Correlation between Teachers Knowledge, Beliefs, and Frequency of Implementation of Brain Based Learning Strategies

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Abstract – Brain-based learning (BBL) is grounded in an understanding of the structure and function of the brain, as well as empirical evidence derived from cognitive neuroscience research regarding optimal learning strategies for the brain. Educational programs that prioritize brain science in their curriculum and instructional methods are commonly referred to as "brain-based." The aim is to achieve efficient and expeditious education. As per the Education Reform, this particular approach is based on research that examines the brain's potential to restructure itself in order to enhance its capacity to retain and retrieve information while engaged in the process of learning. Enhancing one's capacity can be achieved through engaging in physical activity, maintaining a healthy diet, and effectively managing stress levels. The emotional state of an individual can also have an impact on their learning process. This study presents findings on the correlation between teachers' knowledge, beliefs, and frequency of implementation of brain-based learning strategies in primary Science classes. The research questions addressed in this paper are focused on determining the existence of such a correlation. The study comprised 207 educators from elementary schools in Croatia. The results suggest that educators at the primary level possess a sound understanding of brain-centered pedagogical approaches, yet they infrequently put them into practice. The educational process remains entrenched in a historically rooted paradigm that has not adequately shifted towards student-centered teaching. This is evidenced by the persistent employment of traditional, teacher-led instructional methods in elementary Science classrooms.

Keywords – Brain-Based Learning, Brain Centered Pedagogical Approaches, Brain-Compatible Education, Elementary Science Lessons.

I. INTRODUCTION

The pedagogical approaches employed by educators have been largely shaped by psychological theories that exert an influence on human behavior. In order to achieve success in education, it is imperative to incorporate the most effective methodologies that are grounded in research and that take into consideration the ways in which students acquire and comprehend new information. Gamboa, Sung Lai Yuen, von Wegner, Behrens, and Steinmetz [1] have established a distinct correlation between the process of teaching and learning and the neurobiological mechanisms of the human brain. The advancement of our comprehension of brain function and its impact on learning has the potential to bring about a transformation in the methods of teaching and learning. Brain-based learning has emerged as a result of educators and researchers utilizing the findings of brain research to inform their teaching practices. For a considerable duration, rudimentary models elucidating the operational mechanisms of the human brain have existed. During the mid-twentieth century, the brain was compared to a switchboard. The comparison between the left and right hemispheres of the brain was initiated by brain theory during the 1970s. Subsequently, the nomenclature "triune brain" was employed to denote the brain's tripartite division into lower, middle, and upper regions. The higher-order cognitive processes are governed by the middle and upper brain regions, while the lower brain region is responsible for facilitating learning that is essential for survival.

Presently, the theory of the brain places emphasis on attaining a more all-encompassing comprehension of its functions. The concept prioritizes a systems-oriented approach wherein the entirety holds greater significance than the individual constituents. Over the past two decades, neuroscientists have conducted clinical investigations utilizing diverse ethnic populations to obtain reliable data on the functioning of the human brain. This information has facilitated researchers in comprehending the actual functioning of human learning. Scholars have conducted investigations on the

mechanisms by which the human brain obtains, comprehends, and preserves knowledge. At present, scholarly inquiry is centered on three fundamental facets of human learning and the brain. The subsequent section will provide an overview of the current status of research on brain-based learning, as well as an examination of three fundamental factors that influence the underlying theory. This study examines the neuroplasticity and cognitive maturation of the brain, as well as its integration and intricacy.

The growing emphasis on the correlation between the brain and the learning process calls for a concerted endeavor to ascertain and delineate the attributes of brain-centered learning, taking into account both theoretical and practical viewpoints. Brain-based instruction incorporates considerations of individual differences in children's learning. The process can be likened to self-education in the art of thinking like a brain, as posited by Ha, Kim, and Korean Association For Learner-Centered Curriculum and Instruction [2]. According to Versteeg, Hafkemeijer, Beaufort, and Steendijk [3], the concept of brain learning serves as a means of verifying the authenticity of the learning process. Three decades ago, the concept of quality education was characterized by the expectation that students would maintain a state of quiet attentiveness while receiving instruction on a particular subject matter through a lecture format. Can this be considered as the most effective approach to education? It is recommended that educators incorporate the discoveries of neuroscience into their instructional methodologies. According to Rodriguez, Zheng, and Chui [4], the brain represents our cognitive abilities, while the mind refers to the way in which we utilize these abilities.

According to Langer, Jentsch, and Wolf [5], the inclusion of emotions with high intensity such as joy, rivalry, or drama can result in the secretion of adrenaline by the body, leading to a notable enhancement in memory. According to Sakamaki, Tavakoli, Wiebe, and Adams [6], essential components for rewiring the brain include challenge, feedback, novelty, coherence, and time. This assertion emphasizes the significance of these factors in facilitating the process of rewiring the brain. It is imperative that students are afforded sufficient time to engage in reflective practices, assimilate acquired knowledge, and subsequently utilize it in a purposeful manner, in order to foster the development of meaningful connections. Jensen's research in neuroscience enables him to concentrate on three crucial elements of the brain. A comprehensive understanding of the brain's inherent characteristics can be obtained through an examination of its adaptability, intricacy, and adeptness in both competition and cooperation.

The malleability of the brain provides an opportunity for young individuals to acquire knowledge and enhance cognitive abilities. Maes and Almulla [7] posit that exposure to novel environments, experiences, and behaviors can lead to changes in the brain. According to Aranda, Bhatt, Ates, Engel, and Simsek [8], the brain's ability to establish novel connections is impacted by an individual's manner of interaction with the environment. The impact of human activity on cell growth rate has been studied by Jiang, Jang, and Zeng [9], who have identified various factors that can either facilitate or impede neurogenesis. The process of neurogenesis is susceptible to the influence of various factors, including both suppressive and stimulatory variables. For instance, chronic stress and physical activity have been found to exert suppressive and stimulatory effects on neurogenesis, respectively. According to Cook, Reed, and Lockwood [10], genetics does contribute to the development of students' behavior and reasoning, however, it is important to note that these traits are not fixed and can be altered. The neuroplasticity of the brain holds significant relevance to this inquiry due to its impact on the mechanism of acquiring knowledge. If it were discovered that the variables impacting neurogenesis could be modified through distinct instructional strategies, this data would provide support for gender-specific approaches.

The concept of "brain integration" pertains to the degree of collaboration and rivalry among distinct regions of the brain. In order to effectively store and prioritize information and carry out tasks, it is imperative that the distinct regions of the brain engage in cooperative functioning. The phenomenon in which distinct regions of the brain contend for the regulation of identical sets of behaviors and resources is referred to as competition. Occhipinti Liberman and Rendsvig [11] posited that the left hemisphere was accountable for logical reasoning, whereas the right hemisphere was responsible for creative thinking. However, contemporary studies have demonstrated that the left hemisphere is responsible for sequential information processing, in discrete units, and with the aid of language and textual representations. A study conducted by Stockbridge, Sheppard, Keator, Murray, Lehman Blake [12] revealed that the right hemisphere of the brain was activated in response to negative emotions, while positive emotions were found to activate the left hemisphere.

The corpus callosum is a significant agglomeration of neural fibers that facilitates interhemispheric communication between the two cerebral hemispheres. Neurotransmitters facilitate interhemispheric communication by conveying neural signals across the corpus callosum. The intellectual competition known as the cerebral Olympics is indicative of the principle of prioritizing individuals based on their order of arrival. The nascent regions of the brain exhibit a state of receptivity, awaiting external stimuli. According to Ibrahimov, Ismaylov, Orujova, and Mammadov [13], the allocation of space and resources in the network of signals to the brain is influenced by the temporal order of occurrence, frequency of activities, and coherence of actions. Undoubtedly, the human brain exhibits the ability to concurrently manage multiple tasks. Consequently, an environment that is intellectually engaging and offers a variety of stimuli is advantageous for the process of acquiring knowledge. Consequently, it is crucial for educators to utilize a diverse array of pedagogical approaches to impart information and expertise to pupils, encompassing didactic presentations, written materials, experiential learning, and imaginative modes of expression.

This paper aims to present the results of a study that investigated the correlation between the cognitive proficiency, convictions, and frequency of utilization of brain-based learning techniques by educators in primary Science classrooms. The study comprised 207 educators from elementary schools in Croatia. The findings indicate that educators at the primary

level possess a sound comprehension of brain-centered pedagogical approaches, yet they infrequently implement them in their instructional practices. The prevalence of frontal, didactic pedagogical approaches in science classes at the elementary school level indicates a dearth of effective implementation of student-centered teaching methods and the enduring influence of a well-established, historically-rooted paradigm in the realm of education. The rest of the paper is organized as follows: Section II presents a review of literature on brain-based learning. Section III presents a methodology employed for this article. Section IV elaborates the results and presents a discussion of brain-based learning, brain-compatible education, teacher's understanding of the BBL, primary science BBL implementation frequency, and BBL knowledge, beliefs, and application by teachers. Section V presents a conclusion to the research.

II. LITERATURE REVIEW

Habib, Alam, Rahman, Chowdhury, and Shill [14] posit that in order to effect change in education, it is necessary to alter the knowledge, attitudes, and actions of teachers. Educators in Croatia are currently experiencing a deficiency in their BBL literacy. The study aimed to investigate the alignment of primary science education in the Croatian educational system with contemporary perspectives on educational neuroscience and optimal brain functioning for academic achievement. This was achieved through an analysis of primary school teachers' knowledge, attitudes, and beliefs. An effective approach to enhancing education involves assessing the extent to which educators comprehend the principles underlying the pedagogical framework of backward design of learning (BBL). The manifestation of the brain's sophistication or complexity is most evident during the process of learning. The thalamus is responsible for the reception and processing of sensory information. During this interim period, the information is conveyed to the amygdala and other subcortical regions, whereas the occipital and temporal lobes undertake the processing of the data. In the event of an emergency, the amygdala expeditiously initiates the recruitment of other brain regions that are necessary for processing the stimulus. The hippocampus is responsible for receiving and storing data, which is subsequently subjected to further processing and evaluation.

According to Venneri, Duzzi, Pilosio, Rigon, and Meneghello [15], in order to preserve memories in the long-term, the hippocampus gradually organizes, distributes, and integrates them with other cortical regions. The process at hand is intricate and demands a significant amount of time. However, the initial phase of the process occurs rapidly, while the subsequent stages may require several hours, days, or even weeks to complete. Teymournezhad, Azgomi, and Asghari [16] identify seven fundamental components that are crucial to the process of learning. The constituents that contribute to the process include participation, rehearsal, input quantity, coherence, timing, mistake correction, and affective states. The acquisition of knowledge and skills in children is influenced by the intricate interactions of the developing brain, which necessitate adequate stimulation and promote the brain's progressive specialization. The initial stage of acquiring knowledge involves engagement, which refers to the concentrated focus on a specific objective. In [17], a significant aspect to consider is that approximately 90% of learning takes place at a subconscious level. Hence, it can be argued that interest holds significant importance in the realm of education. According to Kerssen-Griep, Trees, and Hess [18], students who are attentive during instruction are more inclined to acquire the knowledge being imparted. Repeated exposure reinforces the neural connections in the brain, a process that is facilitated by repetition.

Montocchio, Niedenthal, Cooper, and Gronstedt [19] have discovered that engaging in repetitive practice facilitates the consolidation of information in an individual's memory. Each synapse is unique and distinct from one another. According to Alahyane and Pélisson [20], there is a constant adaptation to new stimuli. When teaching pupils, using a structured approach increases the likelihood that the information will be retained and then be easily and precisely retrieved. The term "input" refers to the quantity and duration of external stimuli exposure. The process of storing information in long-term memory in the human brain necessitates a certain amount of time. The entity in question may now securely relocate to its long-term memory storage and engage in a period of rest. The presentation of excessive information to children without sufficient time for processing may have an adverse impact on their learning capacity.

As per the research conducted by Autenrieth, Kober, and Wood [21], it has been observed that the human brain has a limited capacity to process information, and can only effectively handle a range of three to seven pieces of information at a given time. Beyond this threshold, the brain tends to become overwhelmed, leading to a loss of new knowledge. Kemp [22] posits that the duration for the settling of dust is contingent upon the student and the specific subject matter. They posit that the emergence of coherence is contingent upon the relevance and pertinence of the information at hand. They posit that the derivation of conclusions or the construction of meaning is an infeasible task in the absence of requisite background information. The enhancement of coherence can be facilitated by providing students with pertinent contextual knowledge and illustrative instances to utilize. Timing is considered as one of the fundamental elements of learning.

According to Kobayashi and Shibuya [23], the brain functions are based on diverse regular cycles or patterns. The ultradian rhythm is a type of circadian rhythm that manifests at regular intervals of 90-110 minutes. Within a single diurnal period, there occur approximately 12 to 16 of these circadian oscillations. Cycles are characterized by fluctuations that include both peaks and valleys. The circadian rhythms remain relatively stable over the course of a day, but can be subject to modification by factors such as physical activity, consumption of caffeine, or exposure to new stimuli. The understanding of these rhythms is crucial in the comprehension of the cognitive processes of the brain. Jensen suggests that learning occurs through the process of making mistakes. Tang et al. [24] acknowledge that direct instruction can be efficacious in certain circumstances; however, he posits that the neural networks of the brain are optimized when learners

engage in the exploration of various possibilities prior to arriving at the most optimal solution. The final aspect to be taken into account is the development of emotions. According to Chung, Dahan, Alarcon, and Fenton [25], emotion is a critical regulator of learning and memory. The probability of an event being retained in memory is contingent upon the intensity of the associated affective reaction. The intensity of an emotional response, whether it be negative or positive, has the potential to enhance an individual's memory of a particular event and their emotional attachment to it.

Sakuma, Kitajima, Nishiyama, Mashino, Hashita, and Nemoto [26] have established a correlation between the suppression of glucocorticoid hormones that affect cognition and the harmful impact of unfavorable emotions such as stress on cognitive aptitude. Recalling distressing events tends to be facilitated, and their neurological effects are more pervasive. Positive emotions have been found to have an impact on memory and recall processes. According to Cools, Aarts, and Mehta [27], dopamine, a neurotransmitter associated with positive experiences, may potentially augment cognitive abilities. The neurotransmitter dopamine is secreted as a reaction to enjoyable occurrences, such as agreeable scents. Caccavale and Finzi [28] discourse highlights that while certain learning regulations are innately ingrained in our cognitive frameworks; experiential factors also significantly influence the learning process of our brains. Dodds [29] has demonstrated that the presence of stress and anxiety can hinder the process of learning by interfering with the communication between the emotional brain, which includes the amygdala and hippocampus, and the rational hemisphere of the brain, specifically the frontal cortex. The amygdala has been associated with the retention of emotional experiences and long-term memory. The utilization of positive emotions in the classroom setting can have significant ramifications, as it has the potential to augment students' aptitude for acquiring and retaining knowledge.

Several academic studies have conducted comparative analyses between BBL and traditional teaching approaches, and have reported statistically significant improvements in students' academic performance as a result of BBL. Educators hold a pivotal position in the implementation of BBL methodologies as they serve as facilitators of the pedagogical process. Makridis, Mavrepis, and Kyriazis [30] have demonstrated that providing educators with professional development opportunities that focus on brain-related topics and teaching strategies that align with the natural learning process can have a favorable impact on how instructors design their lessons and, consequently, on students' learning outcomes. It is imperative for educators to possess knowledge of the BBL framework and implement it in order to enhance the quality of their instructional practices. According to Larsen [31], pedagogical practices that promote the cultivation of strategic thinking and concentration skills are widely regarded as highly beneficial for students. According to the findings of Rahimi and Zhang [32], educators who implemented the BBL observed a higher level of student engagement in the learning process, a decrease in disruptive behavior in the classroom, and an increase in the number of students who exhibited pride in their work, submitted homework more consistently, and attained superior academic performance compared to those who did not utilize the BBL.

III. METHODOLOGY

The objective of this research was to investigate the correlation between educators' acquaintance with inquiry-based learning techniques and their implementation in Science classrooms at the elementary school level. The aforementioned objectives have led to the formulation of the subsequent research concerns: Initially, it is pertinent to inquire about the level of familiarity that educators possess with regards to the BBL framework. What are the attitudes of primary school teachers towards the implementation of the BBL (Blended Learning) approach? What is the frequency of employment of the BBL methodology by instructors of science in elementary schools? Can a significant variance be observed in the level of teachers' knowledge regarding BBL, their perspectives on its execution, and the frequency of its utilization in science classes at the elementary level? Is there a correlation between the level of teachers' familiarity with and their level of enthusiasm for utilizing BBL (Blended Learning) strategies in elementary science classes? Can a significant association be observed between the motivation levels of teachers and their utilization of BBL in the educational setting, as well as their participation in BBL-centered workshops or conferences?

Following a thorough examination of prior surveys conducted in this particular area, a distinctive questionnaire was formulated to cater to the requirements of this research. The initial segment of the survey requested participants to furnish fundamental personal details, such as their gender, age, duration of military service, and educational attainment. The subsequent segment comprised of a total of 30 inquiries that were systematically arranged into three distinct scales. The initial sub-scale examined the educators' foundational knowledge of the BBL, while the subsequent sub-scale analyzed their perspectives regarding the implementation of BBL in primary science education. The final sub-scale gauged the frequency with which instructors incorporated BBL into their teaching practices. The participants utilized a five-point Likert scale to score the items, where the scale ranged from 1 to 5. The scale's endpoints were labeled as "never" and "always," respectively. The numerical values of 1, 2, 3, 4, and 5 corresponded to the participants' level of agreement with the statements, where 1 indicated strong disagreement, 2 indicated disagreement, 3 indicated neutrality, 4 indicated agreement, and 5 indicated strong agreement.

The study involved the participation of 207 primary school teachers in Croatia who completed an anonymous online survey. The participants who were educators responded to the survey in an anonymous manner. The male respondents constituted a mere 3.7% of the total sample size of 107, whereas the female respondents accounted for a significant majority of 96.3%. Seven categories have been established based on the number of years that the respondents have spent in the workforce. The study found that the duration of service varied across the sample, with the majority of participants

(45.8%) having served for a period of 0-5 years. A smaller proportion of participants had served for 6-10 years (8.4%), 11-15 years (12.1%), 16-20 years (10.3%), 21-25 years (7.5%), 26-30 years (8.4%), and more than 30 years (7.5%). The results indicate that a significant proportion of participants possess either an associate's degree (18.7%) or a bachelor's degree (69.2%), with a minority holding a master's degree (12.1%). The results of the survey indicate that a mere 30.8% of participants reported engaging in a workshop or professional conference related to BBL, whereas the majority, 69.2%, reported no such participation. According to the results of a survey conducted among educators, 63% of the respondents expressed their willingness to participate in a conference that is exclusively focused on this particular matter. Merely 1.9% of participants indicated a state of complete lack of motivation, whereas 12.1% expressed a moderate level of motivation, and 22.4% conveyed a high degree of drive.

The study's results were analyzed and presented using the IBM SPSS Statistics 20 software, which adheres to established scientific and statistical standards. Prior to processing, each statement underwent a Kolmogorov-Smirnov test to determine whether the collected data exhibited a significant deviation from a Gaussian distribution. The data for all assertions exhibited statistically significant deviations from a Gaussian distribution. Consequently, the data processing involved the utilization of non-parametric statistical measures and the results obtained from non-parametric statistical tests.

IV. RESULTS AND DISCUSSION

Brain Based Learning (BBL) Overview

The objective of BBL is to achieve significant learning, which involves recognizing the principles governing the functioning of the brain and subsequently formulating pedagogical strategies that align with these principles. The BBL framework constitutes a cognitive construct that facilitates the contemplation of an individual's learning process. The aforementioned is a corpus of knowledge and a collection of guiding principles that facilitate the process of making informed decisions in the realm of education. The objectives of brain research encompass tailoring instruction to suit the distinctive requirements of students, employing diverse approaches, and maximizing the innate learning capabilities of the brain.

Understanding the fundamental nature of learning necessitates an examination of the intricate workings of the brain, a task that can only be accomplished through the study of neuroscience. Van der Velden [33] posits that the essence of teaching is essentially the process of rewiring the brain. Atrey, Singh, Bodhey, and Bilas Pachori [34] contend that the brain operates as a cohesive entity during the process of learning, and therefore, the acquisition of knowledge is not a linear process but rather a unified and cyclical one. The investigation of the brain ought to be the primary undertaking in all educational pursuits. Conversely, threats may potentially yield a detrimental impact on the process of learning. BBL endeavors to enhance the most effective approach to learning, elevate academic achievement, and promote equitable opportunities for success among all students, drawing upon the principles and mechanisms of the brain.

Kolb's learning cycle model incorporates the notion of students' evolving self-awareness regarding their unique learning styles. Engaging in novel experiences and physical activities may enhance students' capacity to establish fresh neural connections. The structure of the brain can undergo modifications due to various stimuli, whether they originate from within or outside the individual, as a consequence of their lived experiences. According to Iniyan, Singh, and Hazra [35], the process of learning involves a fundamental transformation. Exposure to novel experiences is a crucial component of the acquisition of knowledge. **Table 1** presents a summary of the associations between BBL and Kolb's experiential learning model, which constitutes the fundamental concept that both ELT and BBL share.

Table 1. Difference between ELT and BBL

ELT	BBL
The learning cycle has 4 styles of learning. Each individual has their specific styles.	The brain comprises of 4 lobes, and every lobe serves a different duty and function.
The first is information conception, while the second is processing of information.	The left part of the brain is abstract and analytic; the right brain is concrete and holistic.
The learning cycle defines 2 learning dimensions.	The brain defines 2 hemispheres and they have distinct functionalities.
Each learning style provides learners with specific processing and perceptions skills	Every brain has a unique feature
Learning occurs in circulations	The brain operates in unity

Brain-compatible Education

Upon reflection of the history of education, it becomes evident that methodologies that neglected to consider the distinctive attributes and learning modalities of students were unsuccessful. Effectively cultivating students' knowledge, skills, talents, or competences to address everyday challenges is crucial to enhancing and progressing the educational system. However, the conventional approach of teacher-centered instruction is insufficient in achieving this objective. In order to establish a learning environment that is conducive to this goal, educators must adapt their instructional methodologies, the nature of their assignments, and the media they employ to ensure that every student can achieve academic success to the fullest extent of their potential. The implementation of active learning principles, commonly referred to as brain-based learning (BBL), is a viable strategy to facilitate the achievement of this objective by modifying

the conventional learning process. BBL's guiding principles are founded on an understanding of the structure and function of the brain, as well as scientific discoveries from the field of cognitive neuroscience pertaining to optimal learning techniques for the brain.

The field of neuroscience is predicated on the fundamental concept of cerebral or brain plasticity. The concept of "neuroplasticity" pertains to the brain's ability to undergo structural and functional modifications in response to favorable stimuli and behaviors. Prior to the 1960s, the prevailing belief was that the brain was only capable of undergoing changes during childhood, and that upon reaching adulthood, its anatomical structure became immutable. Research in the field of neuroscience has provided evidence that the brain undergoes a process of generating novel neural pathways and discarding pre-existing ones in response to fresh experiences, learning, and memories. The brain has the ability to adapt to novel circumstances through the process of creating new neural connections and eliminating those that are not in use. The objective of these findings was to shed light on the process of human learning, facilitate the development of favorable educational environments, and improve the standard of teaching. Brain-based learning (BBL) is a concept that encompasses several related terms, such as brain-compatible education and brain-friendly teaching, which are commonly utilized in scholarly and vocational literature.

The learning process is comprehensively considered, encompassing the unique characteristics of individuals and their contextual factors throughout all phases. The objective of Brain-Based Learning (BBL) is to create educational settings that enhance cognitive performance by aligning pedagogy with the innate learning mechanisms of the human brain. To attain this objective, it is recommended to create an educational environment that is captivating and promotes student-centered learning. According to Demchenko, Maksymchuk, Bilan, Maksymchuk, and Kalynovska [36], the brain plays a crucial role in the activities of both teachers and students in school. Therefore, it is imperative for educators to consider this aspect when designing their instructional strategies. Failure to do so may lead to frustration and poor academic outcomes for both students and teachers. The author emphasizes the importance of providing equitable levels of cognitive stimulation to both the left and right hemispheres of the brain.

The scientific and professional literature on brain-based learning outlines a number of defining assumptions. a) learning is defined as a physiological process that involves awareness of the indivisible mind-body relationship; b) it emphasizes brain sociability, i.e. the strong influence of human interaction on the learning processes; c) the search for meaning is considered innate, and therefore it is necessary to provide a rich, meaningful environment that challenges every student, and procedures for meaningful organization and categorization of new concepts such as mental mapping in the teaching process; d) the brain always tries to connect new information with already existing knowledge, which is the basis of constructivist teaching; e) emotions are crucial for creating patterns and they significantly affect the learning process, which is why they need to be kept positive; f) the brain processes parts and wholes simultaneously; g) learning involves focused attention and peripheral perception whereby the brain absorbs conscious and out-of-focus information; h) learning involves conscious and unconscious processes which occur simultaneously; i) the brain remembers in different ways and information is being stored and retrieved through multiple memories and neural pathways that are constantly being created; j) the physiological structure and function of the brain changes we learning; k) holistic learning is enhanced by challenge and inhibited by stress, so threatening environment or stress can make learning difficult; and l) each brain is unique, and the ways in which information is processed differ from person to person, which BBL associates with different learning styles and Gardner's theory of multiple intelligences.

The effectiveness of active learning methods, such as inquiry-based learning, learning by discovery, project-based learning, and cooperative learning, has been substantiated by brain research, which is evident from the aforementioned concepts. This demonstrates a pedagogical comprehension of the subject matter. Through the implementation of these instructional approaches, students construct their understanding by analyzing and comprehending their environment, encompassing both tangible and intangible aspects, through active involvement with their surroundings. This pedagogical principle aligns with the constructivist paradigm. The principles mentioned above can be achieved through the implementation of orchestrated immersion, which involves creating a learning environment that inundates students with information, thereby compelling them to engage their local memory system in content exploration. Additionally, encouraging students' relaxed alertness, which involves placing them outside of their comfort zone while ensuring they feel secure enough to tackle the challenge, can also be effective. Finally, active processing, which entails critical thinking, pattern recognition, and comparison of opposing viewpoints, can also facilitate the realization of these principles.

Educators who invest time in understanding the workings of the brain will be better prepared to facilitate the intellectual and cognitive development of their students. The integration of instruction on the brain's inherent cognitive processes and the facilitation of its optimal development would likely result in a significant increase in educational efficiency and the acquisition of substantive knowledge among students. According to Longmuir [37], students who have utilized BBL within the educational setting have expressed a positive perception of the technology and have expressed a desire to utilize it again in subsequent learning experiences. Luong, Falkenberg, and Rahimian [38] discovered that the utilization of BBL methodologies results in a more organic learning experience and mitigates rote memorization by delivering information in a more captivating manner. Consequently, the mitigation of tension and the establishment of a serene ambiance significantly facilitate the process of acquiring knowledge. Incorporating physical activity into routine lessons is an additional approach to promoting organic learning. In [39], engagement in physical activity leads to an increase in the formation of synapses between neurons, thereby promoting cognitive processes. Elevated respiration and

heart rates induced by physical activity, social interaction, and experimental intervention lead to heightened cerebral oxygenation and blood circulation.

In [40], the effectiveness of the movement technique was demonstrated. The study found that "Brain Gym" exercises, which are one of the BBL techniques, aided students who faced challenges in reading and writing by enhancing their ability to concentrate while working in groups, and also contributed to an improvement in their self-esteem. Imani and Habil [41] yielded comparable findings, indicating that the incorporation of physical exercise during instruction has a positive effect on students' problem-solving behavior and academic advancement. Wang et al. [42] indicate that engaging in physical exercise can have a positive impact on both short-term memory and mood, as demonstrated in a study. Apart from engaging in physical activity, it has been observed that the learning environment exerts a significant impact on the neural development of students. Pérez-Chantes, Nolé, and Higuera-Trujillo [43] study on the impact of flexible seating arrangements on academic outcomes suggests that classroom configurations designed in a cluster or U-shape foster greater opportunities for student interaction and collaboration compared to traditional desk rows. According to the BBL framework, it is imperative that students are granted the liberty to move around and engage with their peers while they engage in academic pursuits. According to Jasińska et al. [44], various environmental factors such as space, light, sound, temperature, and air quality significantly impact the cognitive and physical development of children.

The act of displaying posters, paintings, and student work within the classroom environment can potentially enhance the productivity and appeal of the learning space, as perceived by the students. The diverse learning styles of students can be effectively addressed through the implementation of various pedagogical approaches, including game-based learning, humor, music, problem-based learning, collaborative learning, mental mapping, dialogue, and sensitivity to students' emotional needs. The utilization of humor and games for the purpose of reviewing and refining fundamentals has been found to enhance the classroom environment and facilitate greater retention of material among students. It is imperative that students are provided with a secure and consistent environment for academic pursuits, characterized by unambiguous protocols and regular patterns. However, it is equally important to offer ample avenues for investigation and innovation to satiate their inherent inquisitiveness and desire for advancement.

The BBL program prioritizes the uniqueness of each student and their pre-existing knowledge as a catalyst for further academic growth. The utilization of this approach holds promising prospects for significantly augmenting students' aptitude to comprehend novel concepts and positively influencing their learning methodology. According to Darmawan, Fauzi, Santosa, and Nisa [45], the implementation of BBL resulted in enhanced motivation, working memory, retention, and comprehension of previously learned material among students. Their study suggests that the integration of BBL in a classroom environment yields advantageous outcomes in terms of students' attitudes and motivation. Enhancing student enthusiasm may lead to improved academic performance. The implementation of BBL techniques can potentially enhance students' inclination and disposition towards challenging topics.

Teachers' Understanding of the BBL

The primary objective of the initial segment of the questionnaire was to assess the level of proficiency of the instructors with regards to the BBL methodology. The results indicate that educators possess a satisfactory comprehension of BBL. The individuals possess a comprehensive understanding of the principal concepts and possess a strong command of the requisite information to achieve this (M total = 3.97; SD = 0.36). A notable instance pertains to the current focus on the prospective advantages of integrating outdoor education into contemporary classrooms as a strategy to enhance students' cognitive activation by means of their exposure to natural surroundings (M = 4.58; SD = 0.66). Furthermore, it is noteworthy that educators possess a profound comprehension of the potential efficacy of mental mapping and project-based learning in expediting the learning process, specifically within the context of Science education at the elementary school level (M = 4.58, SD = 0.65). Although the respondents possess a fundamental comprehension of BBL, their proficiency in the domains of student affectivity and ingenuity is comparatively limited. The results indicate that educators hold a predominant belief that creative thinking is an innate ability (mean = 3.54; standard deviation = 1.10), and that they perceive emotional processing and logical reasoning as separate cognitive processes (mean = 3.46; standard deviation = 1.25).

Furthermore, the results of the Kruskal Wallis test indicate a significant disparity among teachers of different levels of experience in terms of their familiarity with the notion that effective teaching is based on the belief that all students are capable of achieving success in learning (H = 15,960, p = 0,0014) and the utilization of controversy as a technique to engage student interest (H = 14,420, p = 0.025). Educators who possess less than five years of experience or those who have between 11-15 years of experience are more inclined to believe that all students can achieve success in their learning endeavors compared to their counterparts who have 21 or more years of experience. Educators who have been teaching for a period of 26-30 years are more inclined to concur with the proposition that the academic dispute method is suitable for capturing the attention of students as compared to their counterparts who have only 5 years of experience. The results of this study indicate that the enthusiasm displayed by instructors at the outset of their teaching career can have a significant influence on the learning outcomes of their students. Additionally, experienced educators may possess the ability to make informed decisions regarding the most appropriate instructional methods to employ. The examination results did not reveal any significant statistical differences in the instructors' knowledge of credentials related to BBL.

The BBL's Efficacy in Elementary Science Lessons According to Teachers

The second sub-scale of the study centered on the attitudes of educators towards utilizing BBL in science classes at the elementary level. Educators exhibited favorable attitudes (Mtotal = 3.64, SD = 0.34) towards the potential utilization of the technology in the classroom, albeit with a slight degree of uncertainty. A prevailing notion among educators is that primary school science classrooms could potentially reap advantages from a diverse range of BBL (Blended and Online Learning) strategies. The results indicate that the educators exhibited a high level of readiness and inclination to utilize a diverse range of instructional strategies within their teaching environments, with a mean score of 4.65 and a standard deviation of 0.75. The respondents concur that diverse educational approaches augment their academic achievement, as evidenced by a mean score of 4.79 and a standard deviation of 0.70. Nonetheless, there exists a division among them regarding their perceived level of preparedness to employ BBL within the educational setting, as indicated by a mean score of 2.19 and a standard deviation of 1.14. The results of the Kruskal Wallis test indicate a significant statistical disparity in the instructors' willingness to incorporate novel learning methodologies, as per their professional experience level (H = 33,258, df = 6, p = 0,00). A significant contrast exists in the perspectives of educators who possess 11-25 years of experience and those who have 26 or more years of experience regarding the utilization of diverse pedagogical approaches.

This outcome is logical, as recently certified instructors are more inclined to possess the competencies required to implement inventive teaching methodologies. In contrast, educators who possess more extensive experience often exhibit a proclivity for adhering to established methods and displaying reluctance towards novel techniques. The study reveals that novice educators of elementary and middle school students exhibit a willingness to adopt novel pedagogical approaches and possess the necessary skills to address the challenges of modern-day schooling. The Kruskal Wallis test revealed significant differences in teachers' perspectives regarding the effectiveness of different learning approaches in stimulating cognitive activity (H = 15,344, df = 2, p = 0,00) and the significance of creating a favorable learning environment (H = 24,504, df = 2, p = 0,00). Empirical data indicates a significant statistical correlation between possession of a master's degree by teachers and their positive perspectives on the aforementioned matters. The aforementioned observation suggests that individuals who completed their teacher education programs over 25 years ago exhibit a lower level of openness towards novel findings, thereby corroborating the notion that BBL facilitates greater student engagement in the learning process. Consequently, it is imperative that individuals participate in lifelong learning initiatives to acquire the requisite competencies for proficiently executing innovative pedagogical methodologies.

Primary Science BBL Implementation Frequency

The third variable was employed to examine the frequency of employment of BBL in Science classrooms at the elementary school level. The data indicates that primary school science instructors rarely utilize BBL (Mtotal = 3.35; SD = 0.37). Educators frequently utilize current and revised information (M = 4.09, SD = 0.85) as well as practical situations and engagement with pertinent topics (M = 3.99, SD = 0.72) when designing their courses through BBL methodologies and procedures. The employment of prizes as a motivational tool (M = 2.41, SD = 0.85) and diagrams (M = 2.64, SD = 0.88) as instructional aids are observed to be less frequent in comparison to other noteworthy BBL strategies.

Furthermore, the results of the Kruskal Wallis test indicated statistically significant differences in the frequency with which instructors employed BBL strategies and techniques based on their level of professional experience. Through the application of a statistical test, it was determined that a notable discrepancy existed in the frequency of employment of the mind mapping methodology (H = 16,510, df = 6, p = 0.011). Teachers who have served for 11-15 years and 26-30 years are more inclined to utilize mental mapping, as per statistical analysis, in comparison to respondents with lesser work experience of 5 years. It is probable that their educational background played a role in the observed outcomes. Educators who possess limited expertise are inclined to employ strategies whose durability they estimate.

The individuals possess knowledge of the concept of mind mapping and its potential application in the context of elementary science education. However, due to limitations in time, they resort to utilizing traditional instructional methodologies. The findings indicate a noteworthy variance in the implementation of frontal teaching (H = 8,985, df = 2, p = 0.011), utilization of current and revised information in pedagogy (H = 22,466, df = 2, p = 0,000), non-adherence to the 45-minute lesson constraint (H = 12,558, df = 2, p = 0,002), and promotion of certain types of physical activity during instructional sessions (H = 8,038, df = 2, p = 0.0). The findings indicate that educators who hold a master's degree exhibit a greater propensity to employ BBL techniques and instructional methodologies compared to their counterparts with a bachelor's degree. This trend can be attributed to the advanced level of education attained by master's degree holders, which equips them with enhanced competencies for facilitating effective teaching.

According to statistical data, teachers who hold a bachelor's degree tend to prefer frontal instruction. Empirical evidence suggests that educators possessing a master's degree or higher, as well as those holding a university degree, exhibit a significantly greater propensity to incorporate novel and revised information compared to their counterparts with a bachelor's degree. This is due to the fact that the typical respondent completed their teacher training program more than 25 years ago. The individual's prior academic training did not equip them to navigate the various methods by which the contemporary educational framework has reorganized the dissemination of instructional content.

Furthermore, in accordance with current best practices in education, it has been observed that educators possessing a higher level of academic qualification are less inclined to limit the duration of primary-level Science classes to 45 minutes, as compared to those with only an undergraduate degree. Educators who possess a master's degree are more inclined to

participate in physical activities themselves or encourage their students to do so, with the aim of enhancing concentration and classroom engagement, in comparison to those who have lower levels of education. This is due to the fact that individuals who have completed a college education are more inclined to comprehend the significance of brain gym techniques in establishing a classroom environment that prioritizes the needs of the students. Educators who have attained postgraduate qualifications are comparatively less inclined to adhere to 45-minute class duration, and they are also more prone to utilizing visual aids such as diagrams and demonstrations.

The Kruskal Wallis test results indicated a lack of statistical significance in the relationship between the frequency of BBL technique usage by instructors and their inclination to attend conferences related to BBL (H = 4,964, df = 3, p = 0,174). The study findings indicate that there exists a significant difference in the implementation frequency of BBL methods based on the attendance of educators at workshops or professional conferences dedicated to BBL, as evidenced by the results of a Mann-Whitney test (MWU = 754, Z = -3.157, p = 0.002). Educators who have participated in a workshop or professional conference focused on inquiry-based learning (BBL) are more inclined to implement BBL techniques in the primary science classroom. This highlights the necessity for educators in the present day to engage in continuous professional development throughout their professional trajectories.

BBL Knowledge, Beliefs, and Application by Teachers

The purpose of our study was to examine the potential correlation between teachers' familiarity with BBL and their utilization of it in the classroom, utilizing the Friedman test and subsequent analysis to determine statistical significance. The results of the analysis indicate a significant statistical difference between the factors presented in **Table 2** (x2 = 98.80; df = 2; p 0.01). The study revealed that teachers possessed a significantly higher level of comprehension than students with respect to their attitudes towards BBL and its frequency of employment. Additionally, a notable statistical distinction exists between the viewpoints of educators regarding BBL and its implementation frequency within Science classrooms at the elementary level. The results of the study support the hypothesis that educators, despite their belief in the effectiveness of BBL strategies, do not fully utilize them in their instructional practices.

Table 2. Comparison of teachers' knowledge and attitudes regarding BBL and how often it is used in classrooms

	Mean	Standard deviation	X^2 Friedman test	p	df
Applications frequency	3.35	0.37	98.90	0.00	2
Beliefs	3.64	0.34			
Knowledge	3.97	0.36			

The findings of the Spearman's correlation analysis between instructors' utilization of the BBL approach to instruction and their level of familiarity with it are presented in **Table 3**. The results indicate a significant positive correlation between teachers' comprehension and the frequency of implementing the Backward by Design Learning (BBL) approach in the instruction of primary level science.

Table 3. Relationship between BBL implementation frequency, knowledge, and beliefs

	Applications frequency	Beliefs	Knowledge
Beliefs	0.13	/	/
Knowledge	0.45 **	0.07	/

The examination of the brain has been a longstanding aspect of human culture. However, the notion of educational neuroscience, which pertains to instructing with consideration of the brain, has undergone development within the past thirty years. The aforementioned outcome is a product of advancements in brain research and technology, coupled with educational endeavors aimed at attaining profound insights and more compelling pedagogical rationales. Educational neuroscience is a crucial field as it furnishes additional substantiation for the necessity of customizing instructional approaches to cater to the unique requirements of each learner. The utilization of principles of learning emphasized by contemporary neuroscience is evident in student-centered teaching practices developed under reform pedagogies, such as inquiry-based instruction, project-based learning, and cooperative learning. The foremost objective is to inspire students to attain academic excellence and realize their maximum potential.

As per the findings of this research, educators at the elementary level possess a commendable comprehension of the BBL methodology, albeit its incorporation into their pedagogical practices is infrequent. The prevalence of conventional, frontal teaching methods suggests that a shift towards student-centered teaching has not been widely adopted. This may be attributed to a deeply ingrained paradigm in the history of education. The instructor's proficiency in BBL is considered satisfactory, although it is noteworthy that it surpasses the mean level of competence. Regrettably, this falls short of the requisite benchmark to fundamentally transform our collective perception of education. The findings of the study indicate that educators who possess less experience exhibit a more comprehensive comprehension of the fundamental framework

of BBL. Additionally; the instructors' positive outlook towards the implementation of novel pedagogical approaches is influenced by their level of educational attainment. According to the majority of educators, they would utilize novel instructional approaches if they were provided with extra time.

V. CONCLUSIONS

The significance of education in the implementation of BBL methods in practical settings is highlighted in this study, which indicates that instructors possessing master's degrees exhibit a statistically significant higher frequency of utilizing BBL. The frequency of BBL method usage in elementary science lessons is positively associated with teachers' level of familiarity with the method. Therefore, it is crucial to offer teachers adequate training to ensure the effective implementation of the BBL method. There is a correlation between attending seminars and academic success. This is due to the fact that seminar attendance increases the likelihood of all students receiving quality instruction and achieving their maximum potential. Further investigation is required to comprehend the reasons behind the disparity between educators' cognizance of the BBL methodology and its implementation frequency within the educational setting. It is plausible that educators may favor conventional methodologies due to limited opportunities to test novel pedagogical strategies (as evidenced by the mere two hours per week allocated to Science instruction for the initial three years of primary education in the Republic of Croatia) and the obligation to guarantee that all pupils attain proficiency in the prescribed curriculum. Hence, it is imperative to assess whether the configuration of primary science courses necessitates modification. The study highlights the absence of adequate research and guidelines for the integration of BBL in primary school education, particularly in the lower grades in Croatia. The findings of this study can potentially contribute to the formulation of guidelines for the effective implementation of BBL in primary school education.

Data Availability

No data was used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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