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Trends in the Implementation of Brain-Based Learning in Indonesia: A Systematic Literature Review

Waliyyatu Azzahra [1*], Dimas Febriansyah Krisna Dwiputra [2]

[12] Education University of Indonesia

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Corresponding Author
Email address: waliyyatuazzahra@upi.edu

ABSTRACT

Understanding the brain's mechanisms underlying the learning process holds the potential to revolutionize educational strategies and designs, thereby optimizing the learning experience. Building upon this premise, this study aims to critically review and summarize the evidence of the previous studies that pinpointed the development of the brain-based learning learning implementation in Indonesia and its impact on the learning process . This study applies the systematic literature review method by following the PRISMA 2021 guidelines. We used Scopus and Google Scholar databases from 2013-2022 as the sources. Of the total 2013 articles found, only 92 met the predetermined criteria and then content analysis was carried out. The findings in this study include: (1) there was an increase in research trends related to the implementation of brain-based learning in Indonesia from 2013-2019, but it started to decline in 2020-2022; (2) quasi-experiment dominates the method used; (3) brain-based learning is relevant to be applied at various levels of education; (4) the majority of studies are conducted in the fields of mathematics and science; and (5) the application of brain-based learning has a positive impact on various aspects of learning. Based on these findings, this research provides a scientific contribution as a basis for stakeholders in developing research related to the application of brain-based learning by utilizing methods, educational levels, and fields of knowledge that have not been widely explored. This effort was carried out to encourage novelty in brain-based learning research because its application has been proven to provide various benefits for improving the quality of education in Indonesia.

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1. INTRODUCTION

The realities of the 21st century and the Industrial Revolution 4.0 have brought the Indonesian people into an era of disruption that is synonymous with rapid transformation in various aspects of life such as technological, economic, social, environmental, or educational (Grybauskas et al., 2022; Hecklau et al., 2016; Pabbajah et al., 2020). These conditions require various stakeholders, including in the field of education, to adapt the changes. One response to this challenge is optimizing brain function in the learning process. This is because the brain serves as the primary component which influences how and what a person learns. Understanding brain mechanisms as the basis of the learning process will enable the transformation of educational strategies and designs that can maximize the learning process (Blakemore & Frith, 2005; Weiss, 2000). For this reason, a teacher has a challenge of not overlooking the brain's integral role in the learning process to ensure the delivery of quality education that equips students to meet the demands of the 21st century.

Brain-based Learning (BBL) can be an applicable solution to the aforementioned challenges because its application is based on the principle of creating learning that is in harmony with the natural design of the brain in learning (Jensen, 2008). This is done by considering the various natural elements of the brain in the design and implementation of learning starting from social, emotional, cognitive, kinesthetic, and reflective aspects (Given,

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2002). Furthermore, BBL also considers how the brain system works when taking, processing, and interpreting the information that has been obtained (Adhani et al., 2017; Wiantara et al., 2020). The application of BBL is expected to foster thinking skills, cultivate a conducive learning environment, and establish active and meaningful learning situations for students (Husna et al., 2018; Mastoni et al., 2019; Setyaningtyas & Harun, 2020). One of these hopes will be realized through learning that takes into account the diversity of student learning styles by involving visual, auditory, or kinesthetic elements in the learning process (Dwiputra et al., 2023; Lidiastuti et al., 2020). This illustrates that BBL in its learning process places great emphasis on students (student-centered learning).

Research related to BBL in Indonesia has been carried out quite a lot, starting from the level of early childhood education to tertiary institutions. This is inseparable from the potential of BBL which provides opportunities for students to improve brain function in the learning process so that students can develop their abilities (Adiansha et al., 2018). Based on the results of previous research, several students' abilities that can be optimized through the application of BBL include: communication and meta-analysis skills (Effendi & Marlina, 2021; Findasari et al., 2014; Nilawati et al., 2019; Permana & Kartika, 2021; Syahrir & Prayogi, 2022), connections (Dewi & Masrukan, 2018; Fitri & Zaeni, 2020), problem-solving (Damayanti & Sukestiyarno, 2014; Juliantini et al., 2020; Laksana et al., 2019), critical thinking (Diani et al., 2019; Handayani et al., 2016; Herliandry et al., 2018; Juniatri et al., 2022; Karolina, 2018; Susanti et al., 2019; Triana, 2019), creative thinking (Adiansha et al., 2021; Khoeriyah et al., 2019; Putri et al., 2019; Widiana et al., 2017), reasoning (Dewi & Zahid, 2020), literacy (Kumala et al., 2020), and writing ability (Zuhriyah & Agustina, 2020). The application of BBL can improve the fundamental things which determine the success of the learning process namely motivation, self-efficacy, and student achievement (Isro'i & Ghufron, 2015; Mekarina & Ningsih, 2017; Riskiningtyas & Wangid, 2019; Sani et al., 2019a; Kartikaningtyas et al., 2018). These various benefits certainly make the BBL model attractive to be applied and further developed in the learning process in Indonesia.

Although various research related to BBL implementation has been carried out, there has not yet been a comprehensive analysis of all the information obtained, particularly concerning the development of BBL research in Indonesia. Such research is important to carry out because it can provide information about the extent of the implementation and benefits of BBL in education in Indonesia. This information is intended to serve as a valuable reference for teachers in their instructional practices. . In addition, the findings obtained can also be used as a starting point for future researchers to complete deficiencies in the application of BBL. This endeavor aligns with the overarching goal of optimizing the educational process to foster quality education so that it will also have a positive impact on the development of Indonesian human capital that is adaptive and proficient in addressing the demands of the 21st century and the industrial revolution 4.0.

The following were the questions that directed the literature search and analysis: : 1) How is the development of the number of research publications on the implementation of BBL from year to year? 2) What is the diversity of research methods used in BBL research? 3) What are the variations in educational levels that implement BBL in the learning process? 4) What are the objects of intervention that are the focus of BBL research? 5) What is the impact of implementing BBL on students? This study uses content analysis of 92 selected scientific articles related to BBL implementation in Indonesia. Examining these various aspects can provide an overview of the success of BBL research and open opportunities for the application of the BBL model at educational levels where it is still minimally used.

2. MATERIAL AND METHODS

Search and Selection Process of Literature

The search and selection process for articles in this review was carried out systematically referring to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines developed by Page et al. (2021). This research focused on analysing the various previous articles that were relevant to the implementation of BBL in Indonesia. The articles analysed were obtained on October 23, 2022 by utilising Harzing's Publish or Perish software via the Scopus and Google Scholar databases. The keywords used in the search process were brain-based learning, neuro pedagogy, or neuroscience. A total of 2013 articles were obtained from the search process and then a selection was carried out to obtain articles according to the established criteria.

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Inclusion and evaluation of studies

Articles selected and included in this review must meet several inclusion criteria, such as: 1) this review of literature focuses on materials published between 2013 and 2022 to ensure the analyzed articles accurately reflect the most recent advancements, considering significant developments in implementing BBL in Indonesia over the past decade; 2) the literature, presented as journal articles or conference proceedings, plays a crucial role in confirming that the writing process has undergone extensive academic review and assessment; and 3) the selection criteria encompass articles published in journals indexed in Scopus (Q1-Q4) or Sinta (S1-S3), chosen based on the understanding that these journals adhere to a rigorous evaluation process, ensuring the thorough assessment and quality of the published articles Next, an examination of the exclusion criteria was carried out. The exclusion criteria includes: 1) the articles are in the form literature review; 2) The locations of the research are not in Indonesia; and 3) The articles are not empirical research. In full, the stages of the article selection process through the PRISMA guidelines are explained in Figure 1 below.

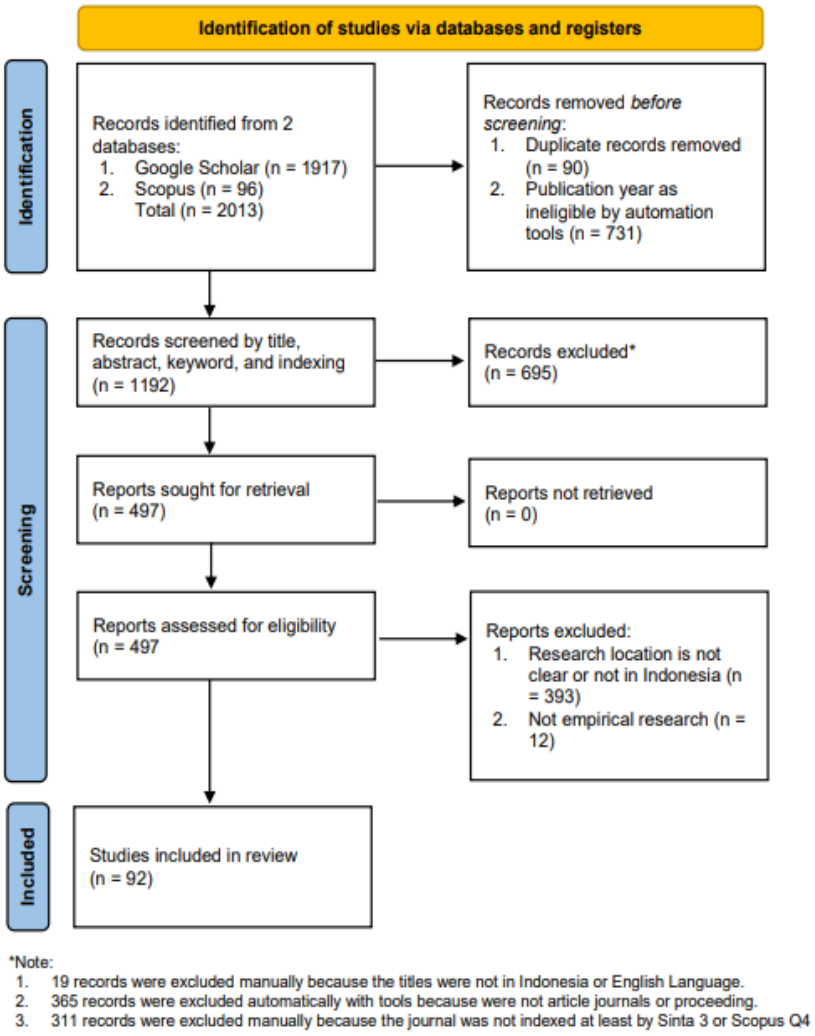

Figure 1. Source search and selection process

After the selection process was carried out, there were 92 articles that met the criteria. Next, the abstract of the article was studied to find the focus of the study. If not available, then the complete publication of the article was searched to find further aspects and categories of study.

Research instruments

The research instrument used in this study was modified from the instrument developed by Susetyarini & Fauzi (2020). The instrument contained five aspects, namely: 1) the number of BBL research publications per

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year; 2) the type of research method used; 3) level of education implementing BBL; 4) BBL intervention subjects; and 5) impact of BBL implementation.

To facilitate the content analysis process, the categories that were the focus of the study for aspects 2, 3 and 4 are presented in Table 1. Meanwhile, aspect 1 was not shown in the table because it only looked at trends and the number of BBL publications so it did not require categorization. As for aspect 5, it was also not included in the initial instrument because there will be the possibility of various impacts from the implementation of the BBL given during the learning process. This impact can be in the form of certain abilities or skills that will be obtained by students after implementing BBL.

Table 1. Aspects and categories used for content analysis

Aspects	Category	References
Research methods	A1. Quantitative research	2 3 4 5 6 7 8 9 10 12 14 17 18 19 21 22 24 25 26 27 28 29 31 32 34 35 37 38 39 41 42 44 45 46 47 48 49 51 52 53 54 55 58 59 60 62 64 65 67 69 70 71 72 73 74 75 76 77 82 83 85 86 87 89 90 91 92
	A2. Qualitative research	15 23 30 33 40 43 64 84
	A3. Research & Development (R&D)	1 11 13 20 36 50 56 61 66 68 78 79 80
	A4. Classroom Action Research (CAR)	16 57 82 88
Education levels	B1. Early childhood education	41
	B2. Elementary school	4 19 21 23 25 26 27 44 47 60 69 79 81 82 88
	B3. VII Grade JHS students	5 11 15 34 46 54 63 64 66 67 75 76 85 87 92
	B4. VIII Grade JHS students	1 2 3 9 10 17 18 22 24 28 29 30 40 70 71 72 77 90 91
	B5. IX Grade JHS students	-
	B6. X Grade SHS	12 13 20 35 36 37 39 42 43 50 52 53 56 59 62 73 74 80 84
	B7. XI Grade SHS	16 32 33 51 55 57 58 61 65 86 89
	B8. XII Grade SHS	-
	B9. College	6 7 8 14 31 38 45 48 49 68 78 83
Intervention objects	C1. Language	5 6 36 48 63 82 84
	C2. Religion	38 43
	C3. Mathematic	3 4 8 9 10 12 14 15 16 17 19 20 21 22 23 24 25 26 27 30 31 32 40 41 42 46 50 52 53 58 59 60 64 67 69 70 71 72 75 76 79 80 81 83 86 87 91 92
	C4. Natural Science	1 2 4 11 13 18 28 29 34 35 37 39 44 47 49 51 54 55 56 57 61 62 65 66 68 73 74 77 85 89 90
	C5. Social Science	33
	C6. Computer Science	78
	C7. Sport & Art	-
	C8. Etc.	45 88

The articles that have been collected are grouped based on predetermined aspects and categories as presented in Table 1 above. Each category contains appropriate articles. Then the calculation results for each category are presented in the form of a diagram or table to make it easier to present the data for further description. The number of articles in the reference column is written in the Appendix.

3. RESULT AND DISCUSSION

Number of Publications on the Implementation of BBL in Indonesia

The importance of creating a learning environment that strengthens the potential of students' brains encourages increased use of the BBL model in Indonesia. This is because BBL offers a balanced approach between right and left-brain work (Amelia et al., 2022; Badriyah et al., 2020; Wulansari et al., 2020). These advantages of

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BBL have attracted the interest of many researchers to investigate further and reveal the wider impact of this model. At least, in the last 10 years we can observe BBL research trends in Figure 2.

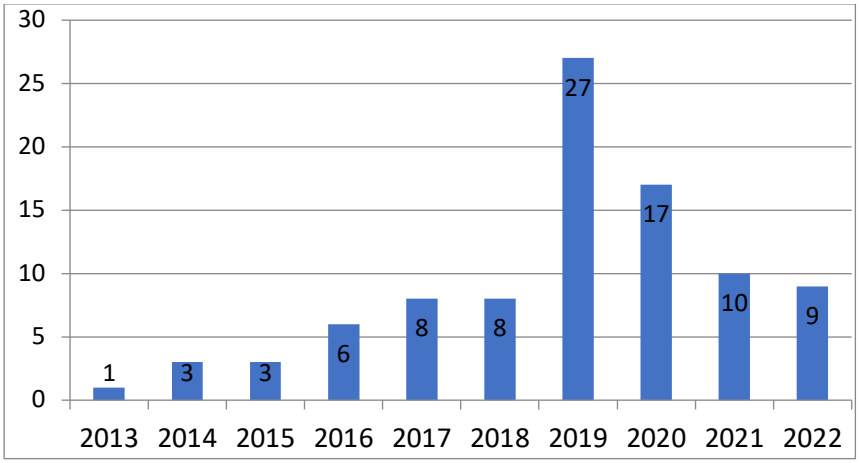

Figure 2. Trends in BBL Research in Indonesia in 10 Years

As of 2013, research on the implementation of the BBL model in Indonesia has increased to reach its peak in 2019 with 27 articles. Entering 2020, the implementation of BBL in Indonesia will begin to decline until 2022. This trend can be interpreted as, first, previous research has comprehensively examined the impact and effectiveness of the BBL model; or secondly, BBL research has reached a saturation level so that it has decreased in the last three years. Therefore, it is necessary to carry out further investigations into the factors causing the decline in research related to BBL in Indonesia.

Types of Research

The research was conducted to improve the quality of education. The emergence of various problems in education makes the wider scope of research conducted. This also makes the diverse views of researchers in highlighting the phenomena and problems that occur. In this case, the accuracy of using the method also determines the success of the research conducted. Through research methods that are relevant to the topics discussed, experts highlight the problems of education in Indonesia by linking them to the implementation of the BBL model as a solution for solving them. From the results of the content analysis of 92 articles, the distribution of research methods used regarding BBL has diversity as shown in Figure 3.

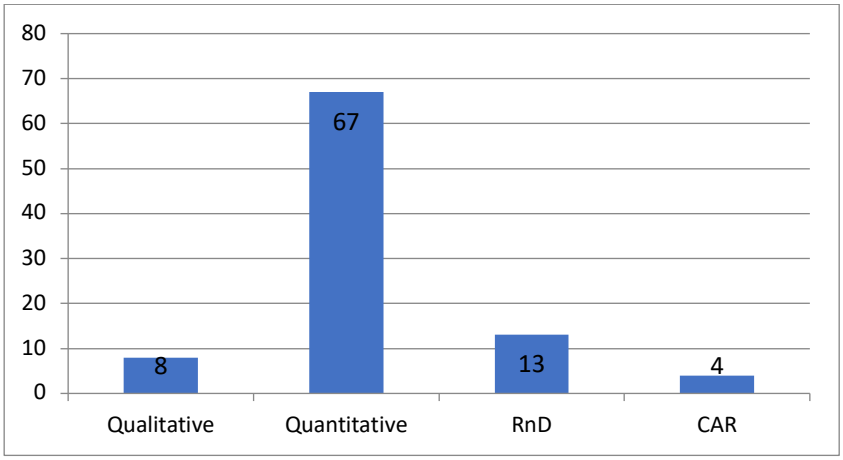

Figure 3. Distribution of research methods used related to BBL implementation

The selection of research methods is based on the needs of researchers in solving problems. The graph in Figure 3 shows the number of studies related to BBL that use the most dominant quantitative method, namely 67 articles. When compared to quantitative research, there are far fewer types of research using qualitative

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methods, RnD, and CAR in BBL research. RnD was found in 13 articles, qualitative research was limited to 8 articles, and CAR was carried out in only 4 studies. The use of this type of research, which is still limited, certainly presents a great opportunity for other researchers to conduct further research and investigations to dig deeper into the potential of the BBL.

Level of Education

In conducting research, the selection of research subjects is one of the things that is highly considered for testing hypotheses. Determining and organizing research subjects is important to know what or who will provide data and information for researchers. Through the learning flow offered, BBL has become an attraction for researchers to test at various levels of education. It is known that almost every level of education has intervened with the implementation of BBL as presented in Figure 4 below.

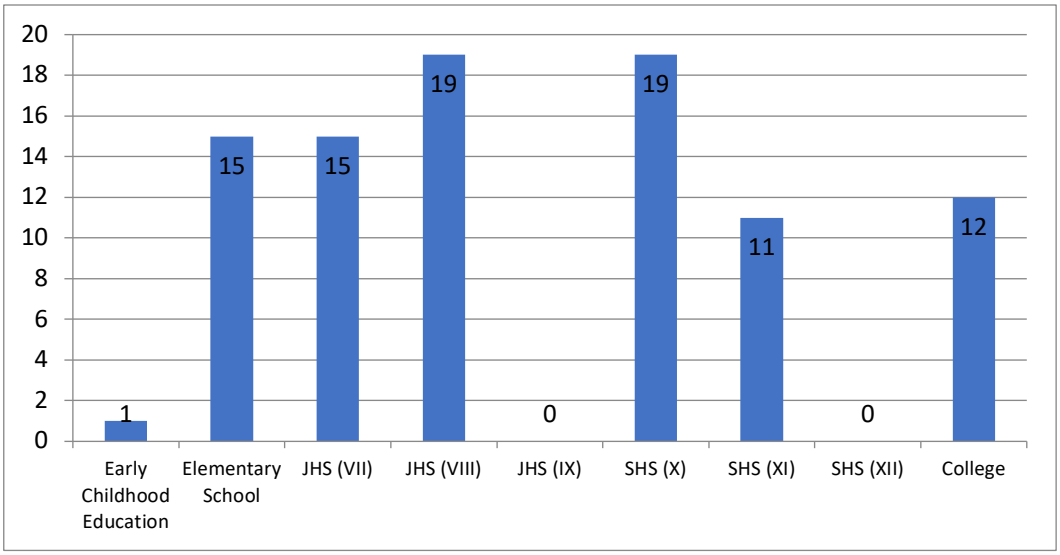

Figure 4. Distribution of BBL Implementation by Education Level

The application of the BBL at various levels of education is increasingly widespread. Figure 4 illustrates that the distribution of BBL research is very diverse, starting from the level of Early Childhood Education to tertiary institutions. The implementation of BBL research is dominated by the Class VIII and Class X education levels, each of which is discussed in 19 articles. It can be seen that there has been no research at all at the level of class IX junior high school and class XII senior high school related to BBL. This shows that the final level of an educational level is rarely used as a research subject. Another interesting thing about the distribution of BBL research is that the implementation of this model has begun to be applied at the early childhood education level, even though it was only found in one study.

Intervention Object

Based on previous research reports, BBL is a conceptual framework that is arranged systematically and is proven to be able to help achieve learning objectives. The learning model is strongly influenced by the nature of the material to be taught . One of the ways to enhance the effectiveness and efficiency of explaining subject matter is through the utilization of appropriate learning models. Active and engaging learning patterns have been shown to facilitate this process (Purnama et al., 2015; Windhari et al., 2013).BBL can be applied in various intervention objects, in this case, specifically , subjects taught to students at school. Through a review of previous research, the BBL model has been applied in various scientific disciplines as shown in Table 2 below.

Table 2. Percentage of BBL Implementation Based on Intervention Objects

Intervention Object	Amount	Percentage (%)
Language	7	7.61
Religion	2	2.17

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Mathematics	48	52.17
Natural Science	31	33.70
Social Science	1	1.09
Computer Science	1	1.09
Sports and Arts	0	0
Other	2	2.17

The data in Table 2 shows that the application of BBL is dominated in science and mathematics learning. Although its application is still limited, it is also applied to other subjects, such as language, religion, social sciences, and computers. This fact is certainly a novelty opportunity for researchers in fields that are still limited in their study. The discoveries also indicate that the introduction of BBL has commenced focusing on specific subjects in primary school and within college educational evaluation courses. The original purpose of this intervention was not defined in the initial plan. Essentially, it can be inferred that BBL proves to be an adaptable and versatile learning approach since it can be applied across diverse learning domains.

Impact of BBL Implementation

BBL is comprehensive learning based on natural brain work patterns so that it can facilitate all individuals with different levels of intelligence. In implementing BBL, teachers use methods that maximize students' intellectual talents so that learning will be student-directed and centered (Sani et al., 2019b). Various aspects that are expected to appear in students during the learning process become the realm of research to examine BBL further. Out of 92 reviewed articles, 86 specifically mention the dependent variable in the conducted research. Meanwhile, six other articles do not elaborate on the aspects affected by the implementation of BBL. From the analysis of the articles carried out, 10 aspects are most dominantly influenced by BBL as in Table 3 below.

Table 3. Dominant Aspects Affected by BBL

Aspects	**Number of Articles**	**Percentage (%)**
Learning outcomes	21	24.42
Critical thinking	18	20.93
Problem-Solving	8	9.30
Creative thinking	7	8.14
Communication	7	8.14
Concept understanding	7	8.14
Connection	6	6.74
Literacy	5	5.62
Retention	4	4.49
Motivation	3	3.49

Based on Table 3, the implementation of the BBL model has a positive impact on students, especially on learning outcomes. This aspect is most commonly used variable as the focus of research as evidenced by a review of 21 articles. Besides, students' critical thinking skills, problem-solving, creative thinking, communication, and connections also show satisfactory results. Furthermore, learning outcomes will be more meaningful if the information conveyed is not easily lost from students' memories. In this case, aspects of retention, conceptual understanding, and other aspects also appear in students after the application of this BBL model. This proves that BBL can create a conducive learning environment for students.

DISCUSSION

Trends in the Number of Research and the Diversity of Their Types

Most research exploring the application of BBL stems from contemporary issues within the educational sphere. These issues encompass a range of challenges such as students' low academic performance, insufficient development of critical thinking and problem-solving skills, lack of learning motivation, and various other educational obstacles. The prevailing learning methods in Indonesia have not effectively optimized students'

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cognitive capacities, resulting in learning outcomes that fall short of expectations (Jazuli et al., 2019; Komarudin et al., 2019; Martyaningrum et al., 2018; Mertha et al., 2019; Prihatin et al., 2017; Rahman & Kharisudin, 2019; Rohmah & Mashuri, 2021). Generally, the conventional teaching models employed by educators have failed to seamlessly align with natural brain functioning throughout the learning process. This discrepancy serves as the impetus for experts to spotlight these issues through diverse research approaches. Through investigations centered on BBL, there is an optimistic outlook that it could offer solutions to address these concerns.

However, it is an evident that in the recent three-year period (2020-2022), there has been a decline in the pursuit of BBL research in Indonesia. This presents a paradox considering the proven benefits of BBL in enhancing learning outcomes, indicating a need for academics to sustain interest in advancing BBL-related research. Upon deeper analysis, this decline seems linked to the predominance of quantitative research methods, particularly quasi-experimental approaches, resulting in a narrower range of research patterns and characteristics due to saturated study results. Consequently, future researchers should contemplate employing alternative research methodologies to generate fresh insights and enrich the discourse on BBL implementation. Given the limited availability of research methods beyond quantitative approaches, this presents an excellent opportunity for other researchers to expand the scope of BBL studies, such as qualitative research, R&D, and CAR.

However, it is an evident that researchers utilizing quantitative methods with quasi-experimental approaches have conducted thorough analyses. The utilization of quantitative data permits interpretations via statistical analysis founded on mathematical principles. This renders the application of quantitative methods in research as scientifically logical and objective. When considering the BBL model, it becomes apparent that the adoption of this method aligns with the principles of the BBL model, fostering a relaxed and enjoyable learning environment, alleviating students' sense of pressure or burden (Permana & Kartika, 2021; Putri et al., 2019). This scenario contributes to the successful implementation of the BBL model, creating a comfortable learning atmosphere for students. Meanwhile, the implementation of qualitative research remains considerably limited.Despite its numerous advantages, notably its ability to intricately and comprehensively define a phenomenon (Kohar, 2022; N. Wahyudi & Widodo, 2020; Zakiyah & Rosyidah, 2021).

Regarding the execution of Research and Development (RnD) research in Indonesia, it is noteworthy that there have been limited endeavors in this area. Content analysis of articles indicates that the BBL model can be further developed by integrating it with other learning models like the Example Model, the AIR Model (Lidiastuti et al., 2020), and the Problem-Based Learning Model (Haryulinda et al., 2020). This blendof learning models has shown improvement in student learning outcomes, enhancing their understanding of the material studied, refining analytical skills, and bolstering self-confidence (Yuliarti et al., 2017). RnD research aimed at product development to bolster the implementation of the BBL model, such as modules and notebooks or textbooks, has also proven successful in honing student competencies (Asfar et al., 2022; Khafid, 2016; Kusumaningrum et al., 2021; Santosa et al., 2019). Initiatives to innovate these learning tools stand as commendable efforts to augment student comprehension. Further innovative products supporting the effective implementation of BBL are highly anticipated to undergo continued development and expansion.

A review of past articles indicates that Classroom Action Research (CAR) is the least frequently undertaken. Research demonstrates that integrating BBL into CAR has resulted in improved learning outcomes, problem-solving skills, motivation, and student engagement (Helmahria et al., 2017; Rasmitadila, 2014). According to Shumsky (1982), CAR holds the advantage of nurturing creativity and critical thinking through open, reflective, or evaluative interactions among teachers and fostering collaborative efforts toward change. Thus, CAR emerges as a suitable research approach for practitioners, including educators.

Opportunities for BBL Implementation at Various Levels of Education

Based on the findings, research on the implementation of BBL at the final level of junior high and high school education has never been carried out. This phenomenon is in line with the tendency of most schools to be selective in granting permission to researchers to conduct research in grades III of junior high or high school due to the tight schedule for preparing for the National Examination. However, in the latest curriculum implemented in Indonesia, the National Examination has been abolished and replaced with a Minimum Competency Assessment which is carried out in grades V of Elementary School, VIII of Junior High School, and XI of Senior High School. Conducting assessments that occur not only at the end of each grade level but also intermittently throughout the educational journey presents an opportunity to evaluate the implementation of the BBL model at each stage. This approach is crucial as it allows for the maximization of students' brain potential within the specified age range.

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Basically, the ability of the human brain has excellent potential, when it is optimally developed and balanced. The ability to function and work power of the brain develops along with individual growth and development. Wahyudi (2017) presented a measurement result which showed that the rate of intelligence development took place very rapidly until adolescence, after which the speed gradually decreased. The peak of development is generally reached at the end of late adolescence. Therefore, in order to optimize the actualization of potential intelligence in students, it is necessary to carry out interventions on the brain that develops this intelligence with each increase in student age. This is crucial for implementing BBL at every level of education to maximize brain function. Of course, the stimulation provided in the learning process must refer to the work of each child's brain.

On the other hand, the implementation of BBL at the early childhood education level is an interesting matter. According to Siegler and Alibali (2005), changes in brain size, structure, and connection patterns have an important contribution to the cognitive development and mindset of children. Furthermore, Santrock (2010) explained that the environment significantly influences children's brain development, particularly during early childhood, when brain growth and development occur rapidly. In addition, the BBL approach can also encourage the ability to communicate, collaborate, and link knowledge at an early age which is important for building a solid learning foundation in the future (Khadijah, 2016). Therefore, the application of BBL at the early childhood education level is an area that is promising and deserves attention in order to stimulate the child's brain to develop properly.

The Potential of BBL Implementation in Various Disciplines with Various Student Conditions

Through learning principles that maximize the potential of students' brains, BBL is suitable for application in various disciplines, especially at the formal education level. The application of the BBL model provides an opportunity to create a learning process that actively and thoroughly engages students' brains, and frees students to build their knowledge of diverse and contextual learning situations (Dewi & Masrukan, 2018; Susanti et al., 2019). BBL is very relevant to constructivism theory because its application provides opportunities for students to find or apply ideas actively while paying attention to the potential and balance of brain work in learning (Wiantara et al., 2020).

The BBL model can provide great benefits in various subjects that have various learning situations. This benefit is supported by the principle of BBL learning which balances the right and left hemispheres (Badriyah et al., 2020). Each part of the brain has a specific function in controlling certain abilities. This also makes students have different characters, interests, and learning styles. For this reason, educational interventions through teachers are important to ensure that students achieve learning goals according to their respective ages, developments, and abilities. From the BBL research that has been done, teachers can give different treatment to students with a more dominant right hemisphere or vice versa. For example, the implementation of BBL is supported by the use of crosswords, puzzles, games, or learning accompanied by music or songs (Badriyah et al., 2020; Gusti et al., 2020; Nahdi & Id, 2015). Besides, other studies have integrated BBL with the scaffolding method by adjusting the level of teacher support to the cognitive potential of a student (Damayanti & Sukestiyarno, 2014). From the various variations of the treatment given, better student learning outcomes were obtained. This study reveals that the teacher's role in identifying and understanding children's interests and talents toward certain subject matter is crucial, and BBL can be an alternative in supporting this.

From the results of the analysis, the implementation of BBL in sports science and art has never been implemented in the last 10 years. Sports science uses physical activity to increase individual capacity as a whole in the form of physical, mental, and emotional aspects (William, 2001). Sports science does not only deal with physical health but involves all aspects of human development including reasoning and thinking. Besides, the characteristics of art which are multilingual in nature function to develop students' creative self-expression abilities in various ways and media (Jailani, 2021). When connected to BBL, the application of this model supports a learning process that prioritizes student activity and creativity (Niswani & Asdar, 2016; Yahya & Solihati, 2022; Yuda et al., 2013). It can be said that BBL in its application also emphasizes the minds-on and hands-on abilities that exist in students. This is certainly an opportunity to implement BBL in sports and arts learning because the BBL principles are relevant to the characteristics of the two disciplines. Furthermore, it is possible that the application of the BBL model can be expanded considering the potential of this model to be able to accommodate multidisciplinary learning activities.

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The Impact of BBL Implementation on Supporting Student Learning Processes

Knowledge does not completely come from outside but is formed by the individual himself in his cognitive structure (Yuntari et al., 2013). This is in line with the principle of student-centered BBL. In the process, the teacher only facilitates the creation of a positive environment and student involvement, so that students' attention, understanding, and memory about learning can last longer (Rukminingsih et al., 2021). Through a systematic BBL learning flow, students' thinking skills are stimulated to understand the subject matter so it is hoped that students' mastery of the material will be better. By applying concepts to integrate learning by maximizing students' brain potential, BBL can create a meaningful learning environment and challenges students' thinking skills (Husna et al., 2018; Susanti & Adamura, 2020; Suarsana et al., 2018). This certainly has a positive impact on supporting the learning process.

When linked to the relevance of 21st-century learning, BBL directs students to have the skills needed, especially in their efforts to find, use, and manipulate information (Aulia et al., 2021; Handayani & Purwati, 2022). Students must be able to use these skills to generate new ideas, so they can practice thinking skills. The application of BBL can also develop student creativity by encouraging students to have ideas and ideas in solving problems based on the knowledge they have (Cahyani et al., 2020; Imanuel et al., 2021). Besides, through the BBL model which involves and considers the potential and how the brain works naturally, the process of remembering and storing information in memory can be maximized (Handayani & Nurfadilah, 2021; Rahmatin & Suyanto, 2019). With the brain's ability to consider things naturally, it is hoped that it can also shift students' knowledge from short-term memory to long-term memory. As explained by Jensen (2008), BBL is rooted in the theory of cognitive neuroscience, namely how the brain works in carrying out its functions.

Overall, the positive impact of BBL implementation appears because it is supported by well-designed principles and directed learning flows. BBL focuses on how to optimize all brain functions through a good environment for learning, namely an environment that challenges students' abilities and is fun, active, and meaningful (Kartikaningtyas et al., 2017; Lusiana & Andari, 2020). The encouragement of fun and love in learning makes students able to absorb material easily and facilitates students to develop self-efficacy because it emphasizes learning that is comfortable, fun, emotionally interesting, and the learning process is per students' brain abilities (Priatna, 2017; Riskiningtyas & Wangid, 2019; Wijayanti et al., 2021; Yudha et al., 2020). Thus, the impact of BBL that has been revealed in various studies can be a basis and reference for educational practitioners to consider BBL as a potential alternative learning model to be implemented.

4. CONCLUSION

In this study, 92 articles published in the last 10 years focusing on brain-based learning were reviewed. It was found that there was an increasing trend of BBL research from year to year using various research methods. Experimental research methods, especially quasi-experiments dominate research related to the implementation of BBL in Indonesia. Meanwhile, BBL is known to have been implemented in various disciplines and shown positive results. The utilization of Brain-Based Learning (BBL) presents a wealth of benefits, empowering students with a diverse skill set crucial for confronting the complexities of the 21st century. These skills span critical thinking, creativity, problem-solving, and beyond. BBL principles underscore the fine-tuning of brain functions within a dynamic educational milieu—one that not only pushes students' capacities but also nurtures an ambiance of joy, involvement, and importance. With these research insights, educators have an open door to effortlessly infuse BBL techniques into their teaching methodologies. Instead, it is suggested to other researchers to study BBL more deeply using other types of research that are still limited in use, namely qualitative research, RnD, and CAR. Furthermore, the implementation of BBL is also recommended to be applied evenly at every level of education with broader and more diverse disciplines.

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