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To cite this article:

Abdul Rahman, S. & Ajineh, A.R. (2025). The effectiveness of Brain-Based Learning (BBL) on students' achievement and knowledge retention in science. *International Journal of Studies in Education and Science (IJSES), 6*(1), 48-65. https://doi.org/10.46328/ijses.122

IJSES International Journal of Studies in Education and Science
2025, Vol. 6, No. 1, 48-65 https://doi.org/10.46328/ijses.122

The Effectiveness of Brain-Based Learning (BBL) on Students' Achievement and Knowledge Retention in Science

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Article Info

Article History

Received:
19 August 2024
Accepted:
29 November 2024

Keywords

Brain-based learning
Science instruction and learning
Academic achievement
Knowledge retention
Motivation towards science

Abstract

The aim of the current study is to investigate the effects of Brain-Based Learning (BBL) on academic achievement and knowledge retention in science subjects for middle school learners. The participants were six graders at one of the private schools in Abu Dhabi, United Arab Emirates (N=85). In the study, a pre-test (before the beginning of the experiment), experimental design (eight weeks), a post-test (week eight at the end of the experiment), and a retention test (ten days after the experiment) have been used to test the hypothesis. The participants were divided into two groups; an experimental group where 40 students were subjected to intervention of BBL during science classes for about eight weeks, and a control group where 45 students had conventional science classes. The pre-test results before the experiment and the post-test conducted at the end of week eight were analyzed to explore the effectiveness of BBL on students' achievement in science, the data showed that there was no significant difference between the control group and the experimental group. As a view to explore the effectiveness of BBL on knowledge retention, the results of the post- test and retention test, conducted ten days after the experiment, were compared and analysed, the data showed that there was a significant difference in the results between the control and experimental groups in the boys' classes. This suggests that BBL approach may be more effective on knowledge retention than the conventional teaching approach.

Introduction

Almost all schools all around the globe share one main goal: improving students' achievements. One way to achieve this goal is through enhancing the quality of teaching instructions and practices. Today many theories and approaches such as multiple intelligence, inquiry-based learning, constructivism, active learning, student-centered classrooms, and many more were put into actions in order to motivate students, involve them actively in the teaching-learning process, and as a result improve their academic performance. Moreover, several theoretical (Gardner, 1993; von Glasersfeld, 1995; Taber, 2006; Wink, 2006) and practical (Akkus, Gunel & Hand, 2007; Barrington, 2004; Cho, Yager, Park & Seo, 1997; Sivan, Leung, Woon & Kember, 2000; Watts, 1999) studies were conducted to come up with different conceptions of teaching. To conform to a more complex learning environment, especially during this COVID-19 pandemic, education process requires more than what was expected in the past. Latest developments in the field of neuroscience have shown that to ensure the effectiveness

of the teaching and learning process, the more significant teaching method would be the Inclusive Approach (Caine & Caine ,1991; Caine et al. 2005; Jensen 1996). These developments have contributed to the exploration of brain-compatible technique known as Brain-Based Learning (BBL). BBL can be defined as an interdisciplinary answer to the question of "what is the most effective way of the brain's learning mechanism" (Jensen, 1998).

Rapid changes happening in all fields, from the technological revolution to the pandemic situations to the various economical and educational challenges, gaining knowledge alone is not enough to overcome the challenges in an ever-changing world unless it utilizes different cognitive capabilities in various life situations (Aslan, 2015), add to this the fact that knowledge cannot be utilized unless it is retained.Conventional education seems to focus on teaching, not learning. However, most of what we learn before, during, and after attending school is learned without being taught to us. One of the most critical challenges for students nowadays is knowledge retention; students tend to forget most of what they learn in a short period of time. This creates a gap as students move from one grade level to another. Therefore, teachers should aim to design attractive plans that engage students and deal with them as active learners when preparing their lessons. Teachers who plant the seeds skillfully and carefully and water them with repetition will help the students harvest a high-quality reap. Thus, learning should involve more elements besides thinking; these elements should consider the learner's whole personality, learners' well-being and institutions' beliefs, values, and missions. If students have the will to learn, they will learn, despite all the distracting issues that might arise. So, learning should meet learners' needs; recognizing and identifying such needs will enable educational leaders to evaluate whether the learning has been successful. Using the acquired knowledge in conjunction with skills and the sense of ownership of their learning, students would retain the knowledge and skills they gain. All these elements can be achieved through BBL approach.

Learning is an ongoing complex process that starts at birth and continues throughout people's life. All what a person does is the result of an experience that influences behavior, decision-making, and developing relationships. Learning is not only an activity undertaken in an educational context. Babies learn to eat, get attention, crawl, then walk and speak a specific language alone as they develop into children and learn an inordinate range of skills. Currently, technological advances and research have encouraged educational leaders to adapt new pedagogical approaches to enhance students' performance and increase their achievements. Aziz (in Shabatat & AlTarawneh, 2016) stated that teaching approaches are still concentrating on memorizing. These make the students only act as a receiver of information sent by the teacher without relating to students' interest and these approaches make students receive the information without thinking independently and processing although the students have imagination and active thinking. This can be clearly demonstrated in the student's achievements as it is noted that when students move from one level to another, sometimes their marks drop, and it is becoming very evident that students are facing problem in relating prior knowledge to a new concept being addressed. Thus, knowledge retention becomes one of the challenges that teachers and students are facing despite the various teaching methods that teachers are implementing in their classrooms. BBL is accepted to support learning because of its all-encompassing methodology towards the students. It is a way to deal with realizing what supports the brain's best common operational standards, with the goal of attaining maximum attention, understanding, meaning, and memory (Jensen, 2008).

In a conventional educational setting, in which the sole aim is the mere transmission of knowledge, teachers try to do the teaching without considering whether the learners are motivated, or whether attitudes towards lessons are met. However, today, through the findings of neuroscientists and psychologists, it is well documented that there is no separation of mind and emotions. Furthermore, emotions, thinking and learning are all linked (Bear, Connors & Paradiso, 2001). The human brain is constantly evolving and adapting itself according to the new demands and challenges of the changing world. BBL is a learning approach that is based on the structure and function of the human brain. Unlike many teaching strategies, BBL provides students with a studying experience-based learning and not memorizing. The BBL approach includes the integration of carefully designed principles with due consideration of their effectiveness before, during and after each lesson.

A brain-based learning approach conceptualizes learning as an ongoing process in which creativity is promoted through difficulties (Lucas, 2003). Keeping in mind that Learning comprises a constant change in behaviour that results from assembling knowledge through drawing on experience and practice (Domjan, 1998; Flaharty, 1985; Gordon, 1989). This indicates that knowledge recognition is a necessary part of Learning since knowledge cannot be utilized when needed unless it is retained. Houston (2001) insists that the retention process cannot be thought separately from the learning process. Even though many types of research have been conducted on the effectiveness of the BBL approach on students' achievement, few analyses were made on the effects of BBL on knowledge retention, especially in UAE. Even though there are many studies regarding BBL approaches on students' achievement and motivation, there is a scarcity in research regarding the effectiveness BBL on the knowledge retention in different subjects particularly in science and in the UAE. For these reasons, the purpose of this study is to investigate the effectiveness of BBL on students' achievement and knowledge retention of science amongst middle school learners.

Research Questions

The study aims to answer the following research questions:

1) Is there a statistically significant difference in the mean scores of the achievement test between students who were taught using BBL approach and those who were taught using conventional approach?
2) Is there a statistically significant difference in the mean scores of the retention test between students who were taught using BBL approach and those who were taught using conventional approach?
3) Is there a statistically significant difference in gender between the control group and the experimental group in academic achievement in science?
4) Is there a statistically significant difference in gender between the control and experimental groups on knowledge retention in science?

Research Hypotheses

Ho 1a: There is no statistically significant difference in the mean scores of the achievement test between students who were taught using BBL approach and those who were taught using conventional approach.

Ho 1b: There is no statistically significant difference in the mean scores of the retention test between students who were taught using BBL approach and those who were taught using conventional approach.

Ho 1c: There is no statistically significant difference in gender between the control group and the experimental group in academic achievement in science.

Ho 1d: There is no statistically significant difference in gender between the control and experimental groups on knowledge retention in science.

Literature Review

Brain Based Learning (BBL) research has been conducted for more than two decades now. According to the Brodnax (2004) the educational area of brain research began to gain more value after the 1980s. BBL and teaching approach based on scientific research on how the brain learns become the focus of many promising types of research (Al-Balushi & Al-Balushi, 2018). Cognitive neurology stresses that understanding the nature of neural networks in the brain helps explain the process of acquiring and retaining knowledge (Bellah et al., 2008; De Jong et al. 2009; Taylor & Lamoreaux, 2008). Different studies have associated different brain regions with different learning tasks (Morris, 2010; Richardson, 2011; De Jong et al.; 2009, Brandoni, 2007). In other words, the brain's capacity to learn is directly related and affected by the number of neurons and how they connect. The brain is believed to create new connections, strengthen existing ones, and weaken or eliminate others (Centre for Educational Research and Innovation, 2007). To help students achieve better and broaden conceptual networks, integrate different elements, link previous knowledge to the newly gained ones, and apply what they have learned to their daily lives.

BBL involves understanding the rules of how the brain processes and utilizing them as a road map to organize learning instructions to achieve meaningful learning (Caine and Caine, 1994). According to Jensen (2008), BBL is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process. In other words, BBL involves the implementation of very well-designed principles, taking into consideration their effectiveness before, during, and after each lesson. In most teaching approaches, students tend to learn through a primary curriculum designed with different learning styles with limited consideration of learners' preferences. Despite the amount of work and effort that teachers spend in such an approach, it inhibits learning through ignoring the brain's natural learning processes and leads to a lack of enjoyment, boredom, and underachievement. (Kok, 2010) believes that teaching practices that cope with the way learners think and feel are the most effective ones to "enhance learners' motivation, thereby increasing their academic achievement". That is why BBL is considered a holistic approach that considers learners' capabilities to maximize their learning and triggers meaningful learning since it addresses learners' whole personal traits.

Brain-Based Teaching Approach is a strategy implemented based on the Brain- Based Learning Principles developed by Caine and Caine (1991), Caine et al. 2005, Jensen (1996) and Sousa (1995, 1998) through related brain research. It was designed in such a way so that the approach will be more compatible to the structure,

tendency, and optimum functions of the human brain and to ensure the effectiveness of the individual learning process (Caine and Caine 1991; Sousa 1995, 1998; Jensen 1996; Caine et al. 2005). Although all teaching processes essentially are brain based, compared to other methods, the BBTA is a strategy specifically created to value the true potential of the brain in a learning process (Caine and Caine 1991; Caine et al. 2005). Unlike traditional methods, this approach is based on the theory that everyone keeps on learning, if the human brain is not prohibited from undergoing its routine processes (Caine and Caine 1991; Jensen 1996). The assumption is made since the human brain is an organ of extremely high potential and that every student can learn effectively if their brain is given the opportunity to function in an optimum manner. Children of all learning styles will benefit from this kind of teaching approach.

Brain Based learning Principles

BBL has been considered as one of the most important topics of the 21st century. Caine and Caine (1994) defined BBL as calibrating teaching following the way the human brain naturally learns. The recent years have witnessed many studies that research examines the effectiveness of BBL on improving students' knowledge, achievement, and knowledge retention in different subject areas, including science. These studies' objectives include teaching individual differences, diversifying teaching strategies, and maximizing the brain's natural learning processes (Gülpınar, 2005).

The brain does not learn things that do not make sense or are not meaningful, teachers need to help students see the meaning and the logic of new information. Goleman (2000) explains the flow as a situation where an individual forgets himself, focuses on what he is doing and enjoys it. The marks of the patterning occurring during activities like these continue forever. They are frequently used as solutions to new problems and based to new opinions. They need to be assisted for learners to start flowing by organizing suitable conditions. Supported needs should be provided to learners on continuing their development and renewing their objectives by preserving long struggle and low levels of stress and allowing them to adjust their steps (Jensen, 1994). As a learning approach, BBL can be observed as a student-centered approach that efficiently improves student achievement and knowledge retention. Because it is based on the structure and function of the brain, it emphasizes meaningful learning rather than memorization.The twelve brain-based learning principles introduced into the literature by Caine & Caine (1994) are extremely important in setting up a learning environment where knowledge retention can be achieved. Caine & Caine (2000) have also identified the implications of the principles for education, which are demonstrated in Table 1.

The brain/mind is social, organizing and categorizing recently learned information and the search for meaning is inherent are among the principles proposed by Caine and Caine (1994), contribute to knowledge retention in science classes. Also, the place of emotions in patterning and learning has been highlighted in one of the principles that could sustain a convenient place in stimulating knowledge retention. The principles of blending what is newly learned with the already existing ones may arouse knowledge retention and make sense of new experiences via addressing background knowledge.

Table 1. Twelve Brain-Based Learning Principles and Their Implications for Education (Kosar, 2018)

Principle	**Educational Implications**
All learning engages the physiology.	Use of different senses and body.
The brain/mind is social.	Stimulating social interaction.
The search for meaning is innate.	Enhancing comprehension by taking into account learners' interest purposes, and ideas.
The search for meaning occurs through patterning.	Perceiving and creating patterns through patterning and associating new patterns with what they already understand.
Emotions are critical to patterning.	Eliciting appropriate emotions before, during and after their experiences with a text.
The brain processes parts and wholes simultaneously.	Embedded details into wholes and simultaneously wholes into parts.
Learning involves both focused attention and peripheral perception.	Deepening students' attention and peripheral perception and learning from the context unconsciously.
Learning involves conscious and unconscious process.	Giving sufficient time to reflect on and process experiences.
We have at least two different types of memory: a spatial memory system and a set of rote learning systems.	Engaging in multiple ways to remember.
Learning is developmental.	Considering individual differences in maturation, learning and prior experiences.
Learning is enhanced by challenge and inhibited by threat.	Supportive, empowering and challenging environment promote learning. While threat intrinsically challenging associated with helplessness environment inhibit learning.
Each brain is uniquely organized.	Integrating individual talents into teaching.

Brain Based Learning Techniques

According to the constructivist learning theory, humans construct knowledge and meaning from their experiences. In other words, the way learners are being taught is as important as what they are taught, keeping in mind that each learner receives the information and knowledge differently. In most educational institutions, teachers are still following a planned curriculum and specific textbooks that are already pre-packed. This is usually an obstacle for teachers to present information in relevant contexts that help them apply what they learn beyond schools (Jenkins, 2006).

Gregory and Parry (2006) state that' it is more appealing to the brain when problem- solving, using multi-sensory activities, peer interaction, and real-life experiences that cannot occur if teachers are using pre-packaged plans.

To apply BBL techniques in a classroom, the teacher should be able to bring in the content and the context together as the subject matter is introduced. Fogarty, (2009) believes that both Piaget and Vygotsky's works support this idea and that their works also validate the twelve principles of BBL.

BBL classrooms are referred to as "brain-friendly places." These classrooms are usually emotionally enriched, where learners are engaged in a highly challenging yet less threatening environment (Fogarty, 2009). According to Caine and Caine (1994). BBL classrooms provide a chance for students to gain meaningful knowledge which will advance their learning experiences by providing information that makes sense to learners and help them connect prior knowledge to the newly gained ones. Hart (1999) points out that "the brain is, by nature's design, an amazingly subtle and sensitive pattern-detecting apparatus; the brain detects, constructs, and elaborates patterns as a basic, built-in, natural function". This means that learners who can connect newly gained knowledge to prior knowledge they already learned and experienced will be able to retain this knowledge and develop an understanding that will help them apply what they have already learned in other situations in the future. In BBL learners will learn the thinking process itself and how to use thinking in learning process (Fogarty, 2002). Taking the twelve BBL principles into consideration, three instructional techniques can be used in the teaching-learning process in BBL classrooms: orchestrated immersion, relaxed alertness, and active processing. These techniques are believed to be the best practices for teachers when preparing their lessons (Caine & Caine, 1994).

Orchestrated Immersion: an effective teaching practice that involves student's concentration on the contents they learn. Orchestrated immersion means to create learning environments that fully immerse learners in an educational experience. The idea is to take information off the page and blackboard to bring it to life in the minds of students. Orchestrated immersion provides learners with rich, complex experiences that include options and a sense of wholeness. During orchestrated immersion, students can gain meaningful learning by relating what they are learning to their real life.

Relaxed Alertness: a relaxing environment that creates the optimal emotional and social climate for learning. Relaxed alertness is the phase that combines cognition and emotion within a learning environment. According to Gulpinar (2005), relaxed challenging environment with low threats provides learners with effective learning practices. Teachers should create an environment that triggers learners' brains to learn by building trust and eliminating any source of fear, like the fear of failing (Caine and Caine 1999).

Active Processing: consolidation of internalization of information by the learner in a way that is both personally meaningful and conceptually coherent. During this phase, students will compare the information they get to prior knowledge. As they start to master the experience, they can then apply what they learn in critical thinking or problem-solving. Active processing necessarily engages emotions, concepts, and values.

Knowledge Retention

Human memory is imperfect. Learners are challenged by increasing the amount of material and content they need to understand, remember, review and master. That is why teachers constantly need to search for effective and

creative teaching strategies that support knowledge retention in learners. BBL approach could be one of the best practices that help increase learning to the highest degree (Pool, 1997) as it implies how the brain works. So, teaching science using BBL approach does not only aim at improving learners' achievement, but it can also help in keeping the knowledge learned for a longer time. According to Tang (2017), mindfulness improves attention, emotion, and self-control, it also helps knowledge, character, and wisdom- based education. It is worth mentioning that learning becomes more effective and retrieving information becomes easier if senses are involved as emotions are easier to remember. BBL engages many different emotional triggers that are helpful in retrieving information (Sprenger, 2010). Moreover, BBL takes into consideration how the brain processes and interprets information, makes connections, stores, and retrieves those messages (Greenleaf, 2003).

Since the brain always seeks patterns, BBL can be an effective teaching strategy using graphic organizers and chunking information. The importance of studying knowledge retention in science could be clarified by the fact that it is always very easy to forget what is learned. Taking into consideration how the brain functions and focusing on the different types of memory would help understanding what is required for knowledge retention to take place. When a stimulus, such as new information or experience is first perceived, it is stored in the primary memory which is considered a short-term storage. When rehearsal of this experience takes place, such as practicing or repeating the experience, long-term storage can take place.

Review of literature reveals that the information processing approach to memory highlighted the necessity of rehearsal for the transfer of the newly acquired knowledge from short term memory to long term memory. (Allison, 2014). Attention and noticing plays a crucial role to encode stimulus into long term memory and attention is put forth as a prerequisite for learning to occur by scholars such as Schmidth (2001). Knowledge retention could be achieved if learners are actively engaged in the learning process through collaboration, chunking, verbal, and visual coding, recall by category (Allison, 2014). Studies by (Eskitürk, 2009) in which the effectiveness of cooperative learning has been investigated reveal that cooperative learning enables knowledge retention. knowledge retention in social studies was also enabled by cooperative learning and systematic teaching based on a study conducted by Korkmaz Toylucu and Tay (2016). Using data from these studies one can conclude that teaching strategies followed in a classroom could play an important role in knowledge retention. One of these strategies is BBL approach (Lucas, 2003).

BBL has gained the attention of many educational researchers. Employing a meta-analysis, Gözüyeşil and Dikici (2014) concluded that brain-based learning techniques have a positive impact on student academic achievement. Moreover, many other studies have shown the effectiveness of BBL on students' achievement in various subjects. A study by Duman (2010) found brain- based instruction to be significantly superior in terms of student achievement compared to conventional instruction. Akyürek (2013) suggested that there is a positive relationship between BBL and students' motivation and attitudes in science class. Saleh (2012) found brain-based learning to be effective in enhancing secondary school students' conceptual understanding of physics and their motivation to learn the subject matter. Making connections was an essential element of the brain-based learning model used in Saleh's study. Similar results have been observed by other researchers. Al Blushi and Al Blushi (2018) found that BBL has great impact on Grade 8 students' direct and postponed retention in science, and they have recommended

training teachers on implementing BBL approach in their classrooms.

Method

Research Design

Based on the objectives, this research adopted a quantitative research paradigm using an experimental design. A convenient sampling technique was used to select 80 grade six students (aged 11-12 years) at a private school in Abu Dhabi, UAE. The study included four classes of grade six - two classes of different genders as the experimental group and were taught science using BBL approach and another two classes of different genders as the control group and were taught using the conventional method. Both groups were tested before the experiment, directly after and the experiment to measure the students' achievements and two weeks later to measure the knowledge retention of science in both groups.

Table 2. Research Design

Pre-Test	**Study Groups**	**Treatment**	**Post-Test**
Science	Control Group	Traditional teaching approach	Science Achievement Test
Achievement Test	Experimental Group	BBL approach	

Sample and Sampling Technique

Convenient sampling technique was used to select 80 Grade 6 students (aged 11 -12 years) from a private school in Abu Dhabi, United Arab Emirates.

Table 3: Characteristics of Participants

Group	**Gender**	**Number**	**Total**
Control Group	Females	17	40
	Males	23	
Experimental Group	Females	28	45
	Males	17	

Instrumentation

Three instruments were used in this current study: lesson plans for the control group, lesson plans for the experimental group and a science academic achievement test.

Lesson Plans for the Control Group

The lesson plans for the control groups consisted of three parts, the starter activity, lesson development and closure.

Activity	Description
Starter Activity	Teacher introduced the lesson objectives to the students then did a warmup activity to relate the prior knowledge to the content being addressed in the lesson. This took different forms from asking questions, to writing a key term and asking students to brainstorm.
Lesson Development	Teacher explained the concepts using PowerPoint presentation that explained the topic, the lesson development had some activities to keep the students engaged, Various activities took place using different digital platforms like edpuzzle, quizziz, padlet. Some of these activities were done on an individual basis like watching a video and answering questions using edpuzzle, while other activities were done as a group work using the rooms in Microsoft Teams where students used to solve a case study together. When doing a group work, the teacher usually assigns the activities based on the student's ability.
Closure	The teacher used to review the main points of the lesson and end it by an exit pass which sometimes included two to three oral questions to check students understanding or five multiple choice questions using digital platforms like Kahoot or Quizziz.

Lesson Plans for the Experimental Group

The lesson plans for the experimental group were also divided into three parts; the starter activity, lesson development where the three phases of BBL approach were integrated and a closure activity.

Activity	Description
Starter Activity	Students were shown a mind map about the topic being taught and do brain gym activities as the teacher introduced the objectives and the topic.
Lesson Development	The lesson development in the BBL approach integrated the three important phases: orchestrated immersion, relaxed alertness, and active processing. *Orchestrated immersion* (10 minutes); students were exposed to the content through PowerPoint slides, short videos, and various visual aids after which students were asked to answer a few questions individually to check their understanding. *Relaxed Alertness* (10-15 minutes); students were asked to work in groups using rooms in MSTeams. These tasks included graphic organisers, mind maps, writing short stories, preparing PowerPoint presentations or posters. Students were given the opportunity to choose the task they wanted, and they were encouraged to discuss their work within their groups. During the relaxed alertness, students were encouraged to play soft music in the background. *Active processing* (10 to 15 minutes); students were given time to present their tasks to the whole class, get feedback and reflect on their own and peer work.
Closure	The teacher reviews the lesson and gives a reward to the best group. The rewards are

Activity	Description
	in the form of certificate of appreciation or champion of the week nominations posted on the school's website, positive feedback email to the parents, or sometimes bonus marks.

Academic Achievement Test

A 30-item academic achievement test was used as pre-test, post-test, and retention test. A pilot study was conducted to test the items and the Cronbach alpha (α) value was 0.772.

Table 4. The Achievement Test Design

Question Number	**Bloom's Taxonomy Level**
1 – 8	Remembering
9 – 16	Understanding
17 – 24	Applying
25 – 32	Analyzing
33 – 36	Evaluating
37 – 40	Creating

Procedure

After defining the experimental and control groups, they both did the pre-test. The experiment took place over a period of eight weeks (5 sessions of 45 minutes per week). Due to the pandemic situation of the outbreak of COVID-19 the lessons for both groups were taught online. At the end of the experiment process, both groups were administered an achievement post-test. Ten days later, the retention was administered again with the purpose of assessing the retention level of the participants.

Validity and Reliability

To ensure reliability of the research design a control group has been used in addition to the experimental group. The control group included the same number of participants of the same age group who were taught without the intervention of BBL. Using a control group made the results more reliable by comparing the results of pre, post and retention tests of both the experimental group and the control group to base the conclusion driven from the experiment on the intervention of BBL.Validity establishes the relationship between the data and the variable or construct of interest. To ensure validity of the data, the academic achievement test was first prepared by the researcher. A pilot study was made and then it was checked and reviewed by two science teachers and the CADU committee. After checking the exam's alignment with NGGS standards and Bloom's Taxonomy and its

difficulties a final 30 multiple choice questions test was approved as the final achievement test that will be used as pre-test, post-test, and retention test. Both groups of students sat for the test.For reliability and validity of the experiment, one teacher was assigned to teach the four sections of grade six. The researcher conducted a training session for the teacher about BBL principles, strategies, and methods of teaching science to examine how BBL could work well in a science class.

Data Collection Procedures

Intact groups were used for both control and experimental groups. Before the experiment started both groups sat for a pre-test that consisted of 30 multiple choice questions that covered the topic being explained during the experiment. Right away after the experiment, by the end of week 4, data was collected from the post-test administered to both groups to measure the students' achievement. 10 days after the experimentation process, the data was collected from the achievement tests used to measure knowledge retention in both experimental and control groups.

Findings

The mean score of the girls in the control group was 57.84% with a standard deviation of 3.60 while the mean score for the girls in the experimental group was 58.04% with a standard deviation of 6.59. A slight difference (0.2%) can be observed between the mean score of the girls' classes in both groups. Similarly, the mean score of the boys in the control group was 55.65% with a standard deviation of 6.59, while the mean score of the boys in the experimental group was 53.93% with a standard deviation of 6.60. Again, a slight difference (1.7%) between the mean scores of the boys' class can be noticed in both groups. To test the significance of this difference a T-Test was performed, and t= 0.487 value was determined for the girls' classes and t=0.377 value was determined for the boys' classes. In both cases, the t-value is more than the p-value (0.05) and this indicates that there were no significant differences between the experimental and control group. In other words, before the experiment process, there was no significant difference of achievements between the control group and experimental group for both genders.

Table 5. The Pre-Test Scores of Control and Experimental Groups

Participants	Gender	Participants (N)	Mean Score (X)	Standard Deviation (SD)	T-Test (*P*)
Control Group	Female	17	57.84	3.60	
Experimental Group	Female	17	58.04	6.59	0.487
Control Group	Male	23	55.65	6.60	
Experimental Group	Male	28	53.93	4.76	0.377

To examine the impact of BBL on the students' achievement, data collected from the pre-test and post-test for both control and experimental group were analyzed.

Table 6. Comparison of the Pre-Test and Post-Test Scores of Control and Experimental Groups

Participants	Gender	Participants (N)	Mean Score of Pre-Test (X)	Mean Score of Post-Test (X)	Difference in the mean Scores
Control Group	Female	17	57.84	75.29	17.45
Experimental Group	Female	17	58.04	78.04	20
Control Group	Male	23	55.65	64.93	9.28
Experimental Group	Male	28	53.93	69.24	15.3

There is a slight difference (2.75%) between the post-test mean scores of the experimental and control group in the girls' classes. Moreover, there was also a slight difference in the students' achievements (2.55%) in the girls' classes when the Pre-test mean scores were compared with the Post-test mean scores for both groups. On the other hand, there was a greater difference (4.31%) between the post-test mean scores of the experimental and control groups in the boys' classes. In terms of achievements, a greater difference (6.02 %) was observed when the mean scores of the Pre-test and Post-Test were compared. These findings suggest that the teaching approaches between control and experimental groups might have an impact on students' achievement levels. They also suggest that BBL approach might be more effective than traditional teaching in science among middle school learners.

To examine this further data, the t-test was calculated to find the significant differences between the results of both groups.

Table 7. The Post-Test Scores of Control and Experimental Groups

Participants	Gender	Participants (N)	Mean Score (X)	Standard Deviation (SD)	T-Test (*P*)
Control Group	Female	17	75.29	4.68	
Experimental Group	Female	17	78.04	5.12	0.314
Control Group	Male	23	64.93	5.47	
Experimental Group	Male	28	69.24	5.44	0.199

There are no significant differences between the mean scores of the Post-Tests between the control and experimental groups for both genders although there was a difference in the mean scores. Based on these findings, the first hypothesis fails to be rejected. To examine the impact of BBL on the knowledge retention is science among middle school learners, data collected from the post-test and retention-test for both control and experimental group were analyzed.

Table 8. Comparison of the Pre-Test and Retention-Test Scores of Control and Experimental Groups

Participants	Gender	Number of Participants (N)	Mean Score of Post-Test (X)	Mean Score of Retention-Test (X)	Difference in the mean Scores
Control Group	Female	17	75.29	66.67	-8.69
Experimental Group	Female	17	78.04	69.91	-8.13
Control Group	Male	23	64.93	66.52	1.59
Experimental Group	Male	28	69.24	77.52	8.28

There is a slight difference (3.24%) between the retention-test mean scores of the experimental and control group in the girls' classes. However, both groups showed lower mean scores in the retention test than the post test. This might indicate a loss in the knowledge retention in both control and experimental groups in the girls' Classes. On the other hand, there was a significant difference (11%) between the retention-test mean scores of the experimental and control groups in the boys' classes. These findings suggest that the teaching approaches between control and experimental groups might have an impact on knowledge retention of science in boys.

To examine this further data, the t-test was calculated to find the significant differences between the results of both groups.

Table 9. The Retention-Test Scores of Control and Experimental Groups

Participants	Gender	Participants (N)	Mean Score (X)	Standard Deviation (SD)	T-Test (*P*)
Control Group	Female	17	66.67	6.4	0.436
Experimental Group	Female	17	69.91	6.47	
Control Group	Male	23	66.52	5.92	
Experimental Group	Male	28	77.52	6.56	0.036

There are no significant differences between the mean scores of the retention- Tests between the control and experimental groups for both girls' classes, and that there is significant differences between the mean scores of the retention-Tests between the control and experimental groups for both boys' classes. This finding suggests that the teaching procedures between control and experimental groups have different effects on the boys' knowledge retention in science for middle school learners and might have no effect on the knowledge retention in science for girls in middle school learners. Based on these findings, the second hypothesis is rejected for males. The data can also be used to reject the fourth hypothesis.

Findings of this study shows that BBL approach appears to have no significant impact on the students' achievement in the science subject among middle school learners, although the mean average scores of the post-test administered for the experimental and control groups reveals higher scores in the experimental group. This contradicts findings by Saleh (2011), Ozden (2008) and Hghigh, (2013), that showed that BBL has a great impact on the students' achievement. Studies by Cengelci (2005) and Wortock (2002). Cengelci (2005), for instance, also found out that the brain-based learning approach improved student achievement in social science courses. Although the findings of this study failed to reject the first hypothesis, some external factors might have affected the results, and they could not be controlled. The fact that the pandemic situation of the outbreak of COVID-19 has forced schools to shift to online learning might have played a major role in such results. It is well known that online learning demotivates students and no matter how hard teachers try to engage them they still feel isolated. Moreover, the exams tests were conducted online which means that there were some chances for cheating, and this might have affected the results. Having a population size and face-to-face learning might support such a claim. These findings also suggest that traditional teaching can sometimes help students gain knowledge, it all depends on the teacher and his/ her way in introducing the content to the students. The fact that both groups were taught by the same teacher and that both groups showed increase in their achievements demonstrated by increase in their mean scores in the science achievement test may indicate that the teacher is very good in transferring knowledge to the students regardless of the strategy. Moreover, the fact that the control group was taught remotely through online learning, using digital tools might have helped the students understand the content better. In addition to this, parents are playing an active role during online teaching, they are now devoting more time and effort with their children. All these factors might have helped students achieve better results.

Regarding knowledge retention, the findings of this study for the girls' classes also failed to reject the third hypothesis. On the other hand, the findings for the boys' classes rejected it. This supports the claim that BBL in fact might have an impact on the students' achievement and knowledge retention especially if studies like the studies of Getz (2003) and Cengelci (2005) suggest that the BBL approach appears to be more effective than the traditional teaching procedures in science courses in terms of enhancing the retainment of the gained knowledge. This also can support the idea that even though traditional teaching helps students gain knowledge, it does not always help them retain the knowledge they gain.

Conclusion

Based on the theoretical observations and the latest research discoveries in the field of human brain, BBL approach strategies are planned in a consistent way to the structure, tendency, and optimum functioning of the brain, to set the seal on an effective learning process. BBL approach is aimed to value the true potential of the brain in a learning process. According to brain-based education, learning is strengthened with emotional involvement, challenging learning tasks, orchestrated immersion, complex and active experiences, enriched environments, and active processing (Caine and Caine, 2005). In brain based comprehensive approaches, learners are encouraged to explore different avenues of taught and to deepen their understanding of the topic, fostering a higher interest for the subject and tasks in hand (Saleh, 2011). As a result, BBL approach uses the information about the human brain to help learners deepen their understandings of the content, resulting in a long lasting and more effective learning.

Although the findings of this research did not fully support this idea, it is worth integrating BBL approach into the lesson plans as it helps learners build strong connections with the content being taught and motivate them to be active learners.

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