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Integrating Brain-based Learning in the Science Classroom: A Systematic Review

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ARTICLE INFO	ABSTRACT
	Brain-based learning (BBL) has been described as an important pedagogy that can be effectively used to enhance different teaching methods or strategies. It uses essential principles from brain-based theory to alleviate the disadvantages inherent in traditional teaching methods to achieve classroom goals and objectives. The use of such learning has significant implications for the teaching and learning of science (biology, chemistry, mathematics, and physics) subjects at elementary and secondary school levels. In this review, we scrutinise and discuss the results from 25 peer-reviewed studies and underline the methodology and strategies used to advance the integration of brain-based learning within science classrooms. We make a meta-analysis systematic review of how such learning has been used in the science classroom, the success achieved, and the different constructs used to integrate it into elementary and secondary schools. The findings reveal that quasi-experimental studies have dominated the methods used in integrating brain-based learning in science classrooms. In addition, this type of learning topped the different constructs used in science classrooms, with its integration mainly in relation to mathematics. It is concluded that the principles of brain-based learning pedagogy can be adequately used in science classroom instruction because they consider the uniqueness of each student's brain. This paper therefore recommends appropriate and continuous integration of such learning in the science classroom, especially in subjects where integration is currently low.

1. INTRODUCTION

The search for the best teaching methods or strategies for use in the science classroom in primary and secondary schools is ongoing and yet to be resolved. This is because all the teaching methods already identified have both advantages and disadvantages, meaning they are not perfect for classroom instruction. This is obvious because the teaching methods and resources used by teachers can contribute significantly to meaningful learning (Varghese & Pandya, 2016). Inappropriate teaching methods can therefore pose a significant obstacle to effective teaching and learning because the approach used remains a crucial factor in determining students' achievement in schools. This argument is more prominent in the teaching of science subjects, in which adequate teaching relies on the use of suitable methods. This teaching method is used in delivering curriculum content to students in the classroom. The adoption of the most relevant teaching method rests on a number of factors, which include, but are not limited to, the content to be taught, the age of the students, the availability of instructional materials, student characteristics, and the time available for teaching. While the importance of using suitable teaching methods or strategies for the realisation of classroom objectives has been emphasised, to date there seems to be a lack of agreement on the best ones for use in the classroom. Researchers are constantly faced with the problem of recognising and identifying the best method to use for instruction in the science classroom as none of the available methods alone is perfect for instruction. However, studies have indicated that one approach to overcoming the disadvantages of the different teaching methods is to use the principles of brain-based learning (Caine & Caine, 2001; Jensen, 2008).

Such learning is an approach to classroom instruction that complies with teaching in the 21st century, in which students are given more opportunity to be responsible for their learning. Contemporary teaching methods emphasise the use of student-centred learning, with the role of the teacher becoming more of a facilitator. Brain-based learning emerged from brain-based theory, which is based on findings from neuroscience. According to

Varghese and Pandya (2016, p.104), "brain-based learning is a comprehensive approach to instruction using current research from neuroscience to determine how human actually learns". Brain-based education involves engagement with methods and techniques developed from tcomprehension of the brain (Jensen, 2008). Ozden and Gultekin (2008) state that brain-based learning is a comprehensive approach to instruction based on neuroscience, which explains how the brain learns naturally and answers the question concerning the most effective way for the brain to learn.

Brain-based learning (BBL) originally derived from brain-based learning theory, which originated from findings in the field of neuroscience. Neuroscience is the scientific study of the brain and deals with its structure and functions (Arun & Singaravelu, 2018; Connell (2009, p.29) defines brain-based learning as "techniques gleaned from research in neurology and cognitive science which is used to enhance instruction". Neuroscience places great value on the brain as a basic factor in learning. This is because students come into the classroom with different backgrounds, so it can be said that the brain of each one is unique. Brain-based learning is therefore based on the arguement that understanding how the brain learns helps students and teachers to appreciate when and why learning occurs from a psychological perspective. Connell (2009) identified the factors that can affect learning, including environmental factors, psychological qualities, the chemical structure of individuals, and their interactions.

BBL became widely accepted following Jensen's (2008) definition of it as a way of thinking about the learning process, which provides a set of principles and a base for knowledge and skills upon which better decisions about the learning process can be made. Although it was not originally meant to be a teaching method or strategy, its principles can be effectively used to alleviate the shortcomings prevalent in other teaching methods (Duman, 2010). Kahveci and Ay (2008) state that Caine and Caine (1994) identified twelve principles that serve as the theoretical framework of implementing this approach in classroom situations: the brain as a parallel processor; learning which engages the entire philosophy; the search for meaning is innate; the search for meaning occurs through patterning; emotions are critical to patterning; every brain simultaneously perceives and creates parts and wholes; learning involves both focused attention and peripheral perception; learning always involves conscious and unconscious processes; we have two types of memory: a spatial memory system and a set of systems for rote learning; the brain understands and remembers best when facts and skills are embedded in natural spatial memory; learning is enhanced by challenge and inhibited by threat; and each brain is unique.

Brain-based learning considers how the brain is designed for meaningful learning to take place. According to the pioneers of the approach, the brain is like other organs and one of its most important jobs is to learn (Caine & Caine, 1994). Since the goal of all teaching is for learning to take place, effective implementation of BBL is important because it emphasises meaningful learning in the classroom (Caine & Caine, 1994). Its approach is closely related to that of constructivism because they both share common principles. Kahveci and Ay (2008) identified a number of approaches that are common to both brain-based learning and constructivism. These include meaningful learning, individual differences in learning, multiple representations in learning, personal and environmental factors in learning, and affective components in learning. BBL is a student-focused and instructor-encouraged methodology that uses students' intellectual gifts and emphasises the importance of learning (Sani, A., Rochintaniawati, D., & Winarno, N., 2019). In this way, students are encouraged to be more responsible for their learning, thereby making them active in the teaching-learning process. This is a different case from the more traditional teaching methods, which render the students in the classroom passive while the teacher is active.

A number of studies on the use of brain-based learning in the classroom show that its use impacts students' achievement positively. Al-Tarawneh, A., Altarawneh, A. F., & Karaki, W. K. (2021), Alanazi (2020), Al-Balushi and Al-Balushi (2018), Saleh and Subramaniam (2019), Sani (2019), Wijayanti, K., Khasanah, A. F., Rizkiana, T., Mashuri, Dewi, N. R., & Budhiati, R. (2021) and Riskiningtyas and Wangid (2019) demonstrate that such learning improved students' achievement in primary and secondary school science, in subjects including the major core ones of biology, chemistry, physics, and mathematics. Few studies have not found a significant positive effect of the use of brain-based learning on students' achievement. Despite this, a wholesome number of studies attest that the use of brain-based learning impacted students' achievement positively. Reviews of previous related studies have attempted to settle the debate on whether brain-based learning has the capacity to positively impact students' achievements in the classroom. For example, in Jordan At-Taraweh et al. (2021) found that the

use of such an approach improved students' achievement in mathematics. This finding was repeated in Indonesia and other countries (Wijayanti et al., 2021; Riskiningtyas & Wangid, 2019; Priatna, 2017; Kartikaningtyas, V., Kusmayadi, T.A., & Riyadi, R., 2018; Noureen, G., Awan, R. N., & Fatima, H., 2017; Mastoni, E., Sumantri, M. S., & Ibrahim, N., 2019). This situation is similar to studies on the effectiveness of brain-based learning in physics; Saleh and Subramaniam (2019), Saleh (2012a, 2012b, 2012c) and Sani et al. (2019a) all found a positive effect of using BBL to improve students' performance in the subject.

A review of the literature reveals that there has been a shift from the use of traditional teaching methods to more innovative ones such as BBL because these prepare students according to global demands (Varghese & Pandya, 2016). According to Ali and his associates (2019), the shift from traditional methods to modern ones inspires not only the students but also the teachers because conventional methods simply promote the rote learning of facts. The BBL strategy is learner centred and teacher facilitated and utilises learners' cognitive development (Jack et al., 2018). In order to effectively implement brain-based learning in the classroom, its proponents have identified three major techniques that can be employed: relaxed alertness, orchestrated immersion, and active processing (Caine & Caine, 1997; Jensen, 2008; Sousa, 2011). These represent a summary of the twelve principles identified and developed by other researchers (Caine & Caine, 1994; Jensen, 2008, Kagan, 2001; Lackney, 2007; Sousa, 1995). Evidence from the literature also reveals that these twelve principles are closely related to one another.

Relaxed alertness involves ensuring a low threat and high challenge to allow the brain to achieve optimal learning. Varghese and Pandya (2016) define an environment of relaxed alertness as one in which children have no fear of repercussions, even if they are wrong. It deals with a state of the brain which is free from threat or negative stress but highly challenged, enabling the learner to internalise information optimally (Saleh & Subramaniam, 2019). According to the principle of brain-based learning, meaningful learning can only take place in a serene environment devoid of threat and fear. This is in contrast with traditional teaching methods which involve fear and threats as a result of the constant competition that arises in the classroom. Orchestrated immersion involves immersing students in the learning environment, which will help them to absorb the material more fully than simply through a lecture or book (Varghese and Pandya, 2016). It aims for the elimination of fear in learners while maintaining a highly challenging environment. Saleh and Subramaniam (2019) argue that orchestrated immersion is an instruction phase that includes a variety of teaching and learning activities related to real life situations and generates a conducive learning environment. Finally, active processing involves analysing situations in a variety of ways in order to gain knowledge (Varghese & Pandya, 2016). Saleh and Subramaniam (2019) define it as a continuous strengthening process for further understanding.

These three brain-based learning techniques are the major principles used in integrating BBL in the classroom. Their effective use can counter the disadvantages found in other teaching methods such an approach has been found to provide an encompassing methodology for students learning (Sani et al., 2019a). The method relates learning to the brain on the basis that improved performance of the brain and its features have a positive impact on learning (Noureen et al., 2017). Brain-based learning combines different concepts which are well suited to existing teaching methods in the various fields of science, language and social sciences. This indicates the fact that BBL can be effectively used in any field of study.

Only a few review studies have been conducted on brain-based learning, specifically its integration into classrooms. One such study investigated BBL strategies for improving students' memory, learning and test-talking success (Willis, 2007). Our review is therefore considered apt as it provides scholastic evidence for the previous literature on brain-based learning. The systematic review has four objectives: (i) to investigate the research methods and subject areas that influence studies on brain-based learning in science classrooms; (ii) to investigate the extent to which brain-based learning has been integrated into science classrooms; (iii) to investigate the constructs used to integrate brain-based learning in the science classroom; and (iv) to investigate the analysis techniques used to integrate brain-based learning in the science classroom. In order to successfully achieve these, the paper is arranged as follows: research questions, method, results, discussion and conclusion.

Research Question
1. What research methods and subject areas influence studies on brain-based learning in the science classroom context?
2. To what extent has brain-based learning been integrated into science classrooms?

3. What constructs have been used to integrate brain-based learning in science classrooms?
4. What analysis techniques dominate studies on brain-based learning in science classroom?

2.   MATERIALS AND METHOD
LITERATURE SEARCH

The study is a meta-analysis systematic review of brain-based learning in elementary and secondary schools. Such reviews are considered to be scientific investigations because they are rigorously, informatively, exhaustively, and explicitly conducted (Gisbert & Bonfill, 2004). This type of approach was used by Mikolajewicz and Komarova (2019), Mogas-Recalde et al. (2021) and Ogegbo and Ramnarain (2021) and was found to be very effective. For this systematic review, we conducted a literature search to identify relevant studies on BBL in science education classrooms. The search was guided by keywords which included 'brain-based teaching method (BBTM)', 'brain-based instructional method (BBIM)', 'brain-based instructional strategy (BBIS)' and 'science classrooms'. Three major reputable databases, Eric, Google Scholar and Scopus, were searched using the keywords above. 1511 articles were identified in the initial search without data parameters. However, this was reduced to 574 after using the keywords. Only peer-reviewed journal articles in English and published between January 2000 and September 2021 were considered.

SELECTION CRITERIA AND SELECTION PROCESS

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was used as selection criteria (Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, P., 2009). Such criteria were used by Ogegbo and Ramnarain (2021) in their systematic review as they provide a clear statement of the selection of articles for a systematic review study. The PRISMA statement consist of a 27 item evidence-based checklist that can be used for appraising published articles. Ogegbo and Ramnarain (2021) argue that the PRISMA guidelines are not intended to be used as a quality assessment tool but instead to ensure consistency and accountability when conducting a systematic review. Our search focused mainly of studies on brain-based learning in the field of science in the context of elementary and secondary schools. Selection and exclusion criteria were adopted to objectively select or exclude articles for review. The reviewed papers in this study were selected based on the following inclusion criteria:

1. They related to the use of BBL in the teaching and learning of science subjects (biology, chemistry, physics, mathematics, and science) in elementary and secondary schools.
2. They described the evaluation of BBT methods and strategies in the science education framework.
3. They were published in peer-reviewed journals and written in English.
4. They were published between January 2000 and September 2021.

The following exclusion criteria were used.

1. Studies not published in peer-reviewed journals.
2. Studies not published in English.
3. Studies not focused on primary/elementary and/or secondary school education.
4. Studies not focused on science subjects (biology, chemistry, physics, mathematics, and science).
5. Studies in books, synopses, theses, dissertations, blogs, technical reports, conferences and other grey areas in literature.
6. Studies that claimed to be on BBL but did not cover its actual use.

A summary of the selected studies on brain-based learning in the science classroom reviewed is provided in Table 1. The PRISMA framework was also used to ensure the quality of the review. In order to carefully conduct the review, the following steps were observed to maintain the quality of the assessment.

1. The removal of duplicate records found from the three databases. A total of 128 articles were removed from the 574 identified in the data search. This left a balance of 446 articles for possible inclusion in the review.

2. The removal of 324 articles due to irrelevant titles. The study was then left with 122 articles which were assessed for eligibility.

3. The removal of 97 of these due to the following eligibility considerations: articles focused on the university context (28); articles focused on primary/elementary or secondary schools but not on science (24); articles not peer-reviewed, including dissertations/thesis and synopses (37); and articles not written in English (8). In all, a total of 25 peer-reviewed articles were considered. A summary of the quality assessment process adopted using the PRISMA framework is shown in Fig 1.
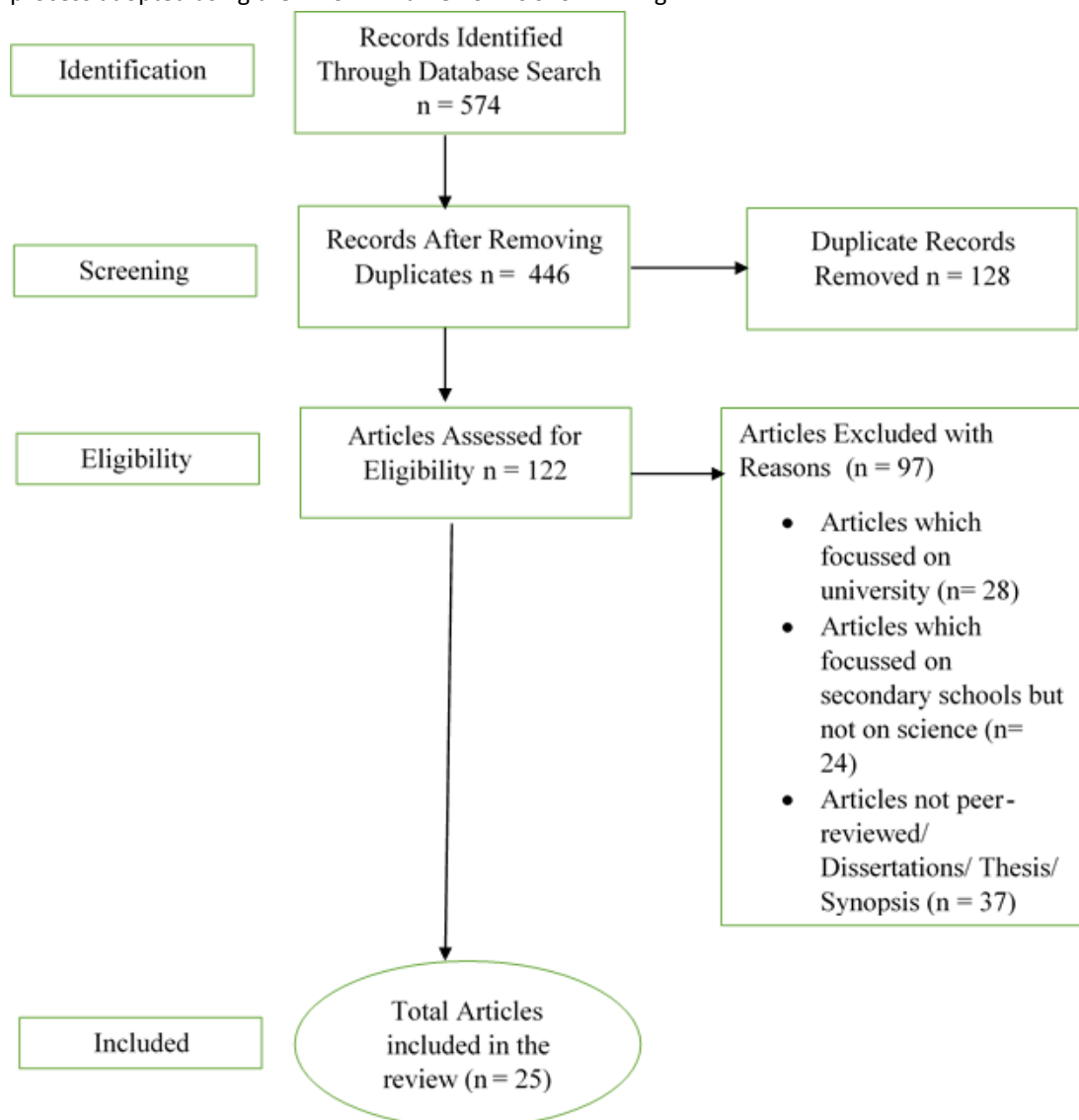

Fig 1. Flow of the systematic review (Adapted from Moher et al.'s 2009 PRISMA Framework)

Table 1. List of the selected reviewed articles

S/N	Author(s)	Year of Publication	Title	Educational Level	Subject Area
1	Alanazi	2020	Brain-based learning as perceived by Saudi teachers and its effect on the chemistry achievement of 7th graders	7th Grade Students	Chemistry
2	Akyürek and Afacan	2013	Effects of the brain-based learning approach on students' motivation and attitude levels in science classes	Primary School Students	Biology
3	Al-Balushi and Al-Balushi	2018	Effectiveness of brain-based learning on grade eight students' direct and postponed retention in science	8th Grade Students	Science
4	Al-Tarawneh et al.	2021	Effect of brain-based learning on developing the spatial ability of ninth grade students with low achievement in mathematics	9th Grade Students	Mathematics (Spartial Ability
5	Aydin and Yel	2011	Effect of brain-based learning in biology education on academic success and attitude	9th Grade High School Students	Biology (Substance Transportation Cell)
6	Aziz et al.	2012	Effectiveness of brain-based learning theory on secondary level students in urban areas	9th Grade High School Students	Mathematics
7	Kartikaningtyas et al.	2018	Effect of brain-based learning with a contextual approach viewed from the adversity quotient	8th Grade Junior High School Students	Mathematics
8	Kusumaningrum et al.	2021	Development of textbook-based brain-based learning (BBL) in the material organization system of life in junior high school science	Junior High School Students	Science
9	Mastoni et al.	2019	Preliminary study of brain-based learning (BBL) and intrapersonal intelligence in junior high school mathematics learning	Junior High School Students	Mathematics
10	Mekarina and Ningsih	2017	Effects of the brain-based learning approach on students' motivation and achievement in mathematics learning	11th Grade High School Students	Mathematics
11	Noureen et al.	2017	Effect of brain-based learning on the academic achievement of th graders in mathematics	7th Grade students	Mathematic
12	Priatna	2017	Application of brain-based learning principles aided by GeoGebra to improve mathematical representation ability	8th Grade Junior School Students	Mathematics
13	Riskiningtyas and Wangid	2019	Students' self-efficacy in mathematics through brain-based learning	4th Grade Students	Mathematics
14	Saleh	2012a	Dealing with the problems of the differences in students' learning styles in physics education via the brain-based teaching approach	Form 4 students	Physics
15	Saleh	2012b	Effectiveness of the brain-based teaching approach in dealing with the problems of students' conceptual understanding and learning motivation towards physics	Form 4 secondary students	Physics

S/N	Author(s)	Year of Publication	Title	Educational Level	Subject Area
16	Saleh	2012c	Effectiveness of the brain-based teaching approach in enhancing scientific understanding of Newtonian physics among Form 4 students	Form 4 students	Physics
17	Saleh and Subramaniam	2019	Effects of the brain-based teaching method on physics achievement among ordinary school students	Ordinary schools	Physics
18	Sani et al.	2019a	Enhancing students' motivation through brain-based learning	8th Grade Students	Physics (Electric circuits and parallel circuits)
19	Sani et al.	2019b	Using brain-based learning to promote students' concept mastery in learning about electric circuits	8th Grade Students	Physics
20	Shabatat and Al-Tarawneh	2016	Impact of a teaching-learning program based on brain-based learning on the achievement of female 9th grade chemistry students	9th Grade Students	Chemistry
21	Triana et al.	2019	Students' mathematical communication ability through the brain-based learning approach using autograph	Grade Students	Mathematics
22	Varghese and Pandya	2016	Study of the effectiveness of the brain-based learning of secondary level students on their academic achievement in biology, their study habits and stress	8th -10th Grade Students	Biology
23	Wijayanti et al.	2021	Mathematical creative thinking ability of students in treffinger and brain-based learning at junior high school	8th Grade Junior Students	Mathematics
24	Willis	2007	Review of research: brain-based teaching strategies for improving students' memory, learning and test-taking success	Review	Science
25	Yaşar	2017	Brain-based learning in science education in Turkey: descriptive content and meta analysis of dissertations	4-6 primary school students	Science

DATA ANALYSIS

The selected peer-reviewed articles were carefully analysed following the criteria defined for inclusion and exclusion. The necessary information was extracted in line with the research questions posed to guide the study. The guidelines also cover how the research method should be considered. For this systematic review, educational research conducted between January 2000 and September 2021 on the integration of brain-based learning in science classes in elementary and secondary schools was analysed. Only 24 empirical studies and one review paper were found and analysed to provide answers to the four research questions. The study adopted the quantitative approach to analyse the data obtained. The research questions were analysed using frequency counts, charts and simple percentages.

3.   RESULTS AND DISCUSSION

Research Question 1: What research methods and subject areas influence studies on brain-based learning in the science classroom context?

Method refers to the range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, and for explanation and prediction (Cohen et al., 2000). Fig 2 shows the research methods that have influenced studies on brain-based learning in science classroom. It can be seen that the most common method used was the quantitative, in 21 (84%) of the studies. Quantitative methods emphasise objective measurements and the statistical, mathematical or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques (Babbie, 2010; Muijs, 2010). This shows that most of the studies on brain-based learning in the science classroom focused on obtaining numerical data and making inferences based on the data obtained. Fig 2 also shows that three (12%) of the studies used the qualitative method. Qualitative methods emphasis the qualities of entities and processes and meaning that are not experimentally measured (Denzin & Lincoln, 2005). The approach provides answers to questions to emphasise how social experience is constructed and given meaning. Only one of the studies (4%) used a systematic review. The results of our study further underline the fact that only a few systematic studies have been completed on brain-based learning, and specifically its use in science classrooms.
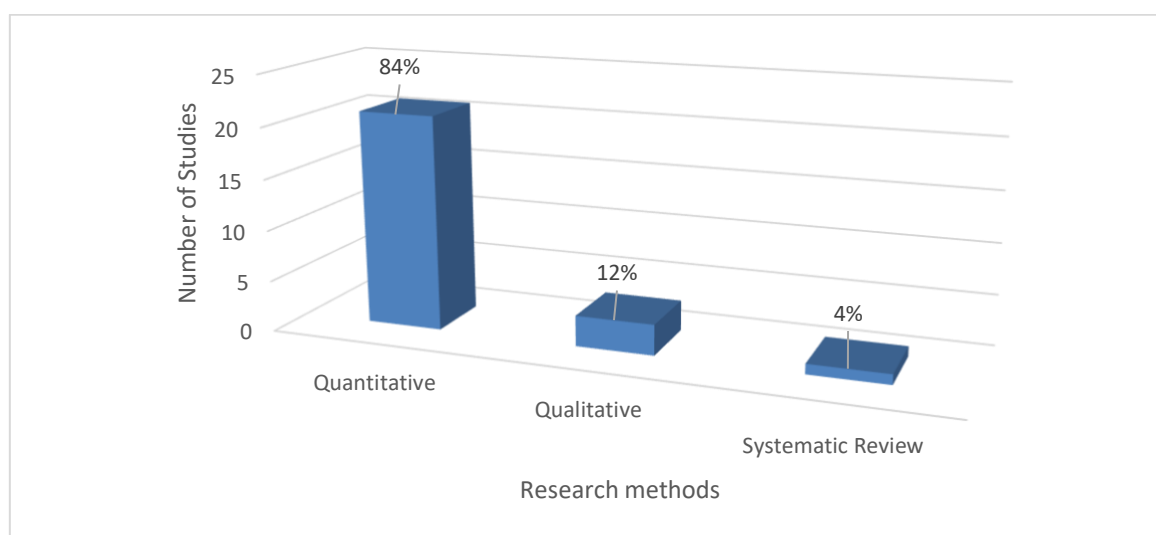

Fig 2. Research methods used in BBL

Regarding the subject areas covered by the studies on BBL science classrooms, Fig 3 shows that 40% were conducted in the mathematics context (10 studies). These included the study conducted by Al-Tarawneh et al. (2021) on the effectiveness of brain-based learning in developing the spatial ability of students with low achievement in mathematics. In Indonesia, Wijayanti et al. (2021) investigated the mathematical creative thinking ability of students in treffinger and brain-based learning in schools. Riskiningtyas and Wangid (2019) investigated student's self-efficacy in mathematics through BBL. Other studies on brain-based learning in mathematics include those by Priatna (2017), Kartikaningtyas et al. (2018), Noureen et al. (2017), Mastoni et al. (2019), Mekarina and Ningsih (2017), Triana et al. (2019) and Aziz et al. (2012). Those focusing on the physics classroom accounted for 24% of the studies reviewed (six studies). These included studies by Saleh and Subramaniam (2019), who investigated the effects of brain-based teaching methods on physics students' achievement in ordinary schools. Other studies on physics include those by Sani et al. (2019a), Saleh (2012a; 2012b; 2012c) and Sani et al. (2019b). All these demonstrated the positive effects of the use of brain-based learning on students' achievement. Fig 3 also shows that 16% of the studies on BBL centred on science (four studies). These included those of Al-Balushi and Al-Balushi (2018), which was conducted in Muscat, and of Kusumaningrum et al. (2021), Willis (2007), and Yasar (2017). 12% of the studies focused on biology classrooms (three studies), namely those by Varghese and Pandya (2016), Akyürek and Afacan (2013) and Aydin and Yel (2011). Only 8% of the studies related to chemistry (two studies), those of Alanazi (2020) and Shabatat and Al-Tarawneh (2021). The findings from our study show that BBL was mostly integrated in mathematics classrooms compared to the other major science subjects.
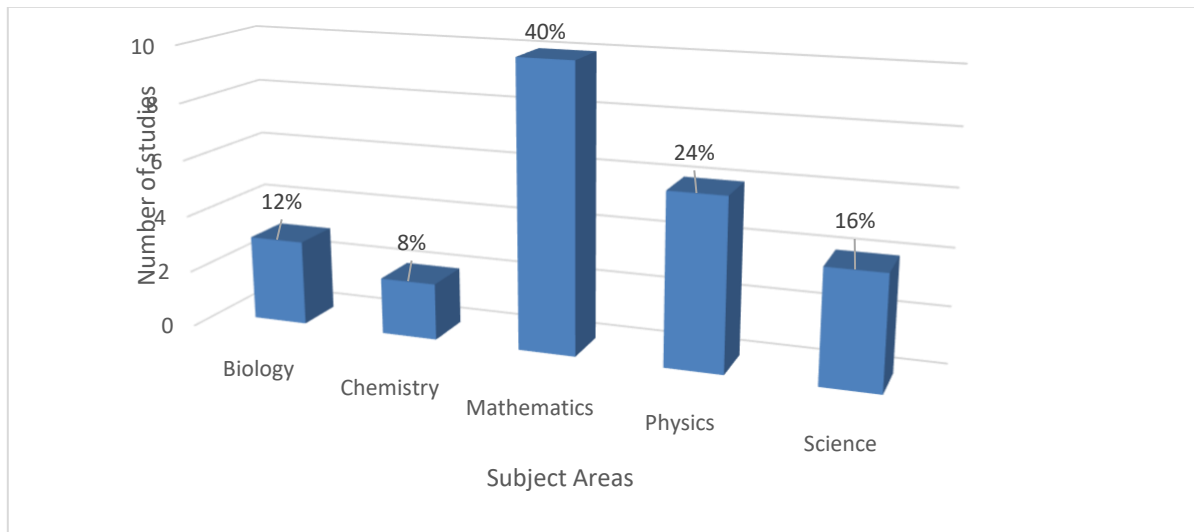
Fig 3. Subjects areas Influenced by BBL

Research Question 2: To what extent has brain-based learning been integrated into the teaching and learning of school science?

Fig 4 shows the extent to which brain-based learning has been integrated into elementary and secondary school science classrooms. It can be seen that the highest integration of BBL is among 4th to 9th grade schools (16 studies), accounting for 64% of the studies. This was followed by the integration of BBL in secondary schools, which accounted for 16% of the studies. These include those by Al-Tarawneh et al. (2021), Alanazi (2020) and Wijayanti et al. (2021). 12% of the studies conducted on the integration of BBL in science classrooms focused on form school students (3 studies), namely those of Saleh (2012a; 2012b; 2012c), while only 8% of the studies were conducted on primary schools. The findings from the studies reveal that BBL has been mostly integrated for the teaching and learning of school science in grade schools.
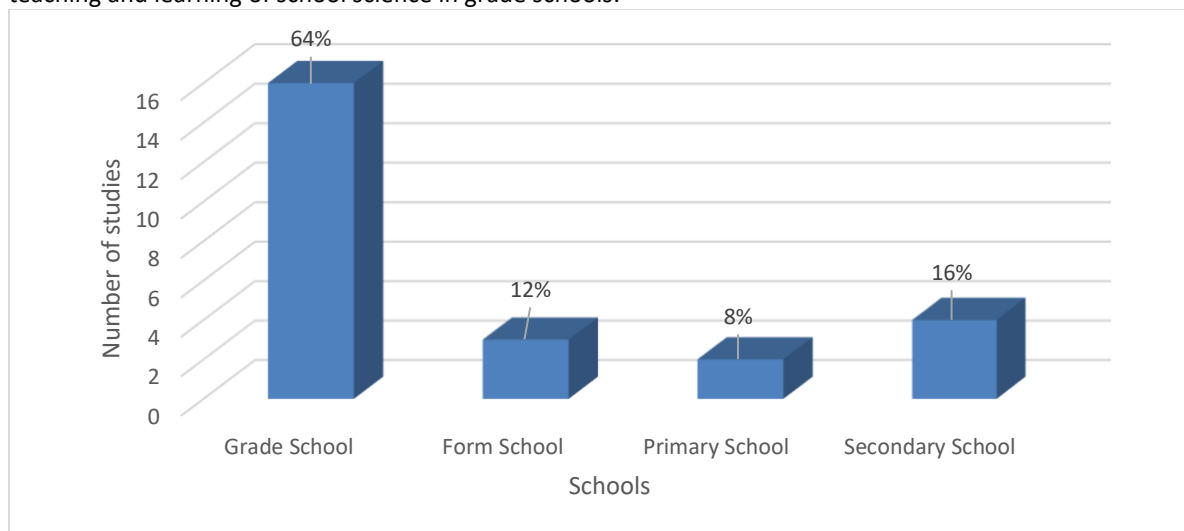

Fig 4. Integration of BBL into school science classes

Research Question 3: What are the constructs used in integrating brain-based learning in science classrooms?

The integration of BBL into science classroom is gaining more importance, especially as a result of the innovations from the field of neuroscience. As this is still evolving, this is also the case for BBL and its integration into the classroom using the carefully identified principles of brain-based learning. Fig 5 shows the different

constructs that have been used in integrating BBL into science classrooms. It can be seen that most of the studies (68%) used brain-based learning (BBL) as a construct for integration in the classroom; for example, those of Al-Tarawneh et al. (2021), Alanazi (2020), Al-Balushi and Al-Balushi (2018), Sani et al. (2019), Wijayanti et al. (2019), and Riskiningtyas and Wangid (2019). About 12% each, of the studies used the brain-based learning approach (BBLA) and brain-based teaching approach (BBTA) to integrate BBL into science classrooms. Fig 5 also shows that 4% each, of the studies used the brain-based teaching method (BBTM) (Saleh & Subramaniam, 2019) and brain-based teaching (BBT) (Willis, 2007) as constructs for integrating brain-based learning into science classrooms.
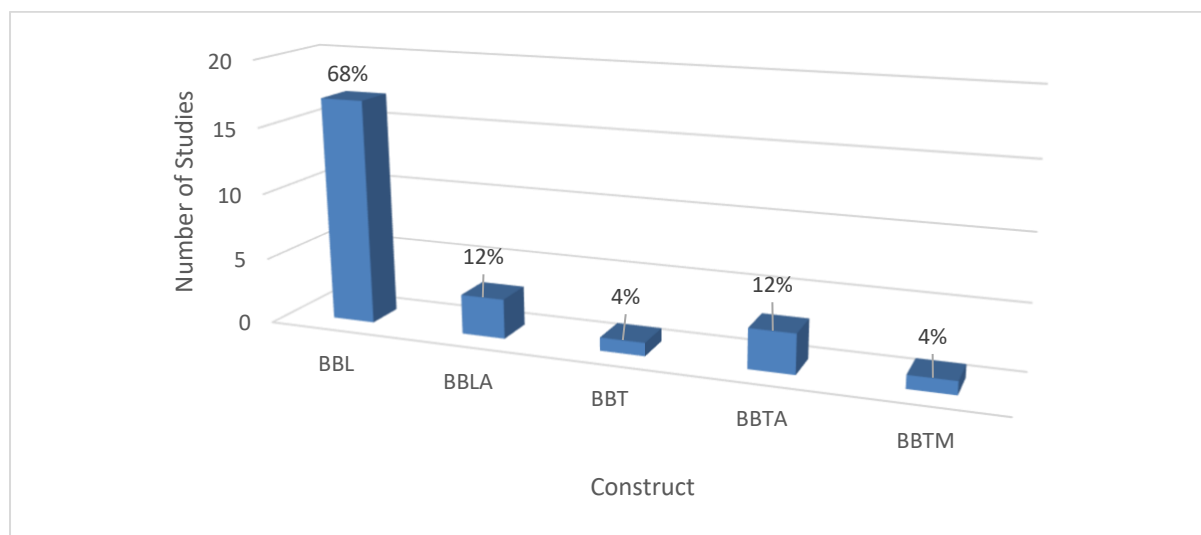

Fig 5. BBL- Brain-based learning, BBLA- Brain-based learning approach, BBT-Brain-based teaching, BBTA- Brain-based teaching approach, BBTM- Brain-based teaching method

Research Question 4: What analysis techniques dominate studies on brain-based learning in the science classroom?

A number of techniques have been used in analysing studies involving the integration of BBL in science classrooms. Table 2 shows that t-tests, analysis of variance, analysis of covariance, mean, standard deviation Mann Whitney, the Sheffe test, multiple analysis of covariance and z-tests are some of the techniques employed. Table 2 shows that t-test analysis technique was the most used (14 studies), either alone or in conjunction with other techniques, when analysing BBL integration in the classroom. This is followed by the use of analysis of variance (ANOVA), again alone or with other techniques (7 peer-reviewed studies). Analysis of covariance (ANCOVA) was also used alone or with other techniques to analyse the integration. Mean, standard deviation and Mann Whitney were used twice individually of together in each of the peer-reviewed articles, while MANCOVA and thge Z-test were used once.

Table 2: Summary of Analysis Techniques Used in the Integration

S/N	Technique Used	Frequency
1	t-test	14
2	ANOVA	7
3	ANCOVA	5
4	Mean	2
5	Standard Deviation	2
6	Mann Whitney	2
7	MANCOBA	1
8	Z-test	1

Note: Some of the studies used more than one analysis technique

4.   **CONCLUSION**

This systematic review has analysed empirical evidence on the use of brain-based learning in elementary/ secondary science classrooms. The results reveal that such learning can be carefully used for instruction in

science subjects in schools. The quantitative method was the most popular in integrating brain-based learning (BBL) in the science classroom. The reason for this is because this method provides greater objectivity and more accurate results. It also encourages the participation of a greater number of subjects who can be used in the generalisation of the results. The qualitative methods was the next most popular method used. Its strength is in providing very rich data on the participants, even though its findings cannot be generalised. The systematic review was the least common method used in the studies. The findings from the study suggest that brain-based learning positively impacts students' achievement in the science classroom because of the evidence recorded in the quantitative studies. The results also reveal that BBL was mostly integrated in grade schools, followed by the secondary schools, although this does not suggest that BBL cannot be used effectively in other levels of education. Another finding was that BBL is the most common construct used to integrate brain-based learning in science classrooms. It is concluded that most of the reviewed articles used the main concept of brain-based learning during integration in science classroom. The findings from this systematic review show that inferential statistics is the most common analysis technique used when integrating BBL in science classrooms. This is because inferential statistics can be effectively used for generalisation. The following recommendations are made:

1. Brain-based learning should be further used for instruction because its effectiveness has been objectively ascertained in the literature through the use of appropriate research methods.
2. The integration of brain-based learning should be further encouraged in other science subjects such as chemistry and physics, where integration is currently low.
3. Efforts should be made to improve the integration of brain-based learning across all levels of education.
4. Different constructs of brain-based learning should be encouraged to improve its integration in the science classroom.

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