



Teacher Pedagogical Competence In A Neuroscience Perspective: A Systematic Review And Meta-Analysis

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Article Information:

Received April, 28, 2023

Revised Juli, 1, 2023

Accepted Juli, 6, 2023

ABSTRACT

This research is a systematic review of the literature that discusses teacher pedagogical competence in a neuroscience perspective. Overview systematically carried out For deepen knowledge, know the results of previous research, and clarify research problems in context pedagogic competence. Overview systematic done with using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) method. PRISMA help para writer And researcher in compile A systematic reviews Where contains guidelines for what items must be in an article. Collected literature Derived from articles published in 2018 to 2023. Based on the results of reading whole content text, there is 19 Which made as article selected. Study This try conducted a literature study on teacher pedagogical competence in a neuroscience perspective.

Keywords: Learning Education, Neuroscience in Education, Pedagogic Competence

Journal Homepage <https://journal.ypidathu.or.id/index.php/jnhl>

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How to cite:

Sai'in, Hiroyuki, H., & Kawachi, A., (2023). Teacher pedagogical competence in a neuroscience perspective: A Systematic Review and Meta-Analysis. *Journal Neosantara Hybrid Learning* 1 (2). 79-93. <https://doi.org/10.55849/jnhl.v1i2.99>

Published by:

Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

As learning agents, professional teachers must have four competencies, one of which is pedagogical competence. In the world of education, especially those dedicated to teachers. Pedagogic competence is a skill or ability that must be mastered by a teacher by looking at the characteristics of students in various aspects of life, both moral, emotional and intellectual (Abaunza & Rodríguez-Conde, 2016; Brika dkk., 2022; Dehghan dkk., 2022). Advances in cognitive technology and research from a neuroscience perspective have had a major impact on our understanding of various brain

functions, not only in the case of a healthy brain, but also in neurological and psychiatric conditions (Pinti, 2020).

When an educator thinks about the sensory characteristics of something like an apple or a sunset, most educators have a conscious visual experience of these things (Pearson, 2019). Visual experience has not yet touched the cognitive aspects that can be done with a pattern of approach. Many studies have found that educators have not optimally used their brains both to solve problems and create new ideas in learning. This cannot be separated from the current education system which only focuses on the left outer brain. This brain is involved in the processing of logic, words, mathematics, and sequences which are dominant for academic learning. The right brain that deals with the rhythm of music, images, and creative imagination has not got a proportional share to be developed. Likewise with the limbic system as the emotional center that has not been involved in learning, even though this emotional center is closely related to the long-term memory storage system. Moreover, the utilization of all parts of the brain (whole brain) in an integrated manner has not been applied effectively in the education system (Vaughn et al., 2020).

O cannot change positively when exposed to a stimulated environment, and the brain can become negative if not given a stimulus. In this regard, it is very important to present an environment that is able to stimulate students to be able to activate their brains (Scheidt, 2015). This stimulating environment needs to be presented under a variety of conditions. The working mechanism of the brain provides an important position in understanding any changes in learning behavior made by a person. Cognitive neuroscience aims to inform educators about the best strategies for teaching and learning. More and more teachers want to know how students think and learn. Research on neuroscience is very important to do because it can increase understanding of memory processes and networks in the brain in general (Cooper & Simons, 2019). we as an educatorTherefore, the goal he did study review systematic is For summarizes results primary research that attempts to describe teacher pedagogic competence in a neuroscience perspective.

Teacher pedagogical competence in a neuroscience perspective

The structure of the nervous system underlies human action, both in cognitive, affective and psychomotor aspects (Batubara & Supena, 2018) . Neuroscience as an alternative framework gives encouragement to teachers to maximize their pedagogical competence about how the students' brains work (Schwartz et al., 2019) . Pedagogic competence is closely related to the ability of educators to be role models for children, internalize values in action, make love the basis for educating children, display authority between themselves and students, and have high responsibility towards children. Pedagogic competence is the ability of a teacher to understand students, design and implement learning, develop students, and evaluate student learning outcomes to actualize their potential.

Pedagogic competence enables an educator to understand many things such as psychological and neural mechanisms for forming impressions, social learning, moral decision-making, and intergroup bias (Hackel, 2018). Basically, pedagogical competence cannot be obtained suddenly. A teacher must study continuously to achieve this ability. This competence can be increased through collaborative activities with colleagues, working with parents, and conducting simple research in the surrounding environment.

Collaborative activities with students will have a good impact, including in understanding neurophysiology. Middle school students will be able to understand the complex nature of neurophysiology if presented simply and illustrated with examples related to their daily lives (Andias, 2018). These collaborative activities can be carried out by educators with their pedagogic competence and developed in a neuroscience perspective or what is known as cognitive neuroscience. Cognitive neuroscience is the study of cognition with an emphasis on brain development and functions. The term cognitive neuroscience comes from "cognition", which is the process of knowing, and "neuroscience", which is the study of the nervous system. Cognitive neuroscience is the study of cognition with an emphasis on brain development and functions (Barbey, 2018). The term cognitive neuroscience comes from "cognition", which is the process of knowing, and "neuroscience", which is the study of the nervous system.

The majority of teacher preparation programs do not address neuroscience in their curriculum (Coch, 2018). In neuroscience it is closely related to pedagogic competence or better known as Neuropedagogic or it can also be called neuroeducation, namely interdisciplinary that combines the fields of neuroscience psychology and education to create improvements in teaching methods and curricula in research and initiatives to use discoveries about learning, memory, language, and other areas. Cognitive neuroscience aims to inform educators about the best strategies for teaching and learning. More and more teachers want to know how students think and learn (Jensen et al., 2022). Neuroscientists on the other hand want to know how teachers' questions drive neuroscience research. The impact of postmodernism is an insight into the complexity map of intellectual thought and practice, the truth of which departs from reason and truth through experience, requires us to understand the essence of education and development about what is known and what is not known (Singh et al., 2022). The effective and efficient use of brain functions is the result of a dynamic interactive process with the environment that includes physical, mental and emotional characteristics resulting in accelerated integration of brain functions and resulting in the optimal expansion of human capabilities.

RESEARCH METHODOLOGY

To make systematic reviews, researchThis use method Preferred reporting Items for Systematic Review and Meta-Analysis (PRISM). PRISM is tool Which used For do evaluation toa systematic review. PRISMA helps writers and researchers in compiling a systematic review which contains guide itemsWhat just Which must There is in A article

Page et al., (2021); Selcuk (2019) and also guided a Campbell systematic review The Campbell Collaboration (2020).

Bibliographical analysis using VOSViewer software. Bibliographic analysis is often used to analyze quantitative data of textual publications, this analysis is part of *scientometrics* using statistical techniques for scientific examination on a particular topic (Callon et al., 1991). Bibliographical analysis expands the view of a study based on the journal, articles and authors (Merigó & Yang, 2017). Bibliographic analysis that is often used is the number of publications and the number of citations (Yu & Shi, 2015). Type analysis This produce useful information _ for researcher Which evaluate activity scientific (Rey-Martí et al., 2016).

Diagram channel in do review systematic use PRISM can seen on Figure 1 and Figure 2.

Figure 1. PRISMA Flowchart

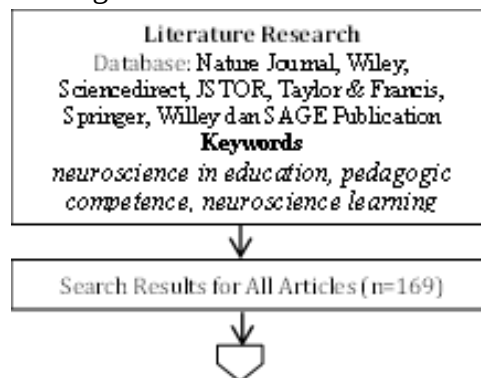
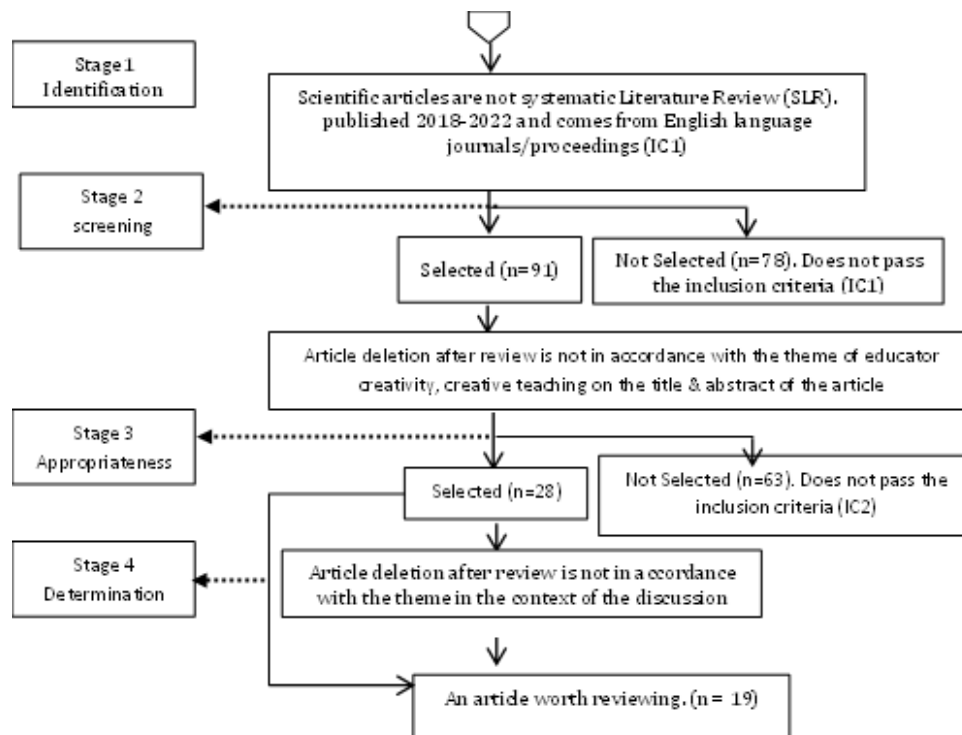


Figure 2. Diagram Channel PRISM (Advanced)



Studies literature collected from databases leading like Nature Journal, Wiley, Scindirect, JSTOR, Taylor & Francis, Springer, Wiley, SAGE Publication and Hindawi. range time literature Which collected is article Which published from year 2018 until year 2023.

A. Criteria Appropriateness

The following inclusion criteria (IC) were defined for guidelines review: IC1: Original articles published in 2018-2023 and originate from journal or proceedings speak English. IC2: for summarizes results primary research that attempts to describe teacher pedagogic competence in a neuroscience perspective

B. Election Literature

Study selection was carried out in four phases as follows:

- 1) Search say key, or strings search, chosen in accordance with interest study this, that is For review results primary research that attempts to describe teacher pedagogic competence in a neuroscience perspective. Strings search related with ("pedagogic neuroscience") And (say key like "pedagogical competence", "neuroscience", other than that said key which shows teacher pedagogic competence in a neuroscience perspective (*neuroscience in education, pedagogic competence, neuroscience learning*)).
- 2) Exploration and selection of titles, abstracts, and say key from article Which identified done based on criteria appropriateness.
- 3) Read in full or in part from article Which No removed on phase previously done For determine is article the must entered in review, in accordance with criteria appropriateness.
- 4) List reference article scanned For find studies related.
- 5) The process of selecting or selecting articles that meet the criteria uses *Zetere software* to make managing the articles easier (Reis et al., 2022).

RESULT AND DISCUSSION

The selection process for articles has been carried out with the criteria for article publication between 2018 and 2023, in the form of research articles, in English and meeting the assessment criteria set by the researcher. The selection resulted in 19 articles being reviewed. The selection process protocol is depicted in the PRISMA flowchart (Page et al., 2021) in figure 1.

Digital libraries Which used in study This is Emerald insight, SAGE Journals, Science Direct, and Taylor & Francis. Identification digital libraries And publisher from selected articles seen on Table 1.

Table 1. Digital Library Study

Digital Libraries	Publisher	Number of Articles
NatureJournal	Nature Reviews Neuroscience	4

Wiley	Annals of the New York Academy of Sciences journal	1
Sciencedirect	World Neurosurgery	1
	Procedia Computer Science	1
	Teaching and Teacher Education	1
	Trends in Neuroscience and Education	1
JSTOR	Peabody Journal of Education	1
Taylor & Francis	Applied Developmental Science	1
	Physiotherapy Theory and Practice	1
Springer	psychonomic bulletin & review	1
	Science & Education	1
Wiley	MIND, BRAIN, AND EDUCATION	2
SAGE Publications	SAGE Journal	1
Hindawi	BioMed Research International	1
cell	Trends in Cognitive Sciences	1

In the discussion sub-chapter of article demography selected Also explained about year rise article selected. Demographics year rise article selected can seen on Table 2.

Table 2. Year of article publication

No	Year	Number of Articles
1	2018	8
2	2019	5
3	2020	4
4	2021	
5	2022	2
6	2023	

Article demographics regarding the countries involved in publication literature review in this research about can seen on Table 3.

Table 3. Countries Involved in the Study

No	Country	Number of Articles
1	Australia	1
2	China	1
3	Germany	1
4	India	1
	Italy	1
5	Portugal	1
6	Switzerland	1
7	UK	3
8	USA	9

Demographics article related method Whichused in publication literature review
in this study can seenin Table 4

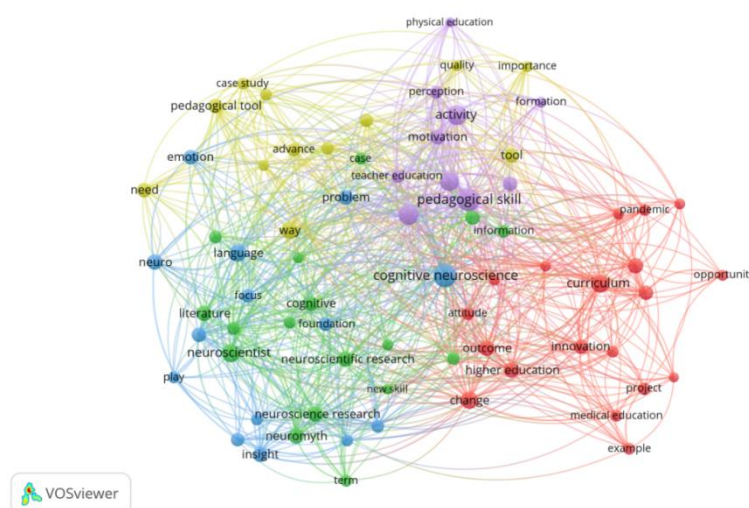
Table 4. Research Methods

No	Method Study	AmountArticle
1	Quantitative	6
2	Qualitative	10
3	Mixture (Quantitative & Qualitative)	3

Results of bibliographic analysis with VOSViewer

co-occurrence metadata analysis of article keywords using the *VOSViewer software* obtained a visualization in Figure 3 below.

Figure 3. Network Visualization



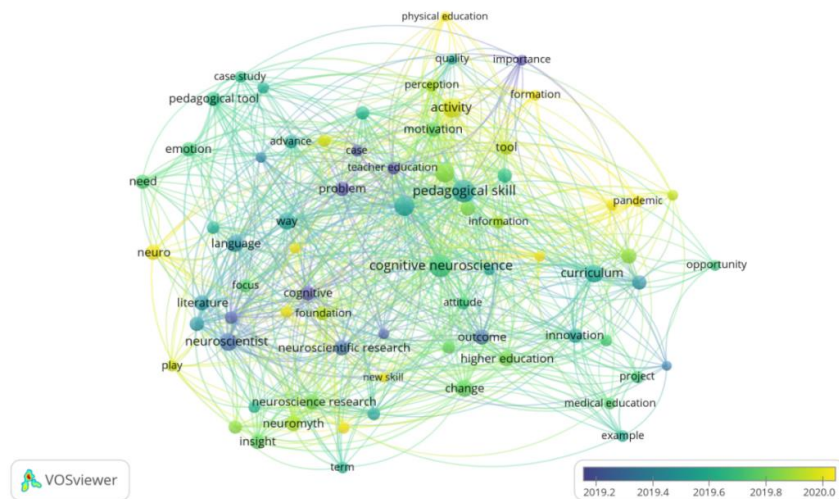
In the picture above there are three major clusters, namely *cognitive neuroscience*, *pedagogical skills and nueroscintis* . There are several keywords that are close and far apart. This can be seen from table 5 below:

Table 5 Nearest and farthest clusters

No	Clusters	Nearest Point	Farthest Point
1	cognitive neuroscience	attitude learning process Outcomes	Cognitive sciences neuros Pedagogical toll
2	pedagogical skills	abilities experience time	play term need
3	Nueroscientist	cognition learning skills literature	tools Activity implementation

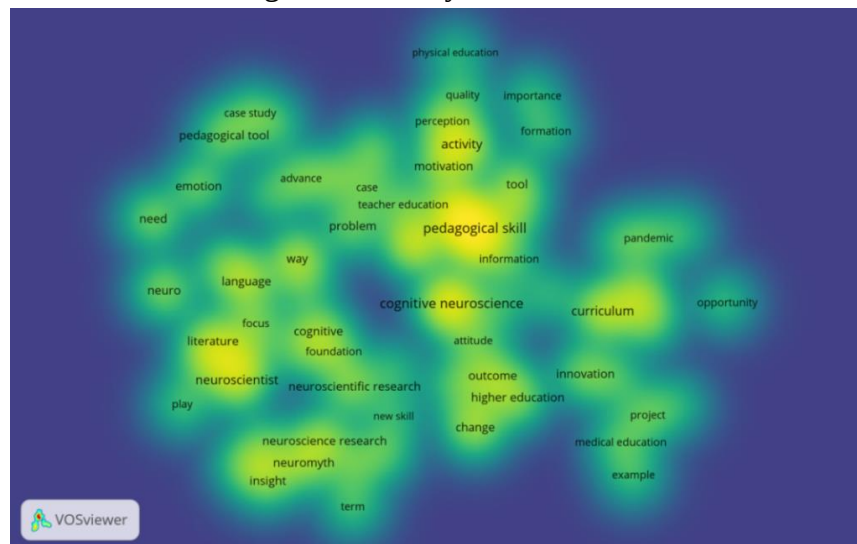
Then in figure 4. regarding *overlay* visualization based on keywords, it can be explained that there are keywords that are still being discussed recently in research related to *cognitive neuroscience* , namely *Neuro*, *Neuroscientific evidence*, *universal design* and *cognitive skills*. Meanwhile, the keywords that have recently been discussed in research related to *pedagogical skills* are *cognitive psychology*, *implementation* and *cognitive skills*

Figure 4. Visualization overlays



In Figure 5 below, the density visualization illustrates the density or emphasis on the topic of the research group. The brighter *the visualization* , the more research or research studies on that topic or keyword and conversely, the darker the visualization, the less research that discusses this theme.

Figure 5. Density Visualization



In Figure 5, the keywords with bright visualization are the keywords *cognitive neuroscience*, *pedagogical skills*, *neuroscience* and *activity*. while the keywords with dark visuals are *physical education*, *emotion*, *opportunity* and *new skills*.

Discussion

While neuroscience has elucidated the mechanisms underlying learning and memory, accurate dissemination of this knowledge to teachers and educators is still limited (Dubinsky et al., 2019). Neuroscience-based learning requires teachers to have adequate and integrated knowledge of the content (material) of the lessons being taught, various pedagogical approaches, and the technology to be used. Teachers must be able to carry out learning in an innovative manner with correct and adequate mastery of material, as well as appropriate pedagogical and technological approaches. Neuroscience is a field of psychology that focuses on the brain in its study.

Neuroscience research opens up the possibility of tracking and even modifying human brain processes, such as decision-making, revenge, or pain control (Lombard et al., 2020). Neuroscience here is tasked with re-surgery of the brain and used as units to process isolated information and will determine which units work, physically or computationally. Neuroscience is also concerned with the interrelationships and relationships between interconnected brain mechanisms and their relevance to behavior (Bassett, 2018). The results of psychology and neuroscience itself are why the two depend on each other when making an information study, because to meet the need for finding physical evidence of the structure of the mind is theoretical in nature, neuroscientists also need to link their findings with brain function and more knowledge comprehensive, this can also be a clinical target as the findings of behavior and brain pathology, neurological function is also experiencing increased performance models of the human mind, the development of software that can behave like the human brain by computer experts, learning about the brain Humans can develop rapidly and have not been seen before.

Neuroscience in education is often used to study language and math cognition processes, but is not widely applied to conceptual change and science learning, for example neurophysiological learning (Vaughn et al., 2020). Neurophysiological learning can be carried out using five stages of learning, namely the preparation stage, the acquisition stage, the preparation stage, the memory formation stage, and the functional integration stage. In this neuroscience -based learning , students are given a stimulus to optimize their nervous system so that they can optimally use the brain in various ways both to solve problems and find new ideas, new ideas, creativity, and innovation in the learning process .

The stimulus given in the learning process must look at the neural mechanism. The mechanisms that support social interaction are different from those involved in social observation and highlight the role of the so-called 'mentalization network' which must also be considered, so as to produce a mentality side for learners (Redcay & Schilbach, 2019). Social cognitive processes can be grouped into three domains related to (a) perceptual processing of social information such as faces and emotional expressions

(social perception), (b) understanding the cognitive or affective states of others (social understanding), and (c) planning behavior by considering other people's goals, besides one's own goals (social decision making) (Arioli, 2018). Neural mechanisms in the human brain has enormous intelligence potential . Our brain has two kinds of cells, namely neuron cells and glial cells. The intelligence of students is largely determined by the number of connections between neuron cells in the brain. There are several principles of neuroscience-based learning, namely (a) Learning to absorb information is best done in the morning, while for repetition, processing, and reflecting on information it is best done in the afternoon. (b). Learning will help the brain to maintain its attention if students every 90 minutes stretch their muscles for about 10 minutes. c. The right and left hemispheres of the brain experience cycles of efficiency, for that learning should use a variety of activities. d. Able to develop the right and left brain hemispheres in a balanced way. (e). Learning is focused on discussing the material. (f). Learning by paying attention to changes in movement, light, contrast, and color. (g). Learning by paying attention to environmental factors such as room temperature, class color choices, display color designs. (h). Students get adequate nutrition and nutrition. (i). Improving the positive emotional condition of students with fun activities, games, humor.

Neuroscience-based learning requires teachers to have adequate and integrated knowledge of the content (material) of the lessons being taught, various pedagogical approaches, and the technology to be used. A learner's current level of intrinsic motivation can also influence how he or she processes performance-related feedback. It is still not entirely clear how the nature of performance feedback can affect individual feedback processing (Ng, 2018). Teachers must be able to carry out learning in an innovative manner with correct and adequate mastery of material, as well as appropriate pedagogical and technological approaches. Knowledge about how to integrate technology, pedagogical approaches into learning activities is called by Mishra & Koehler (2006) TPACK (Technological, Pedagogical, and Content Knowledge). Neuroscience-based learning aims to allow teachers to optimize the brain development potential of students in the learning process by using appropriate pedagogical and technological approaches.

Systems neuroscience seeks explanations for how the brain implements various perceptual, cognitive, and motor tasks (Richards et al., 2019). By mastering neuroscience-based innovative learning, it is hoped that teachers will be able to deliver students to have the ability to solve the problems they face critically, creatively, communicatively and collaboratively according to the principles of brain work. With innovative learning, teachers must be able to adapt the curriculum in ways that meet students' needs. (Darling-Hammond et al., 2020). Social neuroscience has an active impact on neurology and psychiatry training (Ibáñez et al., 2018). The students' needs in question are the social and emotional aspects that are adjusted to the current context. Thus, the quality of the learning process that the teacher does can be improved according to the demands of the times. The implementation of neuroscience-based learning includes, first, orchestrated immersion by creating a learning environment that challenges the ability to associate and

develop students' thinking through stimulation in the form of giving meaningful problems in the form of puzzles, games that are attractive and interesting. Second, relaxed allergy by creating a fun learning environment and stimulating students to actively participate during the learning process (Alm & Nkomo, 2020; Dubinsky dkk., 2019). For example learning outside the classroom, learning with music media, learning in the form of group discussions, learning using interesting simulations and others. Third, active processing by creating learning situations so that students build their own knowledge by actively involving all the senses such as observing eyes, writing hands, mouth for discussing, and other limbs.

The definition of the field of educational neuroscience is (a) the application of the findings of neuroscience and into the classroom; (b) overlapping and interdisciplinary collaborations in psychology, neuroscience, and education; (c) a bridge that translates technical language and jargon between education and neuroscience (Li et al., 2020) . Neuroscience-based learning requires activity in learning, both teachers and students, there will be no more passive and tense learning as students just stay silent while listening to the teacher's lecture. If learning is passive, then it doesn't activate the brains of students much so that learning outcomes will not be optimal. Conversely, if learning is active and fun, students can be invited to move, laugh, ask and answer questions and respond in the learning process. This will activate brain areas so that learning is much more successful and meaningful.

The function of how neuroscience in learning is the application of neuroscience into the classroom to improve educational practice, collaboration or integration of various disciplines, bridging or translating languages from various disciplines (Feiler & Stabio, 2018). In this neuroscience-based learning function, students are given a stimulus to optimize their nervous system so that they can optimally use the brain in various ways both to solve problems and find new ideas, new ideas, creativity, and innovation in the learning process. This approach allows each individual to switch between strategies flexibly (Kendal et al., 2018), Neuroscience-based learning can make connections between cognitive processes in the brain and the behavior that will be produced. This can be interpreted that every command that is processed by the brain will activate important areas of the brain so that the brain activation of students increases and mastery of learning material is maximally successful.

CONCLUSION

Neuroscience is an education system that studies the workings of the nervous system. Education in general pays little attention to this system . Ignoring this system causes the learning atmosphere to become monotonous. Neuroscience is a scientific study of biophysical components related to cognition, affect, and social using an interdisciplinary approach between cognitive psychology, neuroscience, artificial intelligence, and biology. The main goal of neuroscience is to study the biological basis of every behavior . That is, the main task of neuroscience is to explain human behavior from the point of view of the activities that occur in the brain. Neuroscience is the study

of the brain and mind. The study of the brain is fundamental to understanding how we feel and interact with the outside world and especially what humans experience and how humans affect others.

Learning using a neuroscience approach is learning that prioritizes the ability of inter-connected neurons or nerves centered on the brain as the coordination of cognitive and affective thinking. Learning with a neuroscience approach is learning that prioritizes the ability to connect neurons or neurons located in the brain as coordination between cognitive and emotional thinking.

Mindset or thinking can be changed with a neuroscientific process, namely by means of cognitive therapy through positive awareness and thinking to create a positive mindset, as an example is changing the mindset about mathematics.

Research results in educational neuroscience have inspired education practitioners to develop approaches that facilitate the brain to work optimally, namely brain-based learning (brain-based learning). This approach considers what is natural for the brain and how the brain is influenced by the environment and experience so that the learning process does not force students to learn, but encourages students to learn on their own (1). Intelligence Optimization, Education should develop intelligence, not memorization, namely through brain stimulation to think. A smart brain increases creativity and new inventiveness to find new things that have never been thought of. (2). Balance the function of the right and left brain, right brain and left brain have different functions. The right brain is more intuitive, random, irregular, divergent. The left brain is linear, regular, and convergent. Education should develop both hemispheres of the brain in a balanced way. Exploratory and divergent learning, more than one possible correct answer will develop both hemispheres of the brain. (3). Triune Brain Balance, Education must develop in a balanced way the functions of the upper, middle and lower brain (logic, emotion and motor) which are often called the head, heart and hands. This is in accordance with the goals of national education, namely to develop intelligent, skilled, and noble human beings.

Basically, pedagogical competence cannot be obtained suddenly and requires continuous training and makes it a habit so that one can consciously carry out indicators of success as a teacher. Based on the literature, indicators of teacher pedagogic competence are as follows: (1) mastering the characteristics of students, in this case every teacher should be able to record and use information about the characteristics of students to assist the learning process; (2) Second, on the indicator of mastering learning theory and educational learning principles, this indicator enables the teacher to determine various approaches, strategies, methods, and learning techniques that educate creatively in accordance with teacher competency standards; (3) Third, developing the potential of students to actualize their potential, in this case the teacher identifies the potential development of students through programs that support students to actualize their potential; (4) Fourthly curriculum development, teachers should be able to arrange syllabus according to the curriculum; (5) educational learning activities that adapt to the

needs of students; (6) effective, empathetic and polite communication with students, and the seven assessments and evaluations.

While the implementation of neuroscience-based learning includes: (1) orchestrated immersion by creating a learning environment that challenges the ability to associate and develop students' thinking through stimulation in the form of giving meaningful problems in the form of puzzles, games that are attractive and interesting; (2) relaxed alertness by creating a fun learning environment and stimulating students to actively participate during the learning process. For example learning outside the classroom, learning with music media, learning in the form of group discussions, learning using interesting simulations and others . (3) active processing by creating learning situations so that students build their own knowledge by actively involving all the senses such as observing eyes, writing hands, mouth for discussing, and other limbs.

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