EFFECT OF BRAIN BASED LEARNING ON PROBLEM SOLVING SKILLS

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Introduction

Today's need is to make educational process effective, child cantered and activity based. So the teachers have to get acquainted with new techniques of teaching and learning process. Teachers' efforts of creating conducive environment help students achieve complex learning goals. Teachers are responsible for creating learning environment in the classroom.

Brain plays a significant role in thinking, memory, emotions and learning. These play significant role in human development and performance. Advancement in these aspects impact human learning and education. Brain research contributes to human learning to a great extent. This helps in keeping abreast with the latest developments in the world of knowledge.

Educationists use these research findings to advance their knowledge of teaching learning. Teaching techniques and strategies are based on theories about how brain learns. These theories are known as Brain Based Learning (BBL). According to Caine and Caine, (1995) and Jensen (2005) these set of strategies is called as Brain Based Learning (BBL) or Brain Compatible Learning (BCL) teaching methods.

Research on BBL has shown encouraging results in the development of cognitive skills. As mathematics develops critical abilities like abstract reasoning, logical thinking and problem solving skills in students, it was decided to study the effectiveness of BBL in achieving these critical skills by using BBL approaches for teaching mathematics. Problem solving skills mainly require logical thinking and abstract reasoning as the fundamental abilities, hence it was decided to study these fundamental abilities. Research was undertaken to study the Effectiveness of Brain Based Learning Approaches of teaching Mathematics in terms of Problem Solving skills with reference to Logical Thinking and Abstract Reasoning.

Objective of the study

To study effectiveness of Brain Based Learning (BBL) approaches of teaching Mathematics in terms of Logical Thinking and Abstract Reasoning.

Hypothesis

1. There is no significant difference between mean scores of Logical Thinking of control group and experimental group.

2. There is no significant difference between mean scores of Abstract Reasoning of control group and experimental group.

Theoretical Perspective

BBL is based upon natural functioning of brain. The theories supporting BBL focus on capabilities of brain. Craig (2003) defines BBL as a set of principles based on research on neuroscience. Melton (2009) defines BBL as an orchestration of real life problems by providing enriched and appropriate learning experiences to decipher the meaning of different concepts. Caine and Caine (1991) are the pioneers of BBL theory. They have proposed twelve principles based on research evidence. These principles are given below.

1. The brain is a parallel processor.
2. Learning engages the whole physiology.
3. The search for meaning is innate.
4. The search for meaning comes through patterning.
5. Emotions are critical to patterning.
6. The brain processes wholes and parts simultaneously.
7. Learning involves both focused attention and peripheral perception.
8. Learning always involves both conscious and unconscious processes.
9. We have spatial memory system and a set of systems for rote learning.
10. We understand and remember best when facts and skills are embedded in natural, spatial memory.
11. Learning is enhanced by challenge and inhibited by threat.
12. Each brain is unique.

The three instructional techniques associated with brain-based learning are as follows.

(i) Orchestrated Immersion - creates a learning environment that fully immerses students in many educational experiences;

(ii) Relaxed Alertness - eliminates fear in the learners while maintaining highly challenging environments; and,

(iii) Active Processing - allows the learner to consolidate and internalize information by actively processing it.

Implementation of Brain Based Teaching Approach

BBL is based upon seven brain compatible instructional principles given by Caine and Caine (1991, 2003; as cited in Sousa 2006 and Jenson 1996).

(i) Activation is the phase where students' prior knowledge which is also known as memory processor system, is stimulated to facilitate learning transfer.

(ii) Clarify the outcomes and paint the big picture is the phase where students visualize their pre-set goals and activate right brain and reduce the anxiety and get ready to achieve the goal.

(iii) Making connection and develop meaning is the stage where existing knowledge is connected with the new knowledge. Thus the students get ready to receive new information.

These three phases of teaching activities are thought to be able to create "relaxed alertness" among students.

(iv) Doing the learning activity is the stage where the students relate to the new stimuli or knowledge and get ready to immerse in the learning experiences appealing to different types of learners in the classroom. Students are encouraged to be in the state of "orchestrated immersion", which immerses them in multisensory experiences.

(v) Demonstrating students' understanding is the stage for brain-active processing. Here the students consolidate and internalize the information.

(vi) Review for students' retention is the activity that requires students to use working memory to summarize the lesson, which helps to strengthen the transfer process.

(vii) Preview the next topic is the experience that helps the brain pre-processor to focus on the new lesson. This is important to prepare the brain for the new learning activities.

The teaching method based on natural functioning of human brain and maximum activation of innate faculties of human brain is called Brain-Based Learning (BBL) method. BBL theory suggests that learners should be provided safe and threat-free environment for learning. Meaningful presentation of content prepares the learners' brains to store, process and retrieve the information in a soothing way.

BBL approach involves learner centered activities for developing understanding of concepts. These activities focus on learner participation to a great extent. These are based on meeting the cognitive, social and emotional needs of learners with different Learning Styles and Multiple Intelligence.

BBL and Logical Thinking

Problem Based Learning develops higher mental abilities require for problem solving. Abilities like critical thinking, abstract reasoning, and logical thinking together develop problem solving skills.Problem solving is generally regarded as the most important cognitive activity in everyday and professional contexts. Instructional-design research and theory has devoted too little attention to the study of problem-solving processes.

As the level of scholastic achievement increases their maturity increases and this also increased their critical thinking, logical thinking and ability to choose right. Hence their academic knowledge increases their excellence and citizenship qualities (Savant - Bhosle, 2005).

There is an effect of personality and scholastic achievement on the Citizenship Qualities of students. The brilliant students have better citizenship behavior than other students. As the level of scholastic achievement increases their maturity increases and this also increased their critical thinking, logical thinking and ability to choose right. Hence their academic knowledge increases their excellence and citizenship qualities (Savant- Bhosle, 2005). It develops the qualities among the students' of group learning which are more effective than traditional methods of teaching. It also develops the performance ability among the students (Sharma and Sharma, 2009). If students are provided self-learning material, it develops the performance ability to students. (Rosamma, 2013). It can be effective than traditional method of teaching.

BBL and Abstract Reasoning

Abstract thinking is indispensable ability that an individual must possess. Abstract reasoning is a higher mental activity where individual is required to analyze information, identify patterns and relationships, and solve complex problems. This ability helps us to use analogies and relate verbal and non-verbal ideas and their interrelationships. It is an ability to think about objects, principles, and ideas that are not concretely or materially present. It is one of the important dimensions of construct of intelligence. It is akin to symbolic thinking, where object or idea is substituted by a symbol. Mathematics education develops different kinds of reasoning including abstract reasoning. Verbal and non-verbal tests measure the level of abstract reasoning that a person possesses.

There is very little published evidence to conclude the effect BBL might have on the development of abstract reasoning.

Research Gap

Research in BBL has been initiated from 1991. In the last 25 years lot of work has been reported abroad. In India sporadic studies have been published in relation to ------

The studies have been reported in individual strategies in the BBL approaches like cooperative learning and Problem based learning. The other strategies which come under BBL approaches have not been studied.

The published studies with higher mental abilities like abstract reasoning, logical reasoning, and problem solving skill were not available. Studies were found on motivation as a variable; however, interest has not been studied as a dependent variable. Researchers have explored the subjects like languages and science. However, social sciences and mathematics still remain to

be studied. Indian studies are limited to university level students, thus keeping primary and secondary students out of the purview of their research. However, hardly any researcher has used primary schools students as sample in the study.

Definitions of the terms used

Conventional method- It is teaching through lecture, question answer method without considering the diversities in learning styles.

BBL approaches- It is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process. (Jensen, 2008)

Logical Thinking- 'The ability of logical thinking is that which proceeds on the basis of careful evaluation of premises and evidence and comes to conclusions as objectively as possible, through the consideration of all pertinent factors, the use of valid procedures from logic' (Good 1973). Logical thinking is cognitive thinking based on accurate knowledge and information. It is commonly referred to as left-brain thinking. Logical thinking uses the straight facts in order to solve problems. It is the foundation for verbalization skills which helps in acquiring language and analytical thinking.

Abstract Reasoning-Abstract Reasoning is characterized by the ability to use concepts and to make and understand generalizations, such as of the properties or pattern shared by a variety of specific items or events. It is a higher level of thinking which involves analysis of information, identification of patterns and solving problems at complex and intangible level.

Research Design

As the aim of the study was to examine cause and effect relationship between independent and dependent variables, it was decided to adopt Two Group Pretest-Posttest Randomized Experimental Design as it effectively controls all the factors affecting the internal validity of the experiment and various effects that influence dependent variable.

To measure logical thinking of the subjects for this research the test of Logical Thinking developed and standardized by Bertha Marcus (1989) was used. This test contains 16 questions in the form of two statements and three inferences drawn on them. The respondent is expected to choose the best inference drawn by him. The range of scores was between 0 and 16.

To measure abstract reasoning of the subjects for this research the test of Abstract Reasoning developed and standardized by Deferential Aptitude Test Battery (1995) was used. The total score obtained by the student was treated as the performance on Abstract Reasoning.

Treatment was given to students of seventh standard in two different schools, which were equated on different variables. Both the experimental and control groups had 35 students each.

Precaution was taken to control all variables other than the treatment variable to increase internal validity of the experiment.

Data Analysis and Interpretation

Both the groups were found to be equivalent on the dependent variable at the pre test level. The null hypotheses were tested using t test at the 0.05 level of significance.

Dependent Variables	Groups	Pre Test Mean	S. D.	N	df	Diff bet Means	t Obs	t Table	Sig 0.05
Logical Thinking	Expt	4.114	1.997	35	68	0.829	1.625	1.995	Not Significant
	Cont	4.943	2.261	35					
Abstract Reasoning	Expt	6.600	4.401	35	68	1.229	1.103	1.995	Not Significant
	Cont	7.829	4.908	35					

Table 1: Equivalence of Groups on Dependent Variable

Hypotheses Testing

Hypothesis 1 --- Logical Thinking

The data to test the above mentioned hypotheses is given in Tables 2 a and c

Table 2 a: Effectiveness of Experimental treatment in terms of Logical Thinking

Test	Mean	S.D.	N	df	M1- M2	Paired t cal	t table	Sig 0.05
Post	11.714	1.637	35	34	7.600	16.701	2.032	Significant
Pre	4.114	1.997	35					

Table 2 b: Effectiveness of Control treatment in terms of Logical Thinking

Test	Mean	S.D.	N	df	M1- M2	Paired t cal	t table	Sig 0.05
Post	7.371	2.402	35	34	2.428	6.101	2.032	Significant
Pre	4.943	2.261	35					

Table 2 c: Effectiveness of BBL in terms of Gain in Logical Thinking

Groups	Mean	S.D.	N	df	M1-M2	t cal	t table	Sig 0.05
Expt	7.600	2.692	35	68	5.171	8.554	1.995	Significant

Control	2.429	2.355	35					

Interpretation

The t test results of the gain in Logical Thinking show that there is a significant difference in the scores of both the groups. The observed t value is higher than the table t value. Hence the null hypothesis is rejected. Gain in the experimental group is significantly higher than that in the control group. It is therefore, concluded that BBL treatment is more effective in developing Logical Thinking in students.

Hypothesis 2 --- Abstract Reasoning

The data to test the above mentioned hypotheses is given in Tables 3 a and c

Table 3 a: Effectiveness of Experimental treatment in terms of Abstract Reasoning

Test	**Mean**	**S.D.**	**N**	**df**	**M1-M2**	**Paired t cal**	**t table**	**Sig 0.05**
Post	23.914	7.139	35	34	17.314	15.272	2.032	Significant
Pre	6.600	4.401	35					

Table 3 b : Effectiveness of Control treatment in terms of Abstract Reasoning

Test	**Mean**	**S.D.**	**N**	**df**	**M1- M2**	**Paired t cal**	**t table**	**Sig 0.05**
Post	12.342	5.185	35	34	5.513	5.283	1.995	Significant
Pre	7.829	4.908	35					

Table 3 c: Effectiveness of BBL in terms of Gain in Abstract Reasoning

Groups	**Mean**	**S.D.**	**N**	**df**	**M1-M2**	**t cal**	**t table**	**Sig 0.05**
Expt	17.314	6.707	35	68	13.800	9.016	1.995	Significant
Control	4.514	5.055	35					

Interpretation

The t test results of the gain in Abstract Reasoning show that there is a significant difference in the scores of both the groups. The observed t value is higher than the table t value. Hence the null hypothesis is rejected. Gain in the experimental group is significantly higher than that in

the control group. It is therefore, concluded that BBL treatment is more effective in developing Abstract Reasoning in students.

Major Conclusions

The major conclusions drawn from the findings of the study are presented below.

1. The mean scores of the pre and post-test of the control group on Logical Thinking, and Abstract Reasoning were compared. It was observed that the post test scores were significantly greater than those of pre test scores on the respective variables. Hence it is concluded that 'The Conventional teaching approach is effective in enhancing Logical Thinking and Abstract Reasoning in students'.

   The teacher in the control group used the conventional approach for teaching Mathematics. She used deductive approach which stresses using the maxim of from general to particular. The teachers generally teach using this method and students are used to learning by this method. This method saves time which could have been used for more revision. Moreover the teacher used charts which are normally used in day to day teaching of Mathematics. This helped fixing the concepts in Mathematics and further develop Logical Thinking and Abstract Reasoning.

2. The mean scores of the pre and post-test of the experimental group on Logical Thinking, and Abstract Reasoning were compared. It was observed that the post test scores were significantly greater than those of pre test scores on the respective variables. Hence it is concluded that, 'The BBL approach is effective in enhancing Logical Thinking and Abstract Reasoning in students'.

   BBL approach uses variety of techniques for teaching ensuring conducive learning environment in the classroom. It makes learning enjoyable and hence understanding of concepts and retention of learning is longer. It uses techniques based on the psychological development of the students. Though inductive approach requires more time to learn, it helps learning permanently. The environment is kept lively by maintaining flexible classroom structure which is enjoyed by the students. This aids in gaining knowledge by active learning.

   The BBL method improves academic achievement of all types of learners. The orchestrated immersion, relaxed alertness and active processing had developed understanding of different abstract concepts in mathematics among learners of each level of achievement.

3. The mean gain scores of the experimental and the control groups on Logical Thinking and Abstract Reasoning were compared with those of the control group on the these

variables. It was observed that the gain scores of the experimental group were significantly greater than those of the control group on all the variables. Hence it is concluded that, 'The BBL approach is more effective than the conventional teaching approach in enhancing Logical Thinking and Abstract Reasoning in students'.

Many BBL activities were provided such as group discussion, freedom of movement and expression, presentation, motivation for learning, writing answers in own words, positive response of teacher, stress free and challenging learning environment which might have helped the students in participating learning processes and master the content which enhanced mathematical understanding. The experimental group showed significant gain as the learners worked in threat-free, challenging, friendly; and psychologically and physically safe environment which form the part and parcel of BBL. The learners acquired knowledge by involving higher mental abilities of brain. The twelve principles of BBL and three techniques were the foundation of all the classroom interactions. This helped the teacher in presenting the content meaningfully. The students could explore various concepts by working in small groups and analyzing different realistic problems. This was feasible due to identification of patterns. Challenging assignments, riddles, problems helped learners in developing and utilizing higher faculties of brain. Displaying the assigned tasks in the classroom, availing full liberty of discussion with peers or teacher remained effective in inhibiting rote memorization of ideas. The strategies based on all the twelve principles of BBL and three techniques as part of BBL, helped students take active interest in classroom activities and thereby learn the abstract Mathematics.

Variety of tasks improves the performance of the students significantly for learning any content. The aspects of familiarity and novelty satisfy the need of meaning search for the learning brains, the step-wise instruction can be effectively used as a tool of meaningful understanding of a complex idea improved the students' performance in creation of parts and whole and the better performance in uniqueness may be attributed to the typical learning activities like self-work habit, self-reliance, interacting with unseen mathematical problems and being unconscious of answers given in the textbook.

The effectiveness of BBL teaching method maybe attributed to the learners' involvement of natural tendencies of their brains during classroom teaching learning sessions into the process of storing, processing and retrieving of information in accordance with the biological functioning of the brain. The students created deep understanding of different mathematical concepts by following natural mechanism of information handling by the brain.

On the whole, it may be concluded that BBL approach is more effective than the conventional approach in developing cognitive skills of Logical Thinking and Abstract Reasoning.

Recommendations

Education needs to facilitate optimal brain functioning. Scientific research on neuroscience and how brain learns keeps on enriching the literature, which in turn contributes to the body of knowledge related to teaching and learning.

It is concluded from the present research that classroom environment, if kept stress free and threat free, generates learning maximally. Meaningful presentation and concept based teaching help develop students' thinking. Hence the teachers should maintain threat free atmosphere in the classroom, ensure that teaching is concept based and made more interesting as well as challenging for the learners. This will help us understand about knowledge construction and utilization by the brain. The teachers in primary schools can take advantage of implementing the BBL approach in their teaching to bring about acquisition, application and retention of learnt concepts.

Realistic and day to day life problems should be provided to the learners and allow them to identify the patterns in a coherent manner. Thus experiential learning is the soul of teaching using BBL principles and techniques. Individuals learn through experiences. Hence text books of Mathematics should be written in the manner that helps learner developing patterns.

Significance of the study

Mathematics demands comparatively a lot of mental discipline and intellectual skills for understanding and application of its abstract concepts. The learners may construct different mathematical concepts deeply, if teachers organize activities based on BBL principles for them. BBL teaching method encourages learners to act and react in accordance with the natural functioning of their brains. The students will develop higher mental abilities as well as interest in learning Mathematics if the teaching of Mathematics is done using BBL approaches.

The study may help teachers of mathematics to organize such instructional strategies which may activate the in-built faculties of brain. The teachers will be able to present meaningful content, assure students of having say in the classroom, generate enriched classroom environment etc in light of the study. They may avail the findings of the study to enhance the levels of achievement of the learners.

Thus BBL approach, if employed in the classroom, will certainly develop cognitive skills in the students and develop interest in an abstract subject, which is generally disliked by the students.

Conclusion

This research has important implications for learning, especially regarding how we acquire new knowledge, store it in memory and retrieve when needed. When learning new things, memory and recall are strengthened by frequency and recency. The more we practice and rehearse something new and the more recently we have practiced, the easier it is for brain to transmit these experiences efficiently and store them for ready access later. This process is called fluency. Such a paradigm shift of teaching methodology enhances the academic achievement of the learners significantly in mathematics. Unless the content is presented in consistence with the physiology of human brain; the receiving, processing and retrieval of the input data occurs at a poor rate, and vice versa.

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