask learners to reflect on what they remember, what remains difficult, and which strategies helped them.

This is a flexible planning sequence, not a rigid formula. Teachers should adapt it to the subject, age group, learning objective, available time, and evidence of student progress.

VII. An Illustrative Classroom Example

Consider a lesson on fractions for students in the upper-primary grades. The teacher begins by asking students to identify one-half and one-quarter using familiar objects. Students then examine visual representations and work through a carefully explained example.

Next, they solve problems independently and explain why two fractions may represent the same quantity. A brief retrieval activity checks what they can recall, while feedback addresses errors in their reasoning. In the next lesson, students revisit the concept through a practical measurement task.

The lesson integrates prior knowledge, manageable cognitive demands, active processing, retrieval practice, feedback, and spaced review. Its value does not depend on the teacher identifying which brain region is active at each stage. It depends on designing a coherent learning experience informed by established evidence about how knowledge is acquired, retained, and applied.

VIII. Neuro-Informed Pedagogy And 21st-Century Competencies

Neuro-informed pedagogy can contribute to the development of competencies associated with 21st-century education, including critical thinking, creativity, communication, collaboration, self-regulation, and responsible digital participation. These competencies are not produced automatically by brain-based activities; they require explicit instruction, deliberate practice, meaningful assessment, and opportunities to transfer learning to unfamiliar situations.

Critical thinking develops when students evaluate evidence, identify assumptions, compare explanations, and justify conclusions. Creativity can be encouraged through open-ended problems, experimentation, and the development of multiple solutions. Collaboration requires learners to listen, explain, negotiate, and respond constructively to different viewpoints. Metacognitive routines help students monitor their understanding and regulate their learning, while responsible AI use requires them to question generated information and retain ownership of their decisions.

For teacher educators, the implication is that professional development should connect learning science with subject-specific pedagogy. A workshop should not stop at explaining the brain or introducing terminology. Teachers should redesign a lesson, justify their instructional choices, implement the changes, collect evidence of student learning, and reflect on the results. This creates a bridge between scientific understanding and classroom improvement.

Key pointer: Develop 21st-century competencies through explicit teaching, authentic tasks, feedback, reflection, and repeated opportunities to apply knowledge—not through technology use or novelty alone.

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IX. Common Misconceptions And Scientific Cautions

Neuro-informed pedagogy must be distinguished from popular claims that use neuroscience terminology without adequate evidence. Howard-Jones (2014) highlights the persistence of neuromyths in education and the risks created when scientific findings are distorted during their translation into teaching practice.

One common misconception is that students learn best when teachers match instruction to fixed visual, auditory, or kinaesthetic learning styles. Although learners have preferences and different tasks benefit from different representations, the claim that matching instruction to a diagnosed learning style reliably improves learning is not adequately supported. Teachers should select methods according to the learning objective, the nature of the content, accessibility requirements, and evidence of student understanding.

Another misconception is that learners use only a small percentage of their brains, or that a single classroom activity can activate the entire brain and guarantee learning. Learning involves complex and distributed neural processes; no simplistic percentage or universal brain-activation technique can explain educational success. Similarly, the idea that the brain becomes permanently incapable of learning after a particular age is inconsistent with evidence that learning and adaptation continue across the lifespan.

Educators should also avoid treating all stress as harmful, assuming that every student has the same attention span, or interpreting classroom behaviour as direct evidence of a particular brain state. Scientific findings frequently describe probabilities, mechanisms, and conditions rather than universal rules. What works for one learner or task may not work equally well for another.

Key pointer: Distinguish evidence-based principles from commercial claims, popular brain myths, and unsupported promises. Evaluate instructional strategies through credible research and actual learning outcomes.

X. Challenges In Implementing Neuro-Informed Pedagogy

Several barriers may limit implementation. Teachers may have limited time to engage with research, large classes may restrict individualised feedback, and curriculum pressures may encourage rapid content coverage rather than deeper understanding. Access to technology, teacher expertise, school leadership, and the cultural relevance of learning materials may also influence implementation.

These challenges suggest that neuro-informed pedagogy should not be introduced as another isolated educational initiative. It should be integrated into existing curriculum planning, assessment practices, inclusive education policies, and continuing professional development. Schools can begin with small, evidence-informed changes, such as retrieval questions, clearer explanations, improved feedback, and structured reflection. Teachers can then examine whether these practices improve retention, participation, conceptual understanding, and independent application.

Evaluation is essential. Student engagement alone does not prove that learning has occurred, and a positive immediate test score does not necessarily indicate long-term retention. Schools should therefore combine classroom observations, student explanations, low-stakes assessments, delayed retrieval tasks, and evidence of transfer to new situations. Where possible, collaborative inquiry or design-based research can help teachers test, refine, and document promising practices.

XI. Future Directions: From Neuro-Informed Teaching To Neuro-Informed Educational Design

The future of neuro-informed pedagogy lies in developing educational systems that connect learning science, teacher expertise, inclusive practice, and responsible technology. Research should investigate not only whether a teaching strategy improves immediate performance but also whether learners retain knowledge, transfer it to unfamiliar situations, develop independent learning strategies, and maintain their agency when using AI-supported tools.

An important research direction is the development of a human-centred neuro-informed AI pedagogical framework. Such a framework could integrate five interconnected dimensions: cognitive processes, emotional and motivational conditions, evidence-informed instructional design, responsible AI integration, and teacher professional learning. Researchers could use a design-based research approach to develop the framework, test it in authentic classrooms, collect qualitative and quantitative evidence, and refine it through successive implementation cycles. This would help establish which combinations of pedagogical strategies and AI supports are effective, for whom, and under what conditions.

However, the framework should remain evidence-driven rather than assuming that AI can directly identify or interpret a student's neurological state. Its success should be assessed through educational outcomes, learner experiences, teacher judgement, accessibility, privacy, and ethical safeguards.

The ultimate objective is not to make education more technologically sophisticated for its own sake, but to make learning more meaningful, equitable, durable, and human-centred.

XII. Conclusion

Neuro-informed pedagogy offers a valuable perspective for understanding and improving teaching and learning in the 21st century. By drawing on neuroscience, cognitive psychology, and the learning sciences, it encourages educators to pay attention to the processes through which learners acquire, retain, retrieve, and apply knowledge. Its central principles include supporting attention, managing cognitive load, activating prior knowledge, strengthening memory through retrieval and spaced practice, creating emotionally supportive environments, encouraging metacognition, and responding to learner diversity.

The practical value of this approach lies in the quality of its educational application. A teacher does not need specialised brain-imaging equipment to implement evidence-informed teaching. Instead, teachers need a sound understanding of learning principles, the ability to translate research into instructional decisions, and a commitment to evaluating the effects of those decisions.

In an era of artificial intelligence, neuro-informed pedagogy also provides a foundation for protecting the distinctly human dimensions of education. Technology can expand access to information and support personalised practice, but understanding, judgement, creativity, empathy, and responsibility must remain central to the learning process.

Ultimately, effective pedagogy is not about teaching the brain in isolation; it is about designing learning experiences that help the whole person think, understand, remember, connect, and grow.

REFERENCES

The following references are presented in APA 7th edition style and provide a foundation for further reading and academic development.

[1] Dehaene, S. (2020). How we learn: Why brains learn better than any machine … for now. Viking.

[2] Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. Psychological Science in the Public Interest, 14(1), 4–58. https://doi.org/10.1177/1529100612453266

[3] Howard-Jones, P. A. (2014). Neuroscience and education: Myths and messages. Nature Reviews Neuroscience, 15, 817–824. https://doi.org/10.1038/nrn3817

[4] Immordino-Yang, M. H., & Damasio, A. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. Mind, Brain, and Education, 1(1), 3–10. https://doi.org/10.1111/j.1751-228X.2007.00004.x

[5] National Academies of Sciences, Engineering, and Medicine. (2018). How people learn II: Learners, contexts, and cultures. The National Academies Press. https://doi.org/10.17226/24783

[6] Roediger, H. L., III, & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. Psychological Science, 17(3), 249–255. https://doi.org/10.1111/j.1467-9280.2006.01693.x

[7] Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4