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Neuroscience Study in Science Development Elementary School

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Abstract: This study aimed to examine the thoughts of figures in various reference sources to find complete neuroscience study concepts in science development in elementary schools. The method used was a systematic literature review by exploring various scientific papers related to this topic. Source selection is based on several criteria, namely: 1) the literature must be directly related to neuroscience and primary schools; (2) search related literature derived from the results of research reports, national journals, international journals, relevant books, scientific articles, and scientific data related to the study of this article; (3) limitation of the publication year of literature in the last ten years (2011-2020). The results showed that the nervous system structure underlies human actions, both aspects of cognition, affection, and psychomotor. Also, neuroscience studies implementation in elementary schools involves neuroscience, cognitive neuroscience, psychology, educational theory, and learning practices. Meanwhile, the learning concept from a neuroscience perspective empowers the brain's abilities by creating an environment that is challenging, fun, meaningful, and promotes students to be active. Therefore, educational neuroscience is an important future model for elementary school teachers to know.

Keywords: neuroscience, education, elementary school.

科学发展小学的神经科学研究

摘要：这项研究旨在检查各种参考资料中的数字思想，以发现小学科学发展中完整的神经科学研究概念。通过探索与该主题相关的各种科学论文，所使用的方法是系统的文献综述。文献来源的选择基于几个标准，即：1）文献必须与神经科学和小学直接相关；（2）从研究报告，国家期刊，国际期刊，相关书籍，科学文章以及与本文研究有关的科学数据的结果中检索相关文献；（3）最近十年（2011-2020）的文献出版年限。结果表明，神经系统结构是人类行为的基础，包括认知，情感和心理运动两个方面。此外，在小学进行的神经科学研究涉及神经科学，认知神经科学，心理学，教育理论和学习实践。同时，从神经科学的角度来看，学习概念通过创造具有挑战性，有趣，有意义并促进学生活跃的环境来增强大脑的能力。因此，教育神经科学是小学教师认识未来的重要模型。

关键词：神经科学，教育，小学。

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1. Introduction

Studies have shown that humans have not optimally used their brains to solve problems and find novelty ideas, creativity, and innovation [1]. The current educational system focuses only on the outer left brain and does not balance using the right side. Furthermore, the left brain plays a dominant role in processing logic, words, mathematics, and sequences for academic learning. Meanwhile, the right deals with musical rhythms, images, and creative imagination, which has not gotten a proportional share to be developed [2], [3].

Likewise, the limbic system as an emotional center has not been involved in learning, even though it is closely related to long-term memory storage [4]. The use of the whole-brain in an integrated manner has not been effectively applied in the educational system. In the last decade, the brain has been successfully explored on a large scale and has concluded that the brain is the main center of thinking, creation, civilization, and religion [5].

Recent studies in neuroscience have increasingly proven that certain brain parts are responsible for organizing different human intelligence types [6]. Furthermore, mathematics and language are centered in the left hemisphere, although not strictly centered, while musical and spatial intelligence is centered in the right. Kinesthetic intelligence is possessed by the forehead, is centered in the motor area of the cerebral cortex. Intrapersonal and interpersonal intelligence is also structured in the limbic system and is linked to the prefrontal and temporal lobes [1], [7].

Educational neuroscience is a field of study that focuses on educational concepts from the perspective of the brain's work system [8]. It turns out that teachers and parents rarely pay attention to this field, leading to the emergence of a passive and sub-optimal learning atmosphere in stimulating nerve cells in the human brain [9]. Also, teachers and parents who do not understand the biological basis of children's skills and behavior tend to educate them according to their wishes or continue their aspirations. Therefore, the child's learning goals aim to please teachers and parents only and are not optimal in developing all their potential according to their developmental stage [10].

The results in the field of neuroscience have provided a new perspective for the education world in understanding the development of children's behavior and skills in terms of structure and function of the nervous system [11], [12]. For example, mathematics and language intelligence is centered in the left hemisphere, while musical and spatial intelligence is centered in the right brain. Furthermore, kinesthetics is centered in the cerebral cortex's motor region, and intrapersonal and interpersonal intelligence is structured in the limbic system. It is linked to the prefrontal and temporal lobes [13].

These findings have inspired teachers and parents to develop effective learning strategies to improve human potential and intelligence, both physical and spiritual [14]. Besides, neuroscience has succeeded in discovering the biological underpinnings of children's behavioral disorders and skill development. An example is a study on children's brain condition with dyscalculia and dyslexia and what stimuli can be given to cure these problems [15].

The sub-discussion in this study consists of three parts, specifically the nature of educational neuroscience, the study results, and the implementation of primary school education results. The scientific novelty of our research compared to the current regulations in science is that it thoroughly examines the influence of neuroscience on the development of science in elementary schools. The studies discussed include: the purpose of neuroscience in elementary school education, the neuroscience problems in elementary school education, the solution to neuroscience problem in elementary school education, and implement neuroscience in science development in elementary school.

2. Methodology

This study used a library approach, and it aims to collect and analyze data or information contained in the library room, such as journals, reports, scientific magazines, surahs, relevant books, seminar results, unpublished scientific articles, and other related scientific data [16], [17]. Also, this study used an experimental method to analyze the contribution of neuroscience research results in basic education [18].

The selection of source was based on several criteria, namely: 1) literature must be directly related to neuroscience and education in elementary school; (2) search for literature related from the results of research reports, national journals, international journals, relevant books, scientific articles, and scientific data related to the study of this article; (3) restrictions on the year of publication of literature in the last ten years (2011-2020) [19].

Steps to be taken in systematic literature review research include:

1. For planning at this stage, researchers are required to formulate the steps to be carried out and determine the research question;
2. Review (review), where this activity is the implementation stage that focused on the process of searching literature from electronic-based, then researchers select and categorize literature, conduct screening and determine the relevant literature and make conclusions to the entire literature set;
3. Documentation is done by writing and describing the findings of the selected literature complexly. The findings serve as the basis for answering the specified research questions.

The systematic literature review must pay attention to the following stages to get effective and efficient results.

2.1. Define a Research Question

At this stage, the researchers will formulate and determine the question that corresponds to the research. The specified problem formulation refers to the background of the problem that the researcher has presented. The following is a research question in this research, namely:

1. RQ1: What is the purpose of neuroscience in elementary school education?
2. RQ2: What are the neuroscience problems in elementary school education?
3. RQ3: What is the solution to the neuroscience problem in elementary school education?
4. RQ4: How to implement neuroscience in science development in elementary school?

2.2. Search Process

The search process is searching and exploring literature from several electronic bases such as Google Scholar, Scopus, Direct of Open Access Journals (DOAJ), and Garuda Portal. In the next step, researchers assessed the four databases to be used as an accurate source to answer research questions [20].

2.3. Inclusion and Exclusion Criteria

At this stage, researchers determine several criteria for literature that are used as a source of reference and considered relevant to research topics, including:

a) Literature in the form of journals and conferences with the nature of the full text.

b) The publication deadline is at least ten years with a period from 2011-2020.

c) The literature discusses neuroscience and education in elementary school.

d) The literature written in Indonesian or English.

2.4. Quality Assessment

At this stage, the literature that has been determined as a source of reference and considered relevant to the research topic will be identified based on the criteria of inclusion and exclusion that have been described previously [18]. This question was created to look at the feasibility of selected literature. Questions determined based on inclusion and exclusion criteria, namely:

a. QA1: Is the literature used in the form of journals and conferences presented full text?

b. QA2: Has the literature used as a data source been published in the last ten years (2011-2020)?

c. QA3: Does the literature discuss and study neuroscience and education in elementary schools?

d. QA4: Is the literature presented in Bahasa Indonesia or English?

2.5. Data Analysis Process

A note was made in our own words about neuroscience in development science in elementary school [18]. The findings are presented in the form of conclusions that serve as the basis for solving problems and answering research questions. In this final stage, the authors wrote the manuscript, including the introduction, methodology, results and discussion, and conclusion. The study's scope was neuroscience in elementary school in Indonesia.

3. Results and Discussion

In the initial stage, the search process produces 1.740 pieces of literature that have not yet entered the inclusion criteria. Furthermore, the literature obtained through several stages of filter to determine the literature relevant to the topic of research. The final results of ten pieces of literature relevant to research topics were obtained from Google Scholar, Scopus, Direct of Open *Access Journals* (DOAJ), and Garuda Portal. Source selection is based on several criteria, namely: 1) the literature must be directly related to neuroscience and education in elementary schools; (2) search related literature derived from the results of research reports, national journals, international journals, relevant books, scientific articles, and scientific data related to the study of this article; (3) limitation of the publication year of literature in the last ten years (2011-2020). The data obtained is then grouped by journal type and presented in Table 1 for easy understanding by the readers.

Table 1 List of literature relevant to research topics

No	Article Title	Author	Years	Publisher
1	Educational Neuroscience in Basic Education	Coal, H. H., & Supena, A	2018	Journal of Primary Education, Vol. 9, No. 2, page 140–148.
2	How neuroscience informs our teaching of elementary students.	Caine, R.	2018	Comprehension Instruction: Research-Based Best Practices, page 127–141.
3	Metacognitive in children's learning process in neuroscience study	R. Fitri	2017	Journal of Education Theory and Praktis, Vol. 2, No. 1, page 56–64.
4	Neuroscience and education: myths and messages	P. A. Howard-Jones,	2014	Nature Reviews Neuroscience, Vol. 15, No. 12, page 817–822.
5	Neuroscience Education And Its Implications In Elementary School Education	Hengki Wijaya	2018	Journal of Islamic Education Research, Vol. 14, No. 2, page 267-296.

6	Neuroscience and education: Issues and challenges for curriculum.	Clement, N.D., & Lovat, T.	2012	Curriculum Inquiry, Vol. 42, No. 4, page 534-557.
7	Neuroscience education for prekindergarten–12 teachers	Dubinsky, J.M.	2011	Journal of Neuroscience, Vol. 30, No. 24, page 8057-8060.
8	Young children's changing conceptualizations of brain function: implications for teaching neuroscience in early elementary settings.	Marshall, P. J., & Comalli, C. E.	2012	Early Education & Development, Vol. 23, No. 1, page 4-23.
9	Applied educational neuroscience in elementary classrooms: A grounded theory study	Dennis, S. R.	2018	Indiana University
10	What can neuroscience bring to education?	Ferrari, M.	2011	Educational Philosophy and Theory, Vol. 43, No. 1, page 31-36.

Table 2 The results of quality assessment

No.	Author	Years	QA1	QA2	QA3	QA4	Results
1	Coal, H. H., & Supena, A.	2018	Y	Y	Y	Y	Accepted
2	Caine, R.	2018	Y	Y	Y	Y	Accepted
3	R. Fitri	2017	Y	Y	Y	Y	Accepted
4	P. A. Howard-Jones	2014	Y	Y	Y	Y	Accepted
5	Hengki Wijaya	2018	Y	Y	Y	Y	Accepted
6	Clement, N. D., & Lovat, T.	2012	Y	Y	Y	Y	Accepted
7	Dubinsky, J.M.	2011	Y	Y	Y	Y	Accepted
8	Marshall, P. J., & Comalli, C. E.	2012	Y	Y	Y	Y	Accepted
9	Dennis, S. R.	2018	Y	Y	Y	Y	Accepted
10	Ferrari, M.	2011	Y	Y	Y	Y	Accepted

Description:

- Yes (Y), for the literature category used and relevant to the research conducted. The data was chosen as the main source because it has interconnected research topics, discusses and reviews neuroscience and education, and has considerable information.
- No (N) for literature categories that are not used in the research process because they are not relevant to the research topics being researched and are considered inadequate regarding the information presented.

After studying the data analysis results in ten literature, there is neuroscience in elementary school development science. Neuroscience is a new educational system that studies the nervous system. Generally, educators rarely pay attention to this problem, and ignorance of this system causes an unpleasant learning atmosphere. Etymologically, neuroscience is a neural science that studies the nervous system, especially neurons or nerve cells, with a multidisciplinary approach [21]. In terminology, it is a special field of scientific study of the nervous system. It is also called the study of the brain and all other nerve functions [22].

Neuroscience is a field of study regarding the nervous system. It examines the brain's awareness and sensitivity in terms of biology, perception, memory, and their relation to learning. Based on neuroscience, the nervous system and brain are the physical principles for the human learning process. Furthermore, neuroscience is a field of scientific research on the nervous system, and it is the study of the brain and mind [23].

According to a neuroscience perspective, students are the brain activities of learners while receiving lessons and responding to the learning process [4]. In elementary school education, the five brain scanning technology instrumentations below have implications for changing students' brains' views, especially learning activities. Also, passive and uptight learning (students just sit and silent while listening to the teacher's lecture) does not activate the brain; therefore, the results are less optimal. Conversely, active and enjoyable learning (students are invited to move, laugh, and ask questions) activates more brain areas; hence learning is much more successful [24].

After studying the development of neuroscience, this article examines the concept of

3.1. The Purpose of Neuroscience in Elementary School Education

The main purpose of this science is to study the biological underpinnings of each behavior [25]. Therefore, the main neuroscience task is to explain human behavior from the brain activity point of view. Recent research in this field found evidence of an inseparable link between the brain and human behavior (character) [26].

As already mentioned, the current educational pattern is focused mainly on the left brain. Meanwhile, to be smart, the right brain needs to be engaged like the left. The left brain is with words and language, while the right is with music, pictures, and colors [27]. The classroom needs to be managed into a relaxing space

with soft music nuances, great smells, and a high sense of humor. Therefore, utilization of the Whole Brain Approach concerning the left and right hemispheres will clearly show the inseparability of cognitive problems with emotions as a whole [28], [32].

Understanding elementary school students' emotions are key to building the motivation to learn. When information is only presented in words, it is stored in the left brain. Meanwhile, when presented in colorful images, the information is stored on the right side. Therefore, the information presented in a combination of words and images will be absorbed and stored more quickly [3], [31].

3.2. Problems in Elementary School Education

Based on the results of published studies, there are several problems related to the implementation of neuroscience in elementary schools.

3.2.1. The Role of Education at an Early Age

The effectiveness of neuroscience in education depends on the educational role at an early stage [29]. This process of development and shaping in the brain shows that early childhood education is very important. The developmental periods of infants and preschool children can prepare the stage for the mastery of the competencies needed to learn effectively in school [34].

3.2.2. The Complexity of Cognitive Processes

Teaching and learning experiences need to be planned to take into account the complexities of cognitive processes, such as attention and memory [33]. The neuroscience research showed that attention is not a single process but includes many components, such as preparing for a change in an existing condition. The implication is that educators cannot assume certain teaching techniques such as "get students' attention" or "help them remember." Therefore, it is important to be more specific about what attention aspect will be included in the lesson and what memory types will be considered [35].

3.2.3. Student Learning Difficulties (Attention, Involvement, Motivation, Emotions)

Research on the brain showed that the key to correcting deficiencies in a particular lesson is recognizing which aspects are difficult for students and then work to deal with them specifically. For example, teaching cognitive strategies for children's weaknesses can be integrated with traditional reading teaching [36].

3.2.4. The Complexity of Learning Theories

Research on the brain showed that multi-faceted learning theories seem to capture the real world better than parsimony models [30]. Also, there is much unnecessary charge in brain function, which explains the general finding that when a region of the brain known to be associated with a particular function is primarily affected, that function may not be completely lost (another reason the difference between "right-brain" and "left-brain" lacks strong credibility) [37].

3.3. Solution for Neuroscience Problems in Elementary School Education

Some of the practices are problem-based learning, simulation, role-playing, active discussion, visual displays, and a positive climate.

3.3.1. Problem-Based Learning

This type of learning attracts student involvement in learning and helps their motivation. Also, when students study in groups, they can improve their collaboration skills. This learning style requires the student to think creatively and process their knowledge to use it in distinct ways. This method is especially useful for working on projects that do not have a definite correct solution.

3.3.2. Simulation and Games

Simulation roles can be performed via computers, classrooms, or in public places such as museums. This style is in the form of presenting a model in which students observe each other. Both simulation and role-playing provide learning opportunities that students cannot obtain in normal ways. These methods have motivational benefits and can focus on students' attention.

3.3.3. Active Discussion

Students, as part of a discussion, are forced to participate. It means they cannot be passive observers. This increased level of cognitive and emotional engagement can lead to better learning, and as a cognitive activity, it helps them build synaptic connections and new ways of using information.

3.3.4. Visual Appearance

Visual displays help increase attention, learn, and maintain learning. The teachers in activities that use visual displays and invite their students to use them will also highlight visual information processing and improve learning.

3.3.5. Positive Climate

Research on the brain confirms the positive effects of emotional engagements on learning and the formation of synaptic connections. Teachers who create a positive classroom climate will also minimize student behavior problems, and students become increasingly involved in learning [31].

3.4. Neuroscience Implementation in Elementary School Science Development

The results of the neuroscience study above showed that the brain underlies children's behavior and skill

development. However, the results of the neuroscience laboratory cannot be directly applied to learning in the classroom. This is because the laboratory conditions are different from the classroom, and the variables that influence human behavior and skills are quite complex [38].

Tommerdahl in Hidayat proposed five connecting bridges that need to be passed before applying the research findings in the neuroscience laboratory into learning practices. They are neuroscience, cognitive neuroscience, psychological mechanisms, educational theory, and learning classrooms [39]. With this connecting bridge, the results of educational neuroscience research will be more comprehensive in understanding humans.

Like other biologics, children's brains also develop naturally and require nutritional intake to work optimally. Therefore, teachers and parents are responsible for monitoring the nutritional adequacy of children. Furthermore, they are responsible for maintaining biological conditions from various threats and assigning tasks appropriate to the stage of children's brain development [38].

The working system of the lobes in the cerebral cortex explains that active, fun, and student-centered learning is very good at activating the brain. Therefore children's potential develops optimally. Conversely, passive, stressful, and boring learning will make children bored and quickly forget information. This study's results are relevant to Piaget's theory, which explains that learning should encourage children to actively engage in various activities according to their development stage [40].

The results of research in educational neuroscience have inspired elementary school practitioners to develop an approach that facilitates it to work optimally, namely brain-based learning. This approach considers how the environment and experiences influence the brain. Therefore, the learning process does not force students to learn but encourages them to learn independently [41].

a) *Optimization of Intelligence:* Education needs to develop intelligence and not memorization, such as by stimulating the brain to think. An intelligent brain increases creativity and new inventions to discover new things.

b) *Functions balance of the right and left brain:* The right and the left brain have different functions. Furthermore, the right is more intuitive, random, irregular, and divergent, while the left brain is linear, regular, and convergent. Therefore, education should develop both hemispheres in a balanced manner. Also, exploratory and divergent learning by providing more than one possible correct answer will develop both brain hemispheres.

c) *Triune Brain Balance:* Education needs to develop a balanced upper, middle, and lower brain function (logic, emotion, and motor), often referred to as head, heart, and hands. This following the goals of national education, specifically to develop intelligent, skilled, and noble people.

d) *Hand motor development:* Stimulation through hand motor skills needs to be done from an early age. The hand coordination is reversed, in which the right brain controls the left hand, and the left brain controls the right hand. Therefore, it is not appropriate to prohibit children from using their left hand because it develops their right brain [42].

Lestari showed that the brain-based learning approach offers a learning concept oriented towards empowering students' brains by creating a learning environment that encourages them to be active, challenging, fun, and meaningful. Active learning means the learning that promotes children to be active in a process that involves the body and sensory organs. Meanwhile, expected learning means those that make students feel challenged to solve a problem, for example, through games and puzzles. Also, fun learning means learning that makes them comfortable and excited [43].

Therefore, educational neuroscience research results in basic education have encouraged teachers and parents to provide a learning environment appropriate to the later stages of development. This encourages students to actively build their abilities by carrying out various activities that stimulate their brains.

4. Conclusion

Based on the above results, it can be concluded that educational neuroscience is a field that focuses on examining the concept of transdisciplinary education from a neuroscience perspective. The results showed that the nervous system structure underlies human actions, both aspects of cognition, affection, psychomotor, and intelligence. Also, implementing elementary school results involves neuroscience, cognitive neuroscience, psychology, educational theory, and learning practices. Also, the concept of learning from a neuroscience perspective involves empowering the brain's abilities according to its developmental stage. It also involves optimizing teachers' performance by creating a challenging, fun, and meaningful learning environment and encourages students to be active in the learning.

This review's implications are for elementary school education stakeholders to consider neuroscience studies in developing social interactions of teachers and elementary school students in learning so that learning objectives could be maximally achieved.

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