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Research Article

Brain-Based Teaching Principles for EFL Students: Exploring the Impacts on Reading Comprehension

Zahra Rahmani [1], Ehsan Rassaei [2], Mohammad Bavali [3]

1,3. Assistant Professor, Department of Foreign Languages, Shiraz Branch, Islamic Azad University, Shiraz, Iran
2. Professor of Applied Linguistics, Director of Studies (MA in Applied Linguistics), Majan University College, Muscat, Oman

* Corresponding author: **Ehsan Rassaei,** Email: ehsan.rassaei@majancollege.edu.om

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ABSTRACT

This study examined the impact of brain-based learning strategies (BBLS) on the reading comprehension of Iranian EFL learners and identified the challenges they encounter during BBL activities. A quasi-experimental design was employed with 66 participants divided equally into experimental and control groups. Pretest and posttest assessments were administered to measure reading comprehension. Quantitative analysis revealed a significant improvement in the posttest scores of the experimental group, suggesting the efficacy of BBLS in enhancing reading comprehension. Qualitative data from semi-structured interviews were analyzed using thematic analysis, uncovering positive perceptions of BBLS among learners. Participants highlighted the effectiveness of brainstorming, connecting ideas, and pair work in improving comprehension and engagement. These findings align with and extend existing research on cognitive and metacognitive strategies in EFL contexts, emphasizing the potential of BBLS to foster deeper understanding and retention of reading material. The study's implications for educators include the integration of BBLS in reading instruction to enhance learner engagement and comprehension. Future research should explore the long-term impacts of BBLS and its applicability across diverse educational settings and learner populations.

Introduction

The demands on educators to enhance student achievement in the modern era are ever-growing. In response, educators are constantly seeking innovative pedagogical practices to integrate into the classroom (Darling-Hammond et al., 2020). Neuroscience, or brain research, offers exciting possibilities for educational innovation (Fischer, 2009). However, while advancements in brain neuroimaging have garnered significant interest, the field remains relatively young, and translating research findings into practical educational

applications is ongoing (Howard-Jones, 2014; Thomas et al., 2019). Ansari and Coch (2006) argue that exploring the potential of neuroscience techniques could significantly impact educational reform by providing insights into brain function. Understanding how the brain learns can lead to the development of teaching techniques that promote meaningful learning experiences (Caine & Caine, 1994). Additionally, by leveraging knowledge from neuroscience, educators can find strategies to improve student success and achievement (Jensen, 2008).

Following insights from brain research, educational researchers have developed principles for optimal learning. Dornyei (2009) describes methods based on the brain and its language-specific functions. This aligns with Howard-Jones (2014), who highlights the potential of brain-based studies to inform second language (L2) acquisition, a crucial skill set in today's globalized world. Brain-based learning (BBL) strategies focus on creating a positive environment for information processing and consolidation (Sousa, 2017). BBL-oriented instruction emphasizes meaningful processing and integration of information (Bransford et al., 2000). By helping students organize and connect information, educators can create larger and more meaningful memory units. Encouraging students to discover relationships, connect concepts, and see how information relates to their lives fosters deeper comprehension and enhanced recall (Mayer, 2011). Research by Howard-Jones (2014), Immordino-Yang and Damasio (2007), and Goswami (2019) suggests that BBL approaches can significantly improve various student skills and activities, including reading comprehension.

Reading comprehension is a complex cognitive process involving multiple brain regions. According to Kendeou et al. (2014), reading comprehension integrates linguistic and cognitive processes, involving regions such as the left hemisphere's temporal and frontal lobes, which support decoding and comprehension, and the prefrontal cortex, which facilitates higher-order executive functions like inference generation and integration of new information. During reading, the brain processes letters, words, and patterns, drawing upon prior knowledge and activating groups of neurons (Wolf, 2007). Sternberg and Sternberg (2012) emphasize the role of the nervous system in receiving, processing, and responding to information from the environment, forming the foundation for understanding and adaptation.

Despite the potential benefits of BBL for reading comprehension, research on its effectiveness in EFL contexts is limited. This gap aligns with the broader challenge of integrating neuroscience research into mainstream education, particularly in language learning, due to the relative newness of the field (Jensen, 2008). Therefore, this study aims to investigate the effectiveness of BBL principles in improving EFL learners' reading comprehension. Based on the purpose of the study, the following research questions were posed:

- Does the implementation of Brain-Based Learning (BBL) strategies have any significant effect on reading comprehension skills of Iranian EFL learners?
- What are the perceived challenges, perceptions, and experiences of Iranian EFL learners when engaging in Brain-Based Learning (BBL) activities?

Literature Review

The concept of BBL can be traced back to the early 20th century with the pioneering work of educational reformer Maria Montessori. Montessori advocated for a child-centered learning environment that caters to individual learning styles and sensory preferences (Pasquinelli, 2015). Her emphasis on hands-on activities and active exploration laid the groundwork for the development of BBL principles. In the mid-20th century, educational psychologist Benjamin Bloom's work on mastery learning further solidified the foundation for BBL (Bloom, 1984). Bloom's taxonomy of learning objectives emphasized the importance of moving beyond rote memorization and towards fostering higher-order thinking skills, a core tenet of BBL pedagogy.

The late 20th and early 21st centuries witnessed a surge in advancements in neuroscience research, particularly in the field of brain imaging. Technologies like functional magnetic resonance imaging (fMRI) allow scientists to observe brain activity in real time, shedding light on the neural correlates of learning and memory (Sousa, 2017). This newfound understanding of the brain fueled

the rise of educational neuroscience, a field dedicated to bridging the gap between brain research and educational practice (Jensen, 2008). Early pioneers in this field, such as Eric Jensen, advocated for the application of neuroscience research to inform instructional design and optimize learning outcomes (Jensen, 2008).

The integration of BBL principles into English as a Foreign Language (EFL) pedagogy is a relatively recent development, but it holds significant promise for enhancing student engagement and language acquisition. This movement is fueled by the growing body of research on the embodied nature of language learning, which suggests that language comprehension and production are not solely cognitive processes but are also deeply intertwined with our sensorimotor experiences (Pulvermüller, 2013). Scholars argue that language is not just processed in the brain; it is also grounded in the way we interact with the world through our bodies (Kosukas & Luk, 2013).

This perspective aligns perfectly with the core principles of BBL, which emphasize the importance of movement, multisensory elements, and real-world applications. Physical activity has been shown to increase blood flow to the brain, enhance memory consolidation, and improve focus (Ratey & Hagerman, 2008). Incorporating movement into EFL lessons, such as acting out dialogues, using gestures to represent vocabulary, or playing kinesthetic games, can provide a powerful tool for language acquisition. Engaging multiple senses in the learning process creates richer neural pathways and leads to deeper understanding (Sousa, 2017). EFL classrooms that utilize visuals, sounds, tactile experiences, and even taste or smell (when appropriate) can create a more stimulating learning environment and promote stronger memory encoding. When learners can connect language to concrete experiences and see its practical value, they are more motivated and engaged. BBL-informed EFL pedagogy encourages the use of authentic materials, project-based learning that tackles real-world problems, and simulations that allow students to practice language in relevant contexts.

The potential benefits of BBL in EFL classrooms are vast. Studies have shown that BBL techniques can lead to improved vocabulary acquisition, grammar retention, communication skills, and overall learner motivation (Aksu & Metin, 2018; Chang, 2011). Research on the effectiveness of BBL in EFL contexts remains somewhat limited, but some studies have yielded positive results. For instance, Immordino-Yang and Damasio (2007) explored the impact of movement on vocabulary acquisition in EFL learners. Their findings suggest that incorporating movement activities into vocabulary instruction can enhance long-term memory and retention. Similarly, a more recent study by Ali et al. (2019) investigated the impact of kinesthetic activities on EFL vocabulary learning in young learners. Their findings echoed those of Immordino-Yang and Damasio, showing that students who engaged in movement-based activities demonstrated significantly better vocabulary retention compared to those in a traditional learning setting.

Building on these findings, Kosar and Bedir (2020) demonstrated that applying BBL principles, such as activating prior knowledge and fostering emotional connections to learning material, led to higher motivation and improved grammar retention among Turkish EFL learners. Furthermore, Liao et al. (2021) highlighted the benefits of integrating brain breaks and multi-sensory activities in Asian EFL classrooms, resulting in enhanced reading comprehension and learner engagement. Their study underscored the importance of aligning teaching strategies with cognitive load theory to prevent overloading learners' working memory.

Additionally, Funa et al. (2024) conducted a comprehensive meta-analysis on the role of BBL in various educational settings, including EFL contexts. They concluded that incorporating neuroscience-backed strategies, such as spaced repetition and collaborative tasks, significantly boosts both reading comprehension and overall language acquisition. These findings align with the results of Hassan et al. (2022), who explored the integration of mindfulness exercises with EFL writing tasks. Their research revealed marked improvements in learners' writing fluency and grammatical accuracy, suggesting that emotional regulation and mindfulness—core components of BBL—can positively influence linguistic output.

Beyond movement, BBL offers benefits in other areas. A study by Feng and Wang (2020)

investigated the effectiveness of music-assisted instruction in improving EFL learners' speaking fluency and pronunciation. Their findings suggest that incorporating music into speaking activities can help learners develop rhythm, intonation, and confidence in their spoken English. Banerjee and Picard (2014) investigated the use of affective learning strategies, which tap into emotions and motivation, in EFL contexts. Their findings suggest that incorporating these strategies can lead to deeper engagement and improved learning outcomes.

The emotional connection fostered by BBL is another area of exploration. Gülbahar and Graves (2015) examined the impact of storytelling on EFL learners' motivation and vocabulary acquisition. Their research suggests that incorporating storytelling techniques into lessons can create a more engaging and emotionally charged learning environment, leading to increased motivation and vocabulary retention.

Despite the promising potential of BBL, translating theory into practice presents certain challenges. One key challenge lies in balancing the need for BBL activities to promote deeper comprehension while simultaneously supporting the development of decoding fluency, particularly for beginning and intermediate EFL learners (de Beni & Nuessli, 2018). Together, these studies emphasize that BBL, while still an emerging approach in EFL education, offers promising avenues for enhancing learner outcomes, particularly in vocabulary retention, grammar mastery, and engagement.

Method

Setting

The study was conducted at a university setting in Tehran, Iran, during the fall semester of the 2021-2022 academic year. The participants were 66 university students majoring in English language translation. To ensure a homogeneous sample, the students were selected based on their accessibility and were from the same term, course subject, and had the same course instructor. The non-random convenience sampling method was applied (Mackey & Gass, 2005). The students were divided into two intact classrooms, one serving as the experimental group and the other as the control group.

Design

This study employed a mixed methods research design, combining both quantitative and qualitative approaches to provide a comprehensive understanding of the research problem. The integration of these methods allowed for the examination of the research questions from multiple perspectives, a more holistic exploration of the research questions, combining the strengths of both quantitative and qualitative approaches, thereby enhancing the robustness and validity of the findings.

Participants

The study included 66 third-semester BA students, aged 20 to 22. The experimental and control groups comprised 33 students. The majority of participants were female (n = 43), with 25 male students. All participants were native Persian speakers with three to six years of experience attending language classes at private language institutes. During their BA studies, they were required to pass advanced reading courses to enhance their comprehension and general knowledge of English. Furthermore, 5 EFL learners were interviewed and the aim of the semi-structured interviews was to deepen understanding of the effectiveness of BBL strategies in the classroom and explore the learners' personal experiences in detail.

Instruments

The Reading Comprehension Test

A standardized reading comprehension test was used to assess the participants' reading skills. The test, drawn from the reading component of the TEM-4 model test (2011), included four passages labeled Text A, Text B, Text C, and Text D, with a total word count of 1657. These passages covered general topics such as social and cultural issues, making them suitable for English major students at an intermediate level of difficulty. Each passage was followed by five questions, each with four suggested answers (A, B, C, and D). The questions assessed literal comprehension, reorganization, reinterpretation of text information, inference, and evaluation, requiring different cognitive strategies.

The cognitive validity of the test was established by ensuring the reading tasks activated comprehensive cognitive processes (Khalifa & Weir, 2009). The test had a total score of 20 marks, with one point awarded for each correct answer. The time limit for the test was 25 minutes, requiring a reading rate of at least 120 words per minute.

The Reading Comprehension Test has been validated for use with English major students and has shown a high level of reliability (Khalifa & Weir, 2009). Previous studies have reported a Cronbach's alpha of .85, indicating strong internal consistency. For the current study, the reliability was assessed using Cronbach's alpha, yielding a value of .78, which confirms the test's reliability in assessing reading comprehension.

Semi-Structured Interview

After administering the posttest, participants' scores were used to categorize them into three distinct performance levels: low, medium, and high. This classification was based on the distribution of the scores across the entire sample. The specific criteria for these categories were likely determined by dividing the score range into three equal or meaningful intervals. For example, the participants whose scores fell within the lower third of the distribution were classified as 'low performers', those in the middle third were categorized as 'medium performers', and those in the upper third were labeled as 'high performers'. This categorization allows for a more detailed analysis of the data, as it enables comparisons across different levels of proficiency and helps identify patterns or trends within each group.

To gain deeper insights into the participants' experiences with BBL, voluntary semi-structured interviews were conducted. Two students from the low level, three from the medium level, and two from the high level volunteered for the interviews. The participants were allowed to respond in either Persian or English. Each interview lasted approximately 30-40 minutes and was recorded, with the researcher taking additional notes to ensure all checklist items were covered. The interviews focused on discussing the principles, challenges, benefits, and effects of BBL on reading comprehension. The data were transcribed, coded, and analyzed using MAXQDA to identify major themes related to BBL.

Procedure

The instructional procedures for BBL in this study were meticulously designed according to three main categories: relaxed alertness, orchestrated immersion in the complex experience, and active processing of the experience. These strategies were documented on a personal data sheet and aligned with the 12 principles of BBL as outlined by Caine and Caine (1994). Ethical standards were rigorously observed throughout the study to ensure participant welfare and research integrity. Before the intervention, participants were provided with clear, comprehensive information about the study's purpose, procedures, and confidentiality measures. Written informed consent was obtained, and participants were assured they could withdraw at any point without repercussions. To maintain confidentiality, all data were anonymized and securely stored. Below, each principle is connected to the specific classroom strategies used in the study:

1. The Brain is a Parallel Processor: The instructional approach involved linking new information to students' existing knowledge, which engaged multiple brain functions simultaneously. This was achieved by introducing topics and activating background knowledge, thereby fostering a relaxed and comfortable learning environment.
2. Learning Engages the Entire Physiology: Activities such as reading, identifying new vocabulary, and defining unfamiliar words aligned with this principle. By engaging students in physical and cognitive tasks, the learning process involves both the body and the brain.
3. The Search for Meaning is Innate: Pair work and content checking were integral to the classroom procedures. This strategy encouraged students to make sense of new information by connecting it to personal experiences, which is central to the brain's natural search for meaning.
4. The Search for Meaning Occurs through Patterning: Classifying and categorizing content according to personal interests helped students create meaningful patterns in the information they encountered. This aligns with the brain's tendency

to generate and recognize patterns, as described by Caine and Caine (1994).

5. Emotions are Critical to Patterning: Creating a positive learning atmosphere through activities that were personally relevant to students helped to engage their emotions, which in turn enhanced their ability to recognize and generate meaningful patterns.

6. Every Brain Simultaneously Perceives and Creates Parts and Wholes: The process of reviewing and retelling content required students to engage both hemispheres of the brain by processing information in parts and as a whole. This strategy was crucial for deepening comprehension and memory retention.

7. Learning Involves Both Focused Attention and Peripheral Perception: During instructional sessions, students were encouraged to focus on specific tasks while also being aware of the broader context, thereby engaging both focused and peripheral perception.

8. Learning Always Involves Conscious and Unconscious Processes: The instructional strategies encouraged students to engage in both conscious learning, such as reading and understanding texts, and unconscious processes, such as forming connections and retaining information.

9. Two Types of Memory: Spatial and Rote: The strategies employed in the classroom, such as creating word webs and organizing content, catered to both spatial memory (understanding the layout of information) and rote memory (memorizing definitions and concepts).

10. Learning is Developmental: The instructional process was designed to align with the developmental stages of the students, allowing them to build on their existing knowledge and gradually develop more complex understanding through guided practice and feedback.

11. Complex Learning is Enhanced by Challenge and Inhibited by Threat: The classroom environment was structured to be challenging yet non-threatening, encouraging students to engage deeply with the material without feeling overwhelmed.

12. Each Brain is Unique: The instructional procedures were flexible, allowing for individual differences in learning styles and preferences. This was reflected in activities that enabled students to classify and categorize content according to their interests and comprehension.

The principles were reflected in the classroom activities and the participants were engaged practically while reading the reading texts. The following table summarizes these activities.

Table 1.

Principle-based activities implemented in reading texts

Activity	Principle
Introducing topics and activating background knowledge	A Parallel Processor: linking new information to their background
Identifying new vocabulary, and defining unfamiliar words	Entire Physiology: engaging students in physical and cognitive tasks
Making sense of new information by connecting it to personal experiences in pair work	Search for Meaning is Innate
Classifying and categorizing content according to personal interests	Search for Meaning Occurs through Patterning
Engaging their emotions via positive learning atmosphere being personally relevant to students	Emotions are Critical to Patterning
Processing information in parts and as a whole, reviewing and retelling content required students to engage both hemispheres	Brain Simultaneously Perceives and Creates Parts and Wholes
Focusing on specific tasks while also being aware of the broader context	Focused Attention and Peripheral Perception
Conscious learning, such as reading and understanding texts, and unconscious processes, such as forming connections and retaining information	Conscious and Unconscious Processes
Creating word webs and organizing content	Two Types of Memory: Spatial and Rote
Gradually developing more complex understanding through guided practice and feedback	Developmental learning
Engaging students deeply with the material without feeling overwhelmed	Challenge for Complex Learning

Activity	Principle
Individual differences in learning styles and preferences were reflected in activities	Each Brain is Unique

In the classroom, these principles were put into practice through a series of carefully designed activities. For instance, in session 7, the instructor introduced the topic "The Mysteries of Memory Loss" by engaging students in a discussion that linked the new content to their existing knowledge of brain functions and memory. Students then read and analyzed the text, identified difficult words, and worked in pairs to connect content and identify themes. These activities exemplified the integration of the 12 principles, facilitating a holistic and effective learning experience that enhanced reading comprehension.

The intervention began with administering a standardized pre-test to assess participants' baseline reading comprehension skills. After completing the instructional treatment, a post-test identical in format to the pre-test was conducted to measure progress. Both tests, validated for English major students, featured reading passages and comprehension questions aligned with cognitive and academic standards. The treatment spanned 10 instructional sessions, each lasting 90 minutes, conducted over five weeks. During these sessions, participants engaged in BBL-based activities, applying the principles discussed earlier. The sequential design ensured a consistent and structured application of BBL strategies, fostering measurable skill development.

The interviews were conducted in Persian although they were free to interview in English. The interviews included 5 open-ended questions to obtain an explanation regarding their feeling and opinions toward the classroom techniques and strategies, connecting ideas, brainstorming, and their improvement in reading comprehension. Following the collection of data, the pretest and posttest scores were analyzed using descriptive statistics to assess the initial comparability between the experimental and control groups, as well as to evaluate changes after the intervention. Subsequently, independent samples *t*-tests were conducted to determine whether statistically significant differences existed between the post-test scores of the two groups. This analysis aimed to investigate the effectiveness of the BBL strategies on reading comprehension.

The interviews were analyzed using thematic analysis to identify key themes and patterns in the participants' responses regarding their experiences with BBL strategies. MAXQDA software was employed to facilitate the systematic coding and categorization of the qualitative data. Through this mixed-methods approach, both the quantitative differences in performance and the qualitative insights into participants' experiences were examined, offering a comprehensive perspective on the effectiveness of the instructional procedures implemented in the study.

Results

The pretest scores for the experimental and control groups were analyzed to assess their initial comparability. The descriptive statistics, as shown in Table 2, indicate that the mean of pretest score for the experimental group (N=33) was 12.09 (SD=2.67), while the control group (N=33) had a mean score of 12.18 (SD=2.35).

Table 2.
Descriptive statistics of pretest scores

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Experimental	33	12.0909	2.67352	.46540
	Control	33	12.1818	2.35126	.40930

The results of independent sample *t*-test between pretest scores of experimental and control groups are shown in Table 3.

Table 3.
Independent sample t-test between pretest scores of experimental and control groups

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	.097	.756	-.147	64	.884	-.090	.61978	-1.32	1.14
	Equal variances not assumed			-.147	62.97	.884	-.090	.61978	-1.32	1.14

The results of the independent samples *t*-test revealed no significant difference between the mean pretest scores of the experimental and control groups (t (64) =-0.147, p=0.884).

In order to answer the first research question of the study in finding the effectiveness of the BBLS on reading comprehension skills of Iranian EFL learners, the posttest scores for the experimental and control groups were analyzed. The descriptive statistics, as shown in Table 4, indicate that the mean posttest score for the experimental group (N=33) was 16.42 (SD=1.97), while the control group (N=33) had a mean score of 14.30 (SD=2.26).

Table 4.
Descriptive statistics of posttest scores

Groups	N	Mean	Std. Deviation	Std. Error Mean
Experimental	33	16.4242	1.96898	0.34276
Control	33	14.3030	2.25672	0.39285

The descriptive statistics, as shown in Table 3, indicate that the mean posttest score for the experimental group (N=33) was 16.42 (SD=1.97), while the control group (N=33) had a mean score of 14.30 (SD=2.26). The results of independent sample t-test between the pretest scores of experimental and control groups are shown in Table 5.

Table 5
Independent sample t-test between posttest scores of experimental and control groups

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest	Equal variances assumed	.217	.643	4.06	64	.000	2.12	.521	1.079	3.162
	Equal variances not assumed			4.06	62.84	.000	2.12	.521	1.079	3.163

The independent samples *t*-test revealed a significant difference between the mean posttest scores of the experimental and control groups (t (64) =4.069, p <0.001). These findings suggest that BBLS had a significant positive effect on the experimental group's reading comprehension compared to the control group.

In order to answer the second research question, the results of the interview were analyzed. In the interview, the main focus was on the participants' perceptions and experiences of involvement in BBLSs. The content coding was created for all the concepts. After coding the interviews, the themes were classified based on the effectiveness of embedding these strategies, the helpful part of the task, challenges with brain-based strategies, the effect of these strategies in the reading texts, and their recommendations. The thematic analysis was carried out through MAXQDA to identify the respondents' perceptions with the aim of recognizing the themes and subthemes regarding participants' perceptions toward implementing these strategies on their reading comprehension skills. Conducted individually, these interviews were audio-recorded with informed consent, and analyzed using thematic analysis to uncover key themes and patterns emerging from participants' experiences and perspectives.

To find out the participants' perceptions, they were asked: How did embedding brain-based technique help you practice in reading course? Among 80 significant statements, 16 concepts and themes were merged addressing their perceptions towards the classroom strategies. The frequency of the subthemes indicated that the brainstorming was effective. For example, the participants expressed that *one of the most important parts of class is talking about our background knowledge and connecting ideas together which helps us learn better*. Another participant shared, *all strategies can be useful but it is better to have a clear meaning of words*. Similarly, another mentioned, *it is really important to comprehend the content and remember details*. One participant emphasized *the most important thing is extracting ideas in the sentences and having a clear roadmap in texts*. Another reflected, *when we focus on doing activities especially when we check the words together and get feedback, it is good because we understand the meaning and answer the questions*.

The students believed that extracting ideas and connecting ideas in a web creates a roadmap. They realized it was an effective method in the classroom. The important item was the improvement of their comprehension and understanding. As one participant mentioned, *connecting ideas led to better comprehension and then remembering the content*. They repeatedly mentioned that they get a better understanding. They all confirmed that using BBL strategies was very useful in comprehending the texts. They held that the connection of ideas could provide some clue in grasping the meaning and remembering the content.

In addition to their perceptions about the methods used in their reading classroom, they were asked about the effectiveness of their engagement in understanding the text. Educational contexts always require the active participation of learners and expect them to take responsibility for their learning. BBL tries to involve them in innate search for meaning in accordance with Caine et al.'s third principle (2005). Getting the meaning can play a significant role in learning and understanding the content. The extracted concepts (15 out of 80) in the interviews also confirmed that they would benefit greatly from these activities. For example, one participant stated, *I personally think it is really effective to learn new vocabulary, new phrases and remember grammar. The things we had in class helped us to remember all of them*. Another added, *I personally like this part of class that we found the main concepts in the sentences because it is beneficial for both reading and speaking skills*. Another participant mentioned *it was very useful for reading all texts. I use it for different subjects*.

The students were aware of the importance of meaning and understanding the content. They reported the positive effect of embedding this principle in reading classroom is an efficient technique that provides more opportunities for them to engage in finding meaning and understanding. They emphasized it as a good strategy directing them to learn meaningfully.

The other question was about pair work and their interaction with others. Following BBL, students do some tasks in pairs. After the earlier checking for

meaning, they work together to check the content and try to put ideas in a web. They negotiate to find a proper connection. After analyzing the themes, it was revealed that the most frequent concept (20) among themes refers to their interaction in pair work. For example, one participant expressed, *we reviewed the ideas, and then put them in a network. We help each other to find the right connection between the lines*. Another shared, *my friend helped me arrange the concepts because I missed some parts*. Another noted, *we talk together to get clear meaning of sentences which helps us understand the whole text*. Another reflected, *it made us feel better when we work in pairs. Our interactions with our friend prevent monotony and tiresome*.

So, they found that pair work-based tasks are really helpful. They practiced the concepts and checked their comprehension. They might make modifications after negotiation and agreeing on the meaning. The extent to which they mentioned the effectiveness of pair work shows that it really had good effect on their improvement.

Another theme that emerged from the qualitative data was about the type of classification and categorizing the ideas in a text. They were supposed to do classification based on their interests and recognition. It brings a pleasant atmosphere because they make decisions to arrange ideas and support their opinions. Apart from the instructional benefits, the applicants were satisfied with the techniques as it improved their reading comprehension ability. For instance, they believed that the classification of information let them understand the unity in the text. They reflected that *I am sure that I have improved my reading comprehension a lot as I had to classify the concepts in a special order and connect them to the main topic in the text*. Another stated, *in some lessons in which teacher explained the main branches, I felt more clarity to add the details and complete the sub-branches*. Another participant mentioned, *after classification, I knew how the ideas connect together and in followed the same arrangement in retelling or paraphrasing the text*. Another added *it was really helpful because I read the texts and classified first. I saved my time not only in reading and analyzing but also in remembering and comprehension*.

The extract themes and subthemes (15 out of 80) highlighted the positive effect of arrangement while reading the texts. It was revealed that classification of the content enhances their understanding and provides more intelligibility which leads to fast reading. Again, they focus on easy comprehension and remembering after applying classification.

The last question in the interview was about the challenges and problems they had in running the BBL strategies. Despite the positive points about embedding BBL strategies in reading classrooms, some of the applicants mentioned the problems and challenges as the novelty of the technique, time management in earlier sessions, applying them in different contexts, and so on. For example, one participant stated, *we used to read texts and check the meaning of new words to answer some questions like true-false or short questions. My teachers never worked on grasping ideas, connecting them together, and making a web. It was completely new. First, I felt it confused about it and it seemed to be tough time*. Another shared, *in using the new techniques, I usually face with different challenges. I learned how to guess the meanings and find the main concept in each sentence. But connecting the ideas took a lot of time and the other members in group helped me. It was the first time I worked with brainstorming*. Another noted *these new techniques were great. I learned a lot. I think they can be helpful in reading various texts but I need more practice. I'd like to apply them in specified subjects and improve my comprehension*. Another participant mentioned, *I used them in class easily but I cannot use them in real world. Some texts are coherent and we can classify information. Some others are not*.

However, each and every strategy has some challenges and problems, and implementing BBLS strategies was not an exception. According to the classified themes in this section, 14 subthemes out of 80 revealed that they tried to work with new techniques and deal with the challenges. They benefited from the instruction and learned how to apply the BBL principles effectively and improve reading comprehension ability.

Discussion

The current study aimed to investigate the implementation of BBLS and its impact on reading

comprehension among students. The discussion addresses the results in line with the two research questions guiding this study. The findings reveal that the integration of BBLS significantly enhanced students' reading comprehension skills. This improvement aligns with the theoretical foundations of BBLS, emphasizing active participation, interactive learning, and cognitive engagement. Students appreciated activities like pair work, which facilitated collaboration and improved their ability to review and organize textual concepts. This aligns with the collaborative learning benefits outlined by He (2001), who demonstrated that peer interaction enhances comprehension by reducing monotony and promoting engagement.

Additionally, strategies such as brainstorming and idea connections were highly effective, supporting Wallace et al. (2021), who highlighted the value of metacognitive strategies in deepening understanding. Students' reports of improved retention and understanding through brainstorming mirror findings by Bruning et al. (1999), where tools like graphic organizers and concept mapping proved beneficial for comprehension and recall. Similarly, Farhady et al. (2016) emphasized the positive effects of cognitive and metacognitive strategies, further corroborating the outcomes observed in this study.

A significant aspect was the pronounced improvement in posttest scores. The heightened impact may be attributed to the tailored design of BBLS activities, which focused on active and contextual learning, enabling learners to engage deeply with the material. Norris and Ortega's (2000) review primarily examined general task-based and instructional interventions, suggesting that more targeted strategies, like BBLS, can achieve superior outcomes.

Despite its strengths, the study highlighted certain challenges in implementing BBLS. Students initially struggled with the novelty of these strategies and faced time management issues during early sessions. These findings echo He (2001), who documented similar challenges during the adoption of unfamiliar instructional techniques. While Farhady et al. (2016) acknowledged the need for a familiarization period, this study provides a more detailed account of learners' initial difficulties, offering valuable insights for future pedagogical planning.

Another challenge was the gap between classroom learning and real-world application. Participants reported difficulties in transferring BBLS techniques to contexts outside the classroom. This issue, underexplored in prior research, underscores the importance of future studies focusing on the practical application of BBLS strategies to bridge the gap between theoretical learning and real-life usage.

Regarding the second research question, students' perceptions of BBLS were overwhelmingly positive. They valued the interactive and engaging nature of the strategies, particularly activities that connected new knowledge to personal experiences. This supports Caine et al.'s (2005) principle that learning is enhanced when it aligns with learners' intrinsic search for meaning. Participants also expressed appreciation for the flexibility and individuality allowed by BBLS, consistent with motivational theories (MacIntyre & Noels, 1996) that emphasize the role of autonomy and engagement in language learning.

The interviews revealed students' recognition of BBLS's impact on their vocabulary acquisition and comprehension skills. For example, students reported that activities like identifying main concepts and organizing information were beneficial not only for reading but also for broader language skills such as speaking. This multidimensional benefit highlights the adaptability of BBLS in addressing various language competencies, corroborating findings by Zarei and Al-Mozaini (2018), who identified the efficacy of interactive and pattern-based learning methods.

Conclusion

The present study investigated the effects of Brain-Based Learning Strategies (BBLS) on the reading comprehension of Iranian EFL learners, with two primary objectives: to assess the impact of BBLS on reading comprehension and to explore learners' perceptions of these strategies. Quantitative data from pretest and posttest scores revealed significant improvements in the experimental group compared to the control group. The mean posttest scores were significantly higher for the experimental group, underscoring the

efficacy of BBLS in enhancing reading comprehension skills. These findings align with previous research emphasizing the benefits of cognitive and metacognitive strategies in EFL contexts (Ahmadi & Tavakoli, 2015; Wallace et al., 2021).

The second objective of the study focused on understanding learners' perceptions of BBLS. Qualitative data from interviews highlighted the positive effects of brainstorming, connecting ideas, and pair work on participants' reading comprehension. Learners reported that these strategies enhanced their ability to identify main ideas, organize textual information, and retain content, with some participants noting broader language skills benefits such as vocabulary and speaking improvement. However, the study also identified perceived challenges associated with BBLS implementation. Participants initially struggled with the novelty of the strategies, reporting confusion and time management difficulties during the early sessions. Additionally, a gap was observed between classroom learning and real-world application, as learners found it challenging to transfer BBLS techniques to contexts outside the classroom. These findings suggest the need for targeted support during the adaptation period and strategies to bridge the gap between theoretical learning and practical use.

The results of this study have several implications for EFL educators and curriculum designers. First, incorporating BBLS in reading instruction can significantly improve comprehension skills by engaging learners in cognitive processes that facilitate deeper understanding and retention. Educators should consider integrating activities such as brainstorming, connecting ideas, and collaborative tasks into their teaching practices. Additionally, the positive feedback on pair work suggests that collaborative learning environments can enhance student engagement and motivation, which are crucial for effective language learning (MacIntyre & Noels, 1996).

Based on the study's findings, curriculum designers should focus on integrating strategies that promote active participation and interaction, such as pair work and brainstorming. These elements have proven effective in enhancing comprehension and reducing monotony, as evidenced by both this study and prior research (Wallace, et al., 2021). Clear instructions and ample practice opportunities are essential to help students navigate the initial learning curve associated with new BBLS. Providing robust support for vocabulary development is also crucial, as participants highlighted the need for understanding new terms and phrases. Additionally, curriculum designers should develop strategies that bridge the gap between classroom learning and real-world application, ensuring that students can transfer their skills to practical contexts. Addressing the challenges associated with implementing new techniques—such as time management and contextual adaptation—requires ongoing support and resources.

Despite the positive outcomes, this study has several limitations. The sample size was relatively small and limited to Iranian EFL learners, which may affect the generalizability of the findings to other contexts and populations. Additionally, the study's duration was short, focusing on immediate improvements in reading comprehension. Longitudinal studies are needed to assess the sustained impact of BBLS on reading comprehension over time. Finally, the qualitative data relied on self-reported perceptions, which may be subject to biases and may not fully capture the complexities of learners' experiences.

Future research should address the limitations of this study by including larger and more diverse samples to enhance the generalizability of the findings. Longitudinal studies could provide insights into the long-term effects of BBLS on reading comprehension and other language skills. Additionally, exploring the impact of BBLS in different educational contexts and with learners of varying proficiency levels would provide a more comprehensive understanding of its effectiveness. Researchers could also investigate the specific components of BBLS that are most beneficial for reading comprehension and how these strategies can be adapted to different learning environments and subjects.

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