BRAIN-BASED LEARNING IN PRIMARY SCIENCE

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Abstract

Brain-based learning [BBL] is a set of principles in which the learning process is based on knowledge about brain structure and its function and on scientific results in cognitive neuroscience about the most effective and appropriate ways of learning for the brain. That includes structuring an interactive learning environment that respects students' characteristics and encourages creativity, conceptual understanding, and connections. Previous research shows the positive effect of BBL on student motivation, working memory development, maintaining the acquired knowledge, and a better understanding of the learned content. By understanding brain function, teacher can improve his or her teaching and develop the abilities and achievements of his or her students. This paper presents the results of the study whose aim was to investigate teachers' knowledge and beliefs about the implementation of brain-based learning strategies in the learning process and the frequency of its implementation in primary Science classes and to determine whether there is a correlation between these three variables. The study considered a sample of 207 primary school teachers in Croatia. The results show that primary school teachers have a satisfactory level of knowledge about brain-based learning strategies, but they only occasionally use them. Frontal, traditional teaching in primary Science classes is still widely used, indicating that there is still a robust, traditionally grounded paradigm in the educational process without an adequate shift toward student-centered teaching. The results show that teacher education level is significant for their positive beliefs about implementing new learning strategies. Teachers with master-level qualifications apply BBL statistically significantly more often regarding the teachers with bachelor's degrees. A positive correlation between teachers' knowledge about BBL and the frequency of its application in primary science classes shows the necessity of professional teacher training for acquiring adequate knowledge about this method, which could increase the frequency of its application in teaching practice. Most teachers conclude that they would apply different brain-based learning strategies if there would be more time in the teaching process. This situation requires consideration of possible teaching organization changes and the number of primary Science lessons per week.

Keywords: brain-based learning, neuroscience, primary science classes, primary school teachers, teaching strategies for active learning.

1 INTRODUCTION

An analysis of the historical context of education indicates that the education models that do not consider students' individual needs and abilities proved to be dysfunctional. Traditional, teacher-based teaching is not conducive to achieving the educational system's desired quality and progress, which can be attained by successfully developing students' knowledge, skills, abilities, or competencies for coping with everyday life situations. To provide a learning environment that is compatible with achieving this goal, we need to adapt teaching strategies, methods, forms of work, and media to each student's needs and abilities, enabling them to reach the highest level of their academic success. One way to contribute to this is to apply active learning principles, known as brain-based learning [BBL], which makes the learning process different from the traditional one.

BBL is a set of principles in which the learning process is based on knowledge about brain structure and its function and on scientific results in cognitive neuroscience about the most effective and appropriate ways of learning for the brain. The basis of neuroscience is a concept called cerebral or brain plasticity. Brain plasticity is the brain's ability to physically change to adapt to stimuli and habits beneficial to a person. Until the 1960s, there was a belief that the brain could change only during development in childhood and that when a person grows up, the brain gets its final physical structure. However, neuroscience research has shown that new brain pathways are created in the brain, and some pre-existing pathways disappear due to new experiences, new learning, and memories that a person collects. Through the process of creating new pathways and dying out those that are not used, the brain has the ability to adapt to a changing environment. These results sought to explain human learning, develop an appropriate learning environment, and improve teaching.

Apart from the previously mentioned term (BBL), scientific and professional literature mentions other similar terms such as brain-compatible education [1] or brain-friendly teaching [2], but their basic assumptions about a successful learning process generally correspond. It is based on a holistic approach to students, and it observes teaching from the developmental, sociocultural, and other aspects [3]. BBL aims to align teaching and learning with how the human brain is biologically organized for learning [4] and to create learning environments that improve optimal brain function. That includes structuring an interactive learning environment that respects students' characteristics and encourages creativity, conceptual understanding, and connections [1].

Jensen [1] also points out that the brain is intensely involved and connected to everything that teachers and students do in school and emphasizes the need to take this fact into account when teacher prepare the teaching process because of any deviation from the way the brain works may lead to frustration and failure. He particularly emphasizes the brain's complexity and the importance of integrated activation and stimulation of its left and right hemispheres.

In scientific and professional literature dealing with brain-based learning, there are several basic assumptions that characterize this approach to learning: a) learning is defined as a physiological process that involves awareness of the indivisible mind-body relationship [5]; b) it emphasizes brain sociability, i.e. the strong influence of human interaction on the learning processes [6]; 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 [7], 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 [5]; f) the brain processes parts and wholes simultaneously [3]; g) learning involves focused attention and peripheral perception whereby the brain absorbs conscious and out-of-focus information [3]; h) learning involves conscious and unconscious processes which occur simultaneously [7]; 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 [7]; j) the physiological structure and function of the brain changes we learning [6]; k) holistic learning is enhanced by challenge and inhibited by stress, so threatening environment or stress can make learning difficult [7]; 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 [7]. According to the presented principles, it is justified to point out that neuroscience research confirms pedagogical knowledge about the effectiveness of active learning strategies (inquiry-based learning, learning by discovery, project-based learning, and cooperative learning). During these teaching strategies student learns by creating and constructing his/her cognitions (knowledge) based on interaction with the environment (physical and social) and by giving environment their meaning, understanding, and interpretation. This principle of learning is compatible with the constructivist learning paradigm [8].

The previously mentioned principles can be achieved utilizing orchestrated immersion (creating a learning environment in which students are overwhelmed with information and therefore are forced to involve the local memory system in content exploration), by encouraging students' relaxed alertness (students are placed outside their comfort zone, but feel safe enough to engage in the challenge), and active processing (students think, look for patterns, compare what they know with what they see or hear, and make connections, orchestrated immersion, relaxed alertness, and active processing) [3].

By understanding how the brain works, a teacher can improve teaching and develop the abilities and achievements of his or her students. Every teacher should teach students about how the brain works and use mechanisms essential for its better development, which would significantly increase learning productivity and achieve meaningful learning in line with the natural workflow of the brain. Kosar's research [9] confirms that students who have applied BBL in class have a positive opinion about it and want to apply it in their future learning.

Research by Bloomfield et al. [10] has shown that applying BBL techniques facilitates natural learning and that content is presented more entertainingly, thus avoiding learning "by heart". That leads to a reduction in stress and creates a relaxed environment that significantly contributes to increasing the learning process's efficiency. Another way to encourage natural learning is to add movement to the everyday teaching process. Jensen [5] claims that movement is critical for encouraging the learning process because it creates more connections between neurons, promoting active brain functioning [11]. Movement, interactions, and experimental manipulations increase breathing rate and heart rate, increasing blood and oxygen flow to the brain [2]. To prove the effectiveness of the movement technique, Klinek [11] conducted a study which shows that the application of "Brain Gym" exercises, as one of the

BBL techniques, has a positive effect on progress in learning, reading, and writing, focusing students' attention while working in groups, as well as developing the self-esteem of students with reading and writing difficulties. Similar conclusions are reached by Wachob [12], whose research shows that physical activity during teaching positively affects students' behavior during problem-solving and indirectly affects their academic success. Also, it was established that physical activity positively impacts short-term memory and emotions [13].

Apart from movement, the classroom climate in which students learn has a significant impact on neuronal development [14]. In his study of the impact of flexible seating on the learning process, Ridling [15] concludes that the classroom seating arrangement in the form of a cluster or a letter U increases student interaction and collaboration compared to traditional seating in rows. BBL also includes creating a learning environment that allows students to move around and engage socially during the learning process [3]. Barrett and Zhang [16] point out that spatial configuration in the classroom, light, noise, heat, and air quality significantly impact academic achievement and development of students' skills. Creating an aesthetically pleasing classroom climate by displaying posters, paintings, and student papers makes the classroom a stimulating environment suitable for successful learning [5].

Game-based learning, the application of humor, music, problem-based learning and collaboration, mental mapping, conversation, respect for students' emotions, and other techniques enable different ways of learning adapted to different individuals' needs. Humor and games are used to repeat basic information and practice essential skills [17], and they contribute to creating a pleasant classroom climate. The learning environment must be familiar and stable, with well-established rules and routines, but with enough innovation and discovery to satisfy students' need for challenge and curiosity [6]. Also, the BBL emphasizes each student's uniqueness and current knowledge as a foundation for new learning [18]. It can significantly improve students' acquisition of concepts in learning [19] and positively impact students' learning attitudes [20].

Research by Adel and Mourad [21] shows the positive effect of BBL on student motivation, working memory development, maintaining the acquired knowledge [22], and a better understanding of the learned content [23]. Akyurek and Afacan [19] found that the application of BBL in a school subject positively affects students' attitudes towards that subject and increases their motivation to learn. Increased student motivation can lead to increased student success. Similar results can be found in Saleh's research [23], which is why it can be concluded that students' motivation and attitudes toward subjects, especially those that cause difficulties, can be improved by BBL strategies. Some research shows that BBL, compared to traditional teaching methods, also has a statistically significant effect on increasing students' academic achievement [24].

As organizers of the teaching process, teachers play an essential role in the implementation of BBL methods. Research conducted by Wachob [12] shows that teachers' professional development focused on brain-related topics and teaching strategies that support the natural learning process positively impact the teachers' organization of the teaching process and thus on the educational experience of the student. Teachers must understand the principles of BBL and apply them effectively in their teaching. Along with Brain Gym, most teachers consider strategy and focusing skills to be the most beneficial learning activities [12]. Although research by Gözüyeşil and Dikici [25] shows that brain-based learning activities have a positive effect on student achievement, the results of Pociask and Settles [26] show that the teachers who used the BBL noticed that their students were more engaged in learning, that ineffective behavior was reduced in the classroom, and that a greater number of students were proud of their work, began to write homework more regularly and achieved better test results.

According to Weick [27], any effort to reform educational practices involves changing teachers' knowledge, attitudes, and practices. Teachers in Croatia are still insufficiently familiar with the concept of BBL. By examining their knowledge, attitudes, and beliefs, an attempt was made to determine the extent to which primary school teachers in the Croatian educational system are willing to change their teaching practices and whether the teaching of primary science is consistent with contemporary insights about educational neuroscience and how the brain most effectively achieves academic success. Determining teachers` level of knowledge and understanding of their BBL ideas can contribute to the further improvement of teaching and learning.

2 METHODOLOGY

2.1 Research aim

This research aimed to investigate teachers' knowledge and beliefs about implementing BBL methods in primary Science classes and its correlation with their use frequency.

2.2 Research problems

According to these aims, the following research problems have been defined:

1 What is the level of teachers` knowledge about BBL?

2 What beliefs do teachers have about implementing the BBL method in primary science classes?

3 How often do teachers apply the BBL method in primary science classes?

4 Is there a statistically significant difference in the teachers` level of knowledge, beliefs about the implementation of BBL methods, and the frequency of their use in primary science classes?

5 Is there a correlation between the level of teachers' knowledge and beliefs about BBL methods and the frequency of their use in primary science classes?

6 Is there a statistically significant difference in the frequency of implementing the BBL method concerning teachers' motivation and concerning whether they participated in any of the workshops or professional conferences on BBL?

2.3 Research instruments

Based on the analysis of various questionnaires from this research area [28], [11], [29], a special survey questionnaire was made, adjusted to the goals of this research. The first part of the questionnaire collected participants' demographic data (gender, age, years of service, and education). The second part consisted of 30 items divided into three sub-scales. The first sub-scale examined teachers' knowledge about the BBL, and the second sub-scale examined teachers' beliefs about applying the BBL in primary science, while the third sub-scale examined the frequency of its implementation. Participants rated the items on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, and on a scale of 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always).

2.4 Participants

The research was conducted on a sample of 207 primary school teachers in Croatia who voluntarily participated in an anonymous online survey posted on the school's website. Teachers participated in the survey anonymously. Out of a total of 107 respondents, 3.7% were male, and 96.3% were female. Concerning the years of service, respondents have been divided into seven groups: 0-5 years of service (45.8%), 6-10 years of service (8.4%), 11-15 years of service (12.1%), 16-20 years of service (10.3%), 21-25 years of service (7.5%), 26-30 years of service (8.4%) and more than 30 years of service (7.5%). Most of the respondents have a university degree (69.2%) or a bachelor's degree (18.7%), while a small percentage of respondents have a master's degree (12.1%). 69.2% of respondents did not attend any workshop or professional conference on BBL, while 30.8% of respondents actively participated in a workshop or professional conference on this topic. The majority of teachers stated that they are motivated to participate in professional conferences on this topic (63.6%). 1.9% of them stated they were not motivated; 12.1% were partially motivated, while 22.4% were highly motivated.

2.5 Data Analysis

The research results were processed and presented through standard scientific and statistical methods, with the support of the IBM SPSS Statistics 20 software package. Before data processing, the significance of the deviation of the collected data from the standard Gaussian distribution was tested for each of the statements using the Kolmogorov-Smirnov test. The test results showed that all statements' data distribution deviated to a statistically significant degree from the standard Gaussian distribution. Therefore, data processing relied on non-parametric statistical indicators and results of non-parametric statistical tests.

3 RESULTS

3.1 Teachers` knowledge about the BBL

The first sub-scale in the questionnaire examined teachers' knowledge of the BBL method. The results show that teachers generally possess a satisfactory level of knowledge about BBL. They recognize its essential components and are familiar with the facts important for understanding (Mtotal = 3.97; SD = 0.36). That is especially evident in recognizing the importance of basic neuroscience assumptions for understanding the organizational layers within the brain (M = 4.58; SD = 0.66) and highlighting outdoor teaching as a component of contemporary education that could improve the cognitive activation of the students' brain. Also, teachers have a high level of knowledge about the effectiveness of mental mapping and project learning that contribute to accelerating learning in the context of primary Science (M = 4.58, SD = 0.65). However, the respondents are less familiar with the area associated with emotions and students' creativity in the learning process, which are considered important components of BBL. Moreover, the results show that teachers generally agree with the statement that creativity is an innate ability (M = 3.54; SD = 1.10) and that emotions and intelligence are separate brain functions (M = 3.46, SD = 1.25).

Furthermore, the Kruskal Wallis test showed that concerning the length of service, there is a statistically significant difference in teachers' knowledge that effective teaching is based on the belief that all students can achieve success in learning (H = 15,960, p = 0,014), and that controversy is one of the techniques appropriate for attracting student attention (H = 14,420, p = 0.025). Compared to those with 21-25 years of service, a statistically significantly higher number of teachers with minimum years of service (0 to 5) and teachers with 11 to 15 years of service agree that all students can succeed in learning. On the other hand, teachers with more years of work experience (26 to 30 years) agree with the statement that the academic controversy technique is suitable for attracting students' attention to a significantly greater extent than teachers with less work experience (0 to 5 years). These results indicate that the teachers' initial enthusiasm can affect students' learning success and that more experienced teachers can presume how certain methods will affect learning.

The test results also show no statistically significant difference in teachers' knowledge of BBL concerning their qualifications.

3.2 Teachers' beliefs about the efficiency of application of the BBL in primary Science classes

The second sub-scale examined teachers` beliefs about the implementation of BBL in teaching primary science. The results show that teachers generally have positive beliefs about its application in teaching (Mtotal = 3.64, SD = 0.34), but with a slight tendency towards undefined opinion. Teachers mostly agree that implementing different BBL procedures can make primary Science classes more attractive, modern, and enjoyable for students.

Teachers have extremely positive beliefs about implementing different learning strategies and indicate their readiness to introduce them in their teaching practice (M = 4.65, SD = 0.72). They also fully agree that different learning approaches contribute to their effectiveness (M = 4, 79, SD = 0.70). On the other hand, they generally disagree that the initial formal faculty education prepares them sufficiently to implement BBL in teaching (M = 2.19; SD = 1.14).

The Kruskal Wallis test results showed a statistically significant difference in teachers' willingness to introduce different learning strategies concerning teachers' work experience (H = 33,258, df = 6, p = 0,000). Teachers with less work experience (0 to 5 years) have significantly more positive beliefs about applying different learning strategies than the respondents with 11 to 25 and 26 or more years of service. This finding was expected because teachers who recently completed their formal education acquired the appropriate competencies to implement new teaching strategies. On the other hand, more experienced teachers have grown accustomed to traditional teaching methods and have no desire to change them. This finding shows that younger teachers who have just completed their teacher studies are ready to adapt to the challenges of modern educational changes with their openness to the implementation of new teaching strategies.

The results of the Kruskal Wallis test also showed that, concerning their professional qualification, there is a statistically significant difference in teachers' beliefs about introducing different learning strategies (H = 24,504, df = 2, p = 0,000), about the effectiveness of different approaches to learning in stimulating the brain's cognitive activity (H = 15,344, df = 2, p = 0,000), and about comfort, lighting and classroom

temperature being essential for effective learning (H = 8,032, df = 2, p = 0,018). Teachers with a master's degree have statistically significantly more positive beliefs about all of the above. This fact shows that the respondents who completed teacher education programs more than 25 years ago are less open to new findings, indicating that BBL contributes to a better cognitive engagement of students. Therefore, they should be included in lifelong learning programs to acquire appropriate competencies to apply new education methods.

3.3 The frequency of implementation of the BBL in primary Science classes

The third sub-scale was used to examine the frequency of implementation of BBL in primary Science classes. Research results showed that the teachers only occasionally use BBL in teaching primary Science (Mtotal = 3.35; SD = 0.37). Some of the BBL methods and procedures that teachers often use are real-life situations and immersion in problems (M = 3.99; SD = 0.72) and new and updated data for preparing their lessons (M = 4.09, SD = 0.85). However, among the important BBL techniques, they rarely use rewards as an incentive (M = 2.41, SD = 0.85) and diagrams (M = 2.64; SD = 0.88).

Furthermore, the Kruskal Wallis test results showed the differences in the frequency of implementation of BBL strategies and teaching methods concerning teachers' work experience. The results showed a statistically significant difference in the frequency of implementation of the mind mapping strategy (H = 16,510, df = 6, p = 0,011). Teachers with 11 to 15 years of service and those with 26 to 30 years of work experience are statistically significantly more likely to use mental mapping than the respondents with less work experience (0 to 5 years). These results can also be attributed to their teaching experience. Namely, teachers with less work experience are more prone to using methods whose duration they can assume. Although they know what mind mapping is and how to implement it in primary science, they resort to traditional methods due to the lesson's time limitation.

Also, the results showed that, with regard to the professional qualifications of the respondents, there is a significant difference in the frequency of implementation of frontal teaching (H = 8,985, df = 2, p = 0,011), the use of new and updated data in teaching (H = 22,466, df = 2, p = 0,000), disregard of 45-minute lesson limitation (H = 12,558, df = 2, p = 0,002), encouraging some forms of movement during classes (H = 8,038, df = 2, p = 0,018), using diagrams during lessons (H = 14,224, df = 2, p = 0.001) and using demonstration methods (H = 8.152, df = 2, p = 0.017). The results showed that teachers with a master's degree tend to implement these BBL methods and teaching procedures significantly more frequently than teachers with bachelor's degree, which can again be explained by a higher level of education which provides a higher level of competencies for effective teaching.

Teachers with a bachelor's degree are statistically significantly more likely to prefer frontal teaching. New and updated data are statistically significantly more often used by teachers with a master's degree and teachers with a university degree than teachers with a bachelor's degree. That can be attributed to the fact that these respondents completed their teacher training more than 25 years ago. Numerous changes in the organization of teaching in the modern educational system have taken place in the meantime, for which they have not acquired the appropriate competencies during their formal education.

Furthermore, teachers with a university degree are statistically significantly less likely to limit the duration of a primary Science class to 45 minutes than teachers with a bachelor's degree, which is in line with modern BBL. Compared to teachers with bachelor's and university degrees, teachers with a master's degree are more likely to practice or encourage some form of movement to help students to focus their attention and increase their readiness to learn. That can be attributed to a higher education level, i.e., knowledge of the role of brain gym methods in student-centered teaching.

Teachers with master’s and university degrees also tend to use diagrams and demonstrations more frequently, which may be related to the fact that they rarely limit the school hour to 45 minutes.

In this research, the Kruskal Wallis test results also confirmed no statistically significant difference in the frequency of implementation of BBL methods concerning teachers' motivation to attend conferences that deal with BBL (H = 4,964, df = 3, p = 0,174). However, Mann-Whitney test results showed a statistically significant difference in the frequency of implementation of BBL methods depending on whether teachers have already participated in workshops or professional conferences dealing with the topic of BBL (MWU = 754, Z = -3,157, p = 0.002). As expected, teachers who have attended a workshop or a professional conference dealing with a BBL-related topic were statistically significantly more likely to apply BBL methods in primary science. Once again, this confirms the necessity of continuous lifelong professional training of teachers in implementing modern teaching strategies.

3.4 The differences and correlation between teachers` knowledge, beliefs and their application of BBL

The Friedman test and subsequent analysis sought to determine whether there is a statistically significant difference between teachers' knowledge and beliefs about BBL and the frequency of its implementation in their teaching practice. The results of the analysis show a statistically significant difference among the listed components (x2 = 98.80; df = 2; p <0.01) (Table 1). Further calculations of the significance of the difference showed that teachers' knowledge was significantly higher concerning their beliefs about BBL and the frequency of its implementation. Also, teachers' beliefs about BBL are statistically significantly more positive concerning the frequency of BBL implementation in primary Science classes. Based on the obtained results, it was confirmed that teachers, despite their knowledge and beliefs about the importance and usefulness of the BBL methods, do not implement such teaching procedures sufficiently.

Table 1. Comparison of teachers' knowledge and beliefs about BBL and the frequency of its application in practice

	M	*SD*	*Friedman test* x^2	*df*	*p*
Knowledge	3,97	0,36	98,80	2	**0,00**
Beliefs	3,64	0,34			
Application frequency	3,35	0,37			

Also, Spearman's correlation coefficient between teachers' knowledge and beliefs about the BBL method of learning and the frequency of its implementation was calculated (Table 2). The results show a statistically significant positive correlation between teacher knowledge and frequency of implementation of the BBL in teaching primary science, which means that teachers with higher levels of knowledge are more likely to apply BBL processes in teaching.

Table 2. Correlation between knowledge, beliefs, and frequency of implementation of BBL

	Knowledge	*Beliefs*	*Application frequency*
Knowledge	/	0,07	**0,45****
Beliefs	/	/	0,13

4 CONCLUSIONS

Brain research has been present in human society for a long time, but the notion of educational neuroscience, or teaching with the brain in mind, has been updated in the last three decades. It is a consequence of scientific and technological innovations in brain research and pedagogical interests for new understandings and adequate teaching explanations. One of the most significant educational neuroscience features is that it confirms the high value of student-centered teaching. Many student-centered teaching strategies developed within reform pedagogies (inquiry-based teaching, project-based learning, cooperative learning) apply the principles of learning emphasized by modern neuroscience. Their main goal is to encourage successful learning and the development of student potential.

The presented research results showed that teachers have a satisfactory level of knowledge about the BBL method, but they only occasionally use it in primary science teaching. Frontal, traditional teaching is still widely used, indicating no complete shift towards student-centered teaching, but there is still a robust, traditionally grounded paradigm in the educational process. Although we have concluded that the teacher's BBL knowledge is satisfactory, we must emphasize that it is slightly above average. Unfortunately, this is not a sufficient level that is essential to change the overall concept of teaching. This study also finds that teachers with the shortest length of service have a highly developed knowledge of BBL's fundamental setting and that the level of teacher education is variable, which affects their positive beliefs about the implementation of new learning strategies. Most teachers say that they would apply different learning strategies if there would be more time in the teaching process.

This study also shows that the teachers with master-level qualifications apply BBL statistically significantly more often, which shows that education is an essential predictor of using BBL strategies in

teaching practice. A positive correlation between teachers' knowledge about BBL and the frequency of its application in primary science classes means that it is necessary to organize professional teacher training and acquire adequate knowledge about this method, increasing the frequency of its application in teaching practice. Wachob [12] points out that teacher participation in seminars correlates with students` progress in learning because implementing new strategies in teaching increases the probability that every student fully develops their potentials.

The discrepancy between teachers' knowledge of the BBL method and the frequency of its application needs to be analyzed more deeply. One of the reasons for that can be found in the lack of time to implement such learning strategies (in the Republic of Croatia, there are only 2 hours per week of Science classes in the first three grades of primary school) and burdening teachers with the need to fully achieve the curriculum learning outcomes, which is why they prefer to apply approved, traditional methods of learning and teaching. This situation requires consideration of possible changes in teaching organization and the number of primary science lessons per week.

Because there are no research studies about the use of BBL in lower grades of primary school in Croatia and a lack of appropriate guidelines for implementing this method in the teaching practice, research findings can help to make some guidelines to improve the existing situation in teaching practice. The conducted research could also serve as an incentive for further studies of the efficiency of BBL methods for the development of competencies of gifted pupils, as well as those which will determine how teacher training programs can affect the development of teachers' competencies which are necessary for the implementation of BBL methods in primary school classes.

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