Analysis of Neuroscience-Based Learning on Critical Thinking Skills of Elementary School Students

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Abstract

Learning should provide educational experiences that stimulate brain function as part of a meaningful learning method. However, currently, the problem is that most teachers only use conventional learning. This study aims to analyze neuroscience-based learning on the learning responses of elementary school students. Neuroscience-based learning integrates knowledge about how the brain works in learning with teaching methods that can stimulate students' cognition, emotions, and motivation. This study used a qualitative research design method. Data were collected through interviews with three high school teachers at the level and observations during learning with 53 students, as well as observations of student motivation and engagement during the learning process. The results of the study indicate that the implementation of neuroscience-based learning is good, as evidenced by the active responses given by students when teachers provide questions or stimuli. However, it still requires evaluation and improvement to help maximize the improvement of critical thinking skills. Teachers apply creative and innovative strategies in neuroscience-based learning in the classroom by using video aids and concrete media to help students more easily remember what they know, as well as fostering student sensitivity in learning to activate brain function. Student learning success is only assessed through evaluation of outcomes, namely by using descriptive questions, not evaluation of the processes that occur during learning. The role of the principal and teachers is a crucial factor in the success of learning, this can be proven by paying more attention to learning methods, the use of learning media with the hope of always synergizing in realizing new neuroscience-based learning methods and strategies in schools to support maximum learning outcomes.

Keywords: Analysis, Neuroscience Learning, Critical Thinking

INTRODUCTION

Learning is the core of all educational management processes, the quality of successful learning is seen from the output and outcomes produced, learning according to (Mahanani, 2018) is a process of interaction between students and teachers towards the learning environment, (Khan et al., 2021) also states that the learning process is interrelated with learning outcomes, the need to consider students' perspectives on learning in addition to the demands imposed. learning carried out should be fun and can motivate students to study harder at school and can foster active, independent, and creative traits. learning success criteria should be made in detail so that they can truly be observed and measured, Indicators of learning success have the meaning of completeness in the learning process, completeness means achieving competencies that include knowledge, skills, attitudes, or values. completeness functions to ensure that competencies obtained in the learning process can be mastered, learning completeness benchmarks refer to competency standards and basic competencies

contained in the curriculum that focus on cognitive, affective, and psychomotor that are student-centered. In line with the opinion (Anggraini, A. E., et al. 2024) which states that the three main essences/focuses of the independent curriculum are the focus on the development of soft skills and character, the main focus in the independent curriculum is on students. In implementing learning, teachers maximize the use of approaches, methods or learning strategies to support learning achievements, the increasingly complex development of education requires teachers to always innovate and renew in the learning process, in line with the opinion (Mattila et al., 2025) that the renewal process is carried out to free oneself from all forms of difficulties and obstacles that culminate in refreshing or replacing the learning process to build a new path from various aspects that are tailored to students' learning needs, which prioritizes increasing intelligence and how students' brain functions work which are closely related to neuroscience learning.

Neuroscience-based learning is learning that utilizes knowledge about the function of the human brain, this neuroscience-based learning emphasizes the importance of understanding how the brain receives, processes, and stores information in the context of learning. Neuroscience-based learning involves utilizing knowledge about the human brain to support and improve maximum learning, but in field conditions learning only tends to memorize, in certain learning teachers only provide verbalistic, theoretical learning without considering the brain's ability to digest information, learning does not teach intelligence but only provides passive knowledge in stimulating human thought patterns (Sudirman et al., 2024). The difference between conventional learning and neuroscience-based learning, this neuroscience learning is learning to understand how the brain processes, stores, and retrieves information. Emphasizes the role of emotions and motivation in learning. Neuroscience shows that positive emotions can improve information retention, neuroscience-based learning tends to use a multisensory approach (visual, auditory, kinesthetic) because the brain processes information more effectively when it involves multiple senses, in line with the opinion (Ekawati et al., 2024) which states that students have the opportunity to learn more easily if they experience it themselves by conducting experiments, and find meaningful patterns in the context of everyday life. Neuroscience learning links learning methods to individual needs, because each brain has a unique way of processing information. In this case, the use of interesting technology can also stimulate children's multisensory abilities that prioritize students' thinking skills in the independent curriculum.

Neuroscience-based learning is important to pay attention to because it is closely related to the development of children's potential, namely the child's ability to gain understanding and in the learning process and stimulate the part of the brain related to long-term memory (Roja Saputra et al., 2024), according to (Siddiqi et al., 2025) states that in training brain abilities it is necessary to consider the core competencies needed to apply brain stimulation safely and effectively, and help them remember and understand concepts better. (Sari et al., 2024) neuroscience-based learning in elementary schools has great potential to improve the quality of education and provide a more solid foundation for development. By cultivating critical thinking, learners can activate their procedural learning pathways for effective problem solving and decision making, because it allows individuals to question assumptions, evaluate evidence, and approach problems with a rational and open-minded perspective (Yuxian, 2025).

Based on the results of the preliminary study conducted by the researcher, problems were found related to the way students learn in science subjects when determining the main ideas of thoughts where elementary school students have not been able to determine which points are important in a paragraph or text, when students get the task to summarize the main ideas of a paragraph, students do not follow the directions according to the instructions given, students only rewrite what they read as a result of the task of summarizing the main ideas, from the results obtained, this shows that there are problems in students in obtaining and reprocessing the information obtained with the performance of human brain functions, which

this problem is related to thinking abilities, namely students' critical thinking abilities. The purpose of this study is to see how the implementation of neuroscience-based learning in schools trains the critical thinking abilities of elementary school students.

Education prioritizes competencies to support the improvement of learning related to improving students' thinking skills (Sukma et al., 2023) critical thinking skills are the ability to analyze, evaluate, and solve problems using logic to obtain actual and accountable truths (Zubaidah & Malang, 2017) the benefits of critical thinking itself have benefits for increasing in-depth understanding related to understanding concepts both in theory and practice, supporting students in managing their learning abilities, these critical thinking skills can also develop reasoning knowledge and minimize the occurrence of errors or misconceptions in a problem (Lamaro et al., 2024). By understanding how the brain learns and develops, educators can design more effective learning experiences, motivate students, and optimize their cognitive potential. This will ultimately help students become critical thinkers who are able to analyze, evaluate, and create innovative solutions in various contexts (Kustyarini, 2020). Previous relevant research conducted by (Marina et al. 2024) entitled Analysis of Students' Critical Thinking Skills in Science Learning for Grade IV Elementary School Students at SD Negeri 3 Kintamani found that students' critical thinking skills varied. Students who were active in group discussions and analytical tasks demonstrated higher critical thinking skills. However, some students were still passive and less involved in the learning process. Another study conducted by (Widodo et al., 2022) entitled Planning Framework and Outline of a Neuroscience-Based Creative Imagination Model (IKBN) in Islamic Religious Learning at Elementary School level found that the IKBN Model was designed using several learning tools known as cognitive tools or cognitive neuroscience. Most of the method specifications contained in the IKBN model have similar results to the cognitive tools conceptualized by Kieran Egan, but are more specifically aimed at Islamic religious subjects at the elementary school level.

Table 1. Comparison table of previous research with this research

Article	Similarities	Differences
(Marina et al., 2024)	This research explores students' critical thinking skills.	This research has not yet been linked to neuroscience learning concepts; it only focuses on critical thinking.
(Widodo et al., 2022)	This research examines the focus of neuroscience research concepts.	This learning focuses on Islamic learning, the research I will conduct will focus on elementary school students.

From the two studies above, the researcher is interested in taking a study entitled "analysis of neuroscience-based learning on the critical thinking skills of elementary school students", this is important to study because so far this kind of research is still lacking, this is evidenced by the lack of research results that explain neuroscience learning, especially in the Malang district area. The difference in research conducted by (Marina et al., 2024) and (Widodo et al., 2022) previous researchers with this study, lies in the variables that will be used as test variables, for this study using critical thinking variables associated with neuroscience-based learning, while the previous study focused on science subjects and the development of neuroscience-based planning frameworks.

The aim of this research is expected to equip teachers in providing teaching on critical thinking skills by using neuroscience-based learning and to find out how far neuroscience-based learning is applied at the elementary school level, the researcher chose SDN 02 Druju because this elementary school is a core elementary school in Sumbermanjing Wetan sub-district, Malang Regency.

METHOD

Researchers use qualitative research methods with data generated in the form of descriptive analysis from the findings in the field to describe the phenomenon of problems that prioritize the depth of data (Achjar, K. A. H., et al., 2023), the research will be carried out within 1 month which takes place at SDN 02 Druju, Sumbermanjing Wetan sub-district, Malang Regency. This research was conducted independently by researchers in the process of obtaining information using predetermined instruments. targets/objectives to see the implementation of neuroscience-based learning on critical thinking skills involving teacher and student subjects consisting of 3 teachers in high grades and 53 students with age criteria of 10-12 years to see student participation, the techniques that will be used in this study are interviews, observations that will be carried out with teachers and students, interviews consist of 10 questions related to the process during learning for 3 teachers in high grades, observations are carried out to observe students during the learning process in terms of critical thinking skills. Data analysis used in this study was carried out in 4 stages chronologically. First, data collection is carried out using two types of data collection techniques, namely: (a) interviews; (b) observation; (c) data condensation. Second, data condensation is carried out with the aim of selecting or sorting research data obtained through interviews and observations. Third, data presentation is carried out after the data condensation stage is completed and produces data that will be used in compiling the report. Fourth, drawing or drawing conclusions and verification are based on the research results. (Prastiko & Supriyanto, 2020). In a qualitative study on neuroscience-based learning, a researcher who is not part of the community realized that informants were more careful when speaking and providing information regarding the student's learning process.

RESULTS AND DISCUSSION

Based on data obtained at one elementary school in Malang Regency regarding neuroscience-based learning processes, it was found that the implementation had been implemented in every class at the school, but the application had not yet optimally focused on children's neuroscience. The researchers themselves had previously gathered information from school teachers, as presented in Table 2.

Table 2. Categories of interviews

No	Main theme	Sub-theme	Interview Excerpt
1	Neuroscience-based learning strategies	Emotional Management	"I always provide icebreakers or engaging games to help students enjoy the learning process and feel motivated."
		Multi-sensory Activities	"I just make use of the classroom environment, using books or digital media such as PowerPoint."
2	Students' critical thinking skills	Analyzing information acquisition	"Students easily grasp information when they practice it, but some understand it just by looking. Their learning abilities vary greatly."
		Providing arguments and drawing conclusions	"Essentially, every child is different. Some are

No	Main theme	Sub-theme	Interview Excerpt
			active speakers, while others are passive. Even when it comes to constructing arguments, students are still not systematic enough and sometimes just present their arguments haphazardly."
3	Use of Learning Media	The Role of Learning Media	"I use this media solely as a supporting tool to make it easier for children to access information, so I'll still be the one delivering the material."
		Effectiveness of Media Use	"Yes, I think it's quite effective because the material is presented in a colorful way, especially for elementary school children. It's very engaging and makes them more enthusiastic about learning."
4	Classroom Environment	The teacher's role as a facilitator	"I'm simply trying to facilitate children's learning needs by using available media to support their thinking."
		Classroom atmosphere	"I think the classroom conditions are good, but I need to add more images that can stimulate students' emotional engagement. The existing classroom is already colorful, but I need more images."

From the interview results, researchers divided them into several themes, namely neuroscience learning strategies in the classroom, how teachers manage emotions, namely by conducting icebreakers and playing games. From these activities, teachers believe they can arouse children's passion for learning. In fostering multisensory activities, teachers utilize the classroom environment and use learning media that they master, such as books and digital media. For the second theme related to students' critical thinking skills, in acquiring information, most students find it easier to remember when they learn through practice. For the ability to provide arguments and draw conclusions, students have diverse characteristics, in providing their arguments are still not systematic and seem to simply provide answers without thinking first. The third theme related to the use of learning media, where the role of this media is only used as a supporting tool for children's information acquisition. In terms of

effectiveness, the media is quite effective because the media used is appropriate and packaged as attractively as possible according to learning needs. The fourth theme related to the classroom environment, where the teacher's role as a facilitator here only tries to convey information by using learning media to support students' information acquisition. The classroom atmosphere needs to be supplemented with images to trigger emotional involvement and a sense of comfort for students while learning.

Table 3. Summary of media use and teacher challenges

No	Types of Learning Media	Intended Use	How to use	Challenges faced by teachers
1	Power Point	Delivering material with engaging visuals	Displayed during teacher presentations	The use of PowerPoint media does not fully facilitate all students, resulting in students who dislike PowerPoint media being disruptive with other students.
2	Ilustrated Paper	As a learning medium to capture student interest	Paper is displayed at specific times during the learning process.	Image media does not fully provide comprehensive information regarding the material's content (information limitations).

From the learning process, teachers face challenges during the use of learning media, including Power Point media. The purpose of using this media is to convey material in an interesting way. The use of this media cannot fully facilitate all students, some students don't like it, etc. The use of illustrated paper aims to attract students' interest because students like pictures. The challenge of using illustrated paper is that pictures have limited information which cannot provide comprehensive information.

The thematic map findings (Figure 1) demonstrate that the neuroscience approach emphasizes understanding how the child's brain works, the importance of creating a conducive learning environment, and the need for continuous evaluation. Furthermore, this learning is also linked to learning strategies and increased motivation, which are key to optimally activating students' potential. The map shows that students' critical thinking skills do not stand alone but are supported by several indicators, namely: information acquisition, creative ideas, and problem-solving skills. This illustrates that critical thinking in the context of neuroscience is not simply assessing information, but also processing it into new ideas and solving real-world problems. This node connects supporting and inhibiting factors with the development of students' critical thinking. Supporting factors include appropriate teacher strategies, a conducive learning environment, and motivation enhanced through a neuroscience approach. Inhibiting factors include time constraints, differences in student characteristics, and limited supporting resources. Analytically, this map shows that neuroscience-based learning is an important foundation in developing students' critical thinking skills. This process occurs

through brain stimulation mechanisms, learning environment management, teacher strategies, and student motivation.
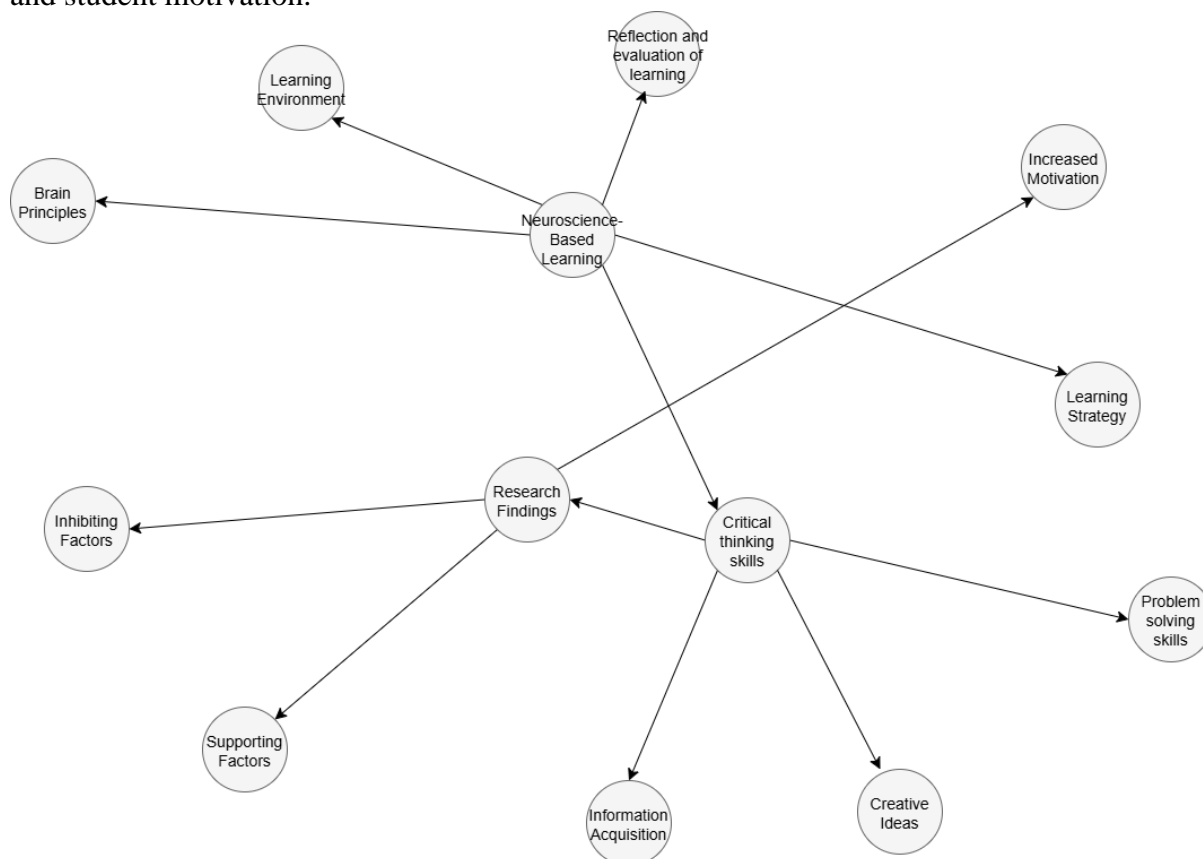
Figure 1. Thematic map of findings

The research findings (Table 4) indicate that teachers do not yet fully understand how neuroscience learning can be applied in the classroom, and teachers are new to the term neuroscience. The importance of neuroscience learning in providing learning that prioritizes brain balance in thinking and acquiring information in problem-solving and meaningful learning, teachers must be able to stimulate students' curiosity by using real-world experiences, activity-based activities, and relevant models. These strategies create connections with real-world contexts, encouraging curiosity and engagement in science (Nasrullah et al., 2021). To stimulate students' thinking skills, teachers create active, student-centered learning, for example, by creating fun learning situations and prioritizing children's multisensory functions that are tailored to the cognitive abilities and characteristics of elementary school-aged children. The selection of learning models and strategies can also activate students' full potential, which ultimately can improve their critical thinking skills (Nuryanti et al., 2018).

Table 4. Example code and supporting citations

No	Main theme	Code	supporting quotes
1	Neuroscience-Based Learning	Learning Strategies	"In the learning process, I maximize the use of learning models and methods, usually by conducting discussions or other collaborative activities in class."
		Brain Principles	"I connect the learning process to the children's experiences, so

No	Main theme	Code	supporting quotes
			that children will connect old knowledge with new knowledge."
		Learning Environment	"I always try to use media that children enjoy. When they enjoy using these media, they'll be more enthusiastic about learning."
		Learning Reflection and Evaluation	"During the reflection process, I only ask about today's learning process, for example, how was the lesson today, what did you learn?" "I conduct the evaluation process by simply giving daily questions."
2	Critical thinking skills	Information acquisition	"Students' information acquisition is good, but not all students receive the same level of information. I usually observe this from their active participation during the learning process."
		Creative ideas	"Students can contribute ideas, but they are still not constructive enough. Therefore, attention is needed to develop their creative ideas."
		Problem-solving skills	"Students are good at problem-solving, but they need to be more accustomed to developing critical thinking skills."
3	Research findings	Supporting Factors	"Support from the principal and all teachers in the learning process, and other supporting factors such as adequate learning media that are appropriate to the child's needs."
		Inhibiting Factors	"Because each student's learning style and circumstances are different, the teacher's role is crucial and presents a challenge in accommodating all students' learning styles."
		Increasing Motivation	"To increase motivation, I usually provide rewards and appreciation to students."

In neuroscience-based learning, the use of learning media is inseparable from both to train students' critical thinking skills. In this case, the teacher showed that in the implementation of learning, several learning media were used, but the use of media was not strong enough to train the neuroscience skills of elementary school children. The use of media must consider the characteristics and types of student learning needs in developing the potential of thinking skills to be a teacher's concern. The use of learning media that involves visual/multimedia functions will further facilitate the teaching and learning process because its use can help students in obtaining solutions to a problem (Mardiana et al., 2023). The use of media plays an important role in the neuroscience-based learning process because by using media it can make children active and increase student learning engagement, with media can also be a stimulus or active response to student learning to the surrounding environment (Sumiati, T., & Gumiandari, S. 2022).

Learning strategies also play an important role in successful neuroscience-based learning. Learning strategies are one of the important factors in the success of learning that focuses on the work of the human brain. The learning strategies in question include learning models and methods. There are several methods that teachers can use in neuroscience-based learning, namely collaborative learning, learning by prioritizing student learning experiences, learning with technology integration to foster brain stimulation in the student learning process (Hariyono, H., et al 2024). In neuroscience learning itself, the use or selection of learning strategies and models is important to consider because it concerns the suitability of learner characteristics which are related to the acquisition of information and brain responses under certain conditions (Fauzia, W. 2023). the selection of appropriate models and methods can be an important factor in learning outcomes that emphasize students' critical thinking functions and provide a comfortable and active atmosphere for students in learning (Setiyoko, A. 2019).

Attention to the process of repetition and learning reflection has a positive impact on the success of the neuroscience learning process. Repetition of information and allowing time for reflection are essential in strengthening long-term memory. It helps students to link new information with existing knowledge to find solutions to real environmental problems around them. In the process of reflecting on learning, the teacher has not provided a way of reflection that emphasizes students' critical thinking skills where the teacher only asks how today's learning process is taught at that time, which focuses on learning activities not on the material, this makes a lack of student sensitivity response in learning as evidenced by the lack of active and responsive students When asked a problem in the learning activities that have been carried out, students become confused and lack focus, this is in accordance with the opinion students who experience deficiencies in the acquisition of reflection can affect the ability to build ideas related to problem solving or build constructive ideas.

In the student learning outcomes assessment system, the assessment carried out by the teacher has not been thorough in the learning process, where the context of the assessment is more likely to be on learning outcomes, the teacher conducts an assessment that only relies on evaluation results and does not use process assessment sheets and so on, this is not in accordance with the neuroscience-based learning approach where assessment in neuroscience-based learning emphasizes understanding how the brain works and how students learn. Assessment focuses not only on the end result, but also on the learning process that students experience. This includes paying attention to factors such as student comfort and motivation in learning (Supena et al., 2023). The results of the interview that the assessment carried out still does not pay attention to the emotional and social learning of students, teachers sometimes still cannot provide feedback or appreciation for the activeness of learning which also has an impact on the ability to think critically and the acquisition of maximum student learning outcomes in learning. This is in line with the opinion (Dewi, 2020) which states that to express their opinions, students can be given stimuli in the form of rewards for adding activeness scores

which have an impact on the more active learning in related classes and in the aspect of critical thinking skills.

The success of neuroscience-based learning is inseparable from all parties, both teachers and schools. Teacher collaboration becomes one of the factors to achieve the maximum results of the implementation of this learning. Teachers play an important role in the realization of neuroscience learning, and their role is closely tied to the methods they employ in making various breakthroughs and improvements for the success of learning, including the preparation of teaching materials, the use of media, the selection of teaching strategies, and learning models to support critical thinking skills and optimal learning outcomes. According to (Sobirin, 2025), the teacher's duties include providing access to adequate resources and preparing a variety of teaching materials. Additionally, support also encompasses training provided to teachers, resources, and school policies that enable teachers to adapt teaching methods according to the individual needs of students, in line with the opinion of (Utama & Aynin, 2016), which states that in order to achieve the learning objectives formulated before the learning is conducted. In order for the learning process to proceed well, teachers must design the lessons to be implemented, especially to determine the steps of learning that align with the characteristics of the material to be taught and create indicators to determine whether the designed lessons can be carried out effectively or not. In this case, the role of the teacher is crucial in providing teaching services to create a learning environment. however, the current situation illustrates the lack of effort made by teachers in providing instruction to enhance students' critical thinking skills, The weak collaboration between the principal and the teachers is the main factor in the lack of optimization of this neuroscience-based learning in realizing students' critical thinking skills. In the implementation of this learning, the principal should provide guidance and attention to support the success of neuroscience-based learning. However, the lack of synergy between the principal has resulted in suboptimal implementation of the existing learning.

CONCLUSION

Neuroscience-based learning has great potential to improve the quality of education, especially in developing students' critical thinking skills. This learning emphasizes an understanding of how the brain works in receiving, processing and storing information, as well as the importance of a multisensory approach in supporting the learning process. However, the implementation of neuroscience-based learning in the field still faces various challenges, such as teachers' lack of understanding of neuroscience, limited use of media that supports students' brains in learning, and lack of reflection that focuses on students' critical thinking development. To maximize the success of neuroscience-based learning, it is important for teachers to better understand this concept and apply it in a way that can stimulate students' creativity, motivation and critical thinking skills. In addition, the selection of appropriate strategies, learning models and media is an important factor in achieving these goals. Solid cooperation between teachers and principals, as well as adequate support for the development of teaching skills, are also indispensable for creating an optimal learning environment. Overall, although the implementation of neuroscience in education has begun, there is still room for improvement and innovation,especially in tailoring learning to the individual needs of students in order to optimize their cognitive potential and development of critical thinking skills.

RECOMMENDATION

Optimizing the use of modules by considering brain performance and neuroscience and encouraging improvement and innovation, especially in adapting learning to the individual needs of students in order to optimize their cognitive potential and the development of their critical thinking skills, as well as continuous evaluation of the extent to which the application of neuroscience principles truly influences the development of students' critical thinking.

Evaluation is not only in the form of academic results, but also indicators of analytical, argumentative, and problem-solving abilities.

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