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Impact of Brain-based Teaching Practices on Students Learning Achievements in Mathematics at Secondary Level

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Abstract: *The purpose of this research project was to determine how brain-based instruction techniques affect secondary students' academic outcomes in mathematics. The sample for the research project comprised 90 students studying mathematics in grade 9. The researcher and math specialists created the tool to determine the effect of brain-based teaching on pupil educational accomplishments. To analyze the data and determine the mean disparity in the academic results of students with excellent, average, or poor performance, Post Hoc Test was used. The intent of the preliminary test was to assign students to trial and control categories based on how well they performed on the examination. Pupils in the experimental group were taught using a brain-based teaching approach while students belonging to the control group were taught using a conventional teaching method. Results of the study demonstrate that students belonging to the experimental group showed far better performance in the post-test compared to students taught through the traditional teaching method.*

Key Words: Working Memory, Learning Achievements, Mathematics

Introduction

Educational organizations are useless without learners. In any educational environment, the pupils are the most valuable resource. The development of a nation's culture and economy is intimately related to a learner's academic achievement. How to effectively give instruction to support a good learning process is one of the key concerns in education (Bolliger & Martindale, 2004). According to research, teaching methods and practises have a big impact on pupils and can either enhance or detract from their ability to learn (Grey, Gryphon, & Nasta, 2005). Ekwensi, Moranski, and Townsend-Sweet (2006) state that a successful teaching approach or method considers the learners' phases of development, the teacher's objectives, the students' objectives, the content that needs to be taught, and the time allotted for instruction. Integrating or utilising multiple methods of instruction might help students understand more while also increasing their retention of what they have learned.

According to Ali et al. (2017), an efficient method of instruction is one that meets the needs of the student throughout the course of instruction.

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According to the Encyclopaedia of Educational Research (1969), teaching methods are the techniques used by teachers to impart knowledge to their students. There are various methods that people can learn. Teaching strategies were cited by Broudy and Palmer (1965) as a way to develop students' speaking abilities and success. As a teacher who understood the value of effective tactics, Socrates used them to inspire his students to meet their goals. Successful teachers constantly work to improve the efficiency and significance of the process of instruction and learning. Making students into knowledge creators rather than merely knowledge recipients is something reputable teachers consistently stress. Developing problem-solving abilities is a major goal of math education. The majority of secondary school students view mathematics as a challenging subject. Along with teaching, a teacher also has the duty to make sure that students are learning. The impact of several causes on learners' productivity is described. The teaching methodology was identified by Farooq & Shah (2008) as the critical element that has a substantial impact on student's academic achievement. Ayeni (2011) asserts that the use of instructional methods can result in the desired changes in learner behaviour. The achievement of educational objectives is aided by using the right teaching methodology (Nafees, Farooq, Tairkheli, & Akhtar, 2012). Deployment of inadequate instructional techniques is cited as the cause of the majority of students' poor performance in a topic. Most pupils consistently perform poorly, which is linked to the use of inefficient instructional techniques (Adunola, 2011). According to the findings of a research study by Ganyaupfu (2013), knowledge transfer calls for the use of instructional strategies that are suitable for the goals at hand. Effective teaching strategies, according to Baradwaj and Pal (2011), attend to the requirements of the students. According to Asha (2017), the achievement of learning objectives depends on the instructional technique being tailored to the needs and preferences of the learners. Ekwensi et al. (2006) contend that utilising only one instructional strategy or approach will not be sufficient to meet all of the learning preferences or objectives of the students.

According to Muhammad (2012), mathematics is a potent instrument that enables pupils to effectively exchange information. Mathematics is a topic that is almost universally needed and plays a significant part in the curriculum. Al-Enezi (2008) described that Math is introduced to all pupils in formal education in grade 9. Klinek (2009) asserts that mastering mathematical concepts involves effort. The majority of Pakistani students view mathematics as a boring and challenging subject (Ali, Ghazi, Shahzad, & Khan, 2010).

Imran (2008) described that in Pakistan, the quality of mathematics instruction is subpar across all stages. The Punjab Education Assessment System (PEAS) outcome data (PEAS, 2011) demonstrates that learners' mathematical proficiency falls short of the necessary levels. According to NFP (1998), antiquated teaching and learning ideas are to blame for Pakistan's dismal educational standards. Applying approaches to instruction that are based on research can enhance the current poor standard of education. The need for changing teaching methods was emphasised by the National Education Commission in 1959. Old teaching practices should be replaced with more contemporary, research-based ones, according to the Education Policy (1972–1980). The NEP (2009) argues for improving the viability of the educational system globally.

The efficiency of the educational process affects how well students learn. Effective instruction is essential to the success of the learning process. According to Nafees (2011), a learning method is a practice that makes it easier for people to communicate the desired knowledge and achieve predetermined goals. The choice of a teaching strategy affects the achievement of learning objectives. According to Mizrachi (2010), the teacher's choice of instructional method determines whether or not the goals of the lesson are met. As a result, it is the teacher's obligation to organize

the material effectively and select the most effective teaching strategy for delivering the material. Teachers must update their knowledge of best practices for teaching in order to meet the demands of today's dynamic society and provide learners with cutting-edge skills.

Math education is a difficult endeavour. In order to guarantee that the educational targets that have been defined are met, providing mathematics instruction requires a comprehensive instructional plan. The instructor is in charge of delivering the content information using the right instructional style. The knowledge that teachers impart to their students must support the growth of their critical thinking, reasoning, and problem-solving skills. In order to make a decision in today's dynamic societies, learners must be able to objectively analyze and evaluate the given circumstances. As a result, educators must rethink their approach to information delivery in order to address the issues of today's society and equip students with the knowledge and abilities necessary to be productive members of society. When the right technique for instruction is used for imparting the intended topic, learning happens effectively. According to Nafees (2011), instructors are effective in employing research-based teaching methodologies to impart information to students. Math is taught using a variety of instructional techniques. It is impossible to say that a specific method of education is appropriate for teaching all subjects to all pupils. No single method can be considered suitable to address the needs of all learners because each method has certain benefits and drawbacks (Martin, Herrera, Kanold, Koss, Ryan, & Speer, 2007). The optimum teaching strategy for achieving the predetermined goals must be determined by the math teacher.

The purpose of education in the twenty-first century is to generate people who can evaluate and analyse a situation objectively and take the appropriate actions to address difficulties. Mathematical proficiency among kids demonstrates that their performance is below minimum expectations. Making ensuring that pupils are learning is part of a teacher's job along with actually teaching. Different factors affect how well pupils are doing in school. Due to obsolete teaching and learning methodologies, Pakistan's low educational standards (NFP, 1998) are to blame. Research-based teaching strategies can be used to improve the dismal quality of education today. The National Education

Commission (1959) emphasised the need for radical shifts in instructional strategies. The Education Policy (1972–1988) calls for a shift away from antiquated teaching strategies and towards modern, research-based approaches. It was recommended in NEP (2009) that measures be taken to make the educational system viable on a global scale.

The primary variable that significantly affects students' learning outcomes, according to Farooq & Shah (2008), is the teaching approach. Ayeni (2011) asserts that we can influence students' behaviour in the desired ways with the aid of educational techniques. According to Nafees, Farooq, Tairkheli, and Akhtar (2012), using the right teaching methodology aids in meeting learning objectives.

Brain-based Learning

The ideas of brain-based learning (BBL), which in turn are based on advancements in the discipline of neuroscience, are the foundation of brain-based teaching (BBT). Neuroscientists may now study how the brain learns thanks to modern technology. According to Saleh and Subramaniam's (2018) research, brain-based instruction has a more positive overall impact on students' learning than traditional instruction. The results of the investigation carried out by Saleh (2012) demonstrate a strong positive impact of the under-consideration teaching approach on students' learning outcomes in physics.

This approach is more efficient than conventional teaching techniques (Duman 2010). Varghese & Pandya's (2016) investigation has shown that brain-based

instruction reduces stress and engages the greatest number of senses, which leads to the greatest amount of understanding. According to Priatna (2017), pupils that receive BBT instruction do better than those who receive traditional instruction. Learner-centred techniques include brain-based instruction. Students do better because they take an active role in their educational journey while the teacher only provides support (Thomas & Swamy, 2014). Social issues, and mental, and psychological variables all have an impact on the way the brain functions, as demonstrated by brain-based learning. According to Caine, R. & Caine, G. (1991) & Jensen, 1996), brain-based teaching improves learning since it is created with consideration for the brain's natural functioning. Research investigations by (Caine, R. & Caine, G., 1999; Greenleaf, 2005) demonstrate that Brain-based instruction is focused on students' learning skills where teachers address the unique learning styles of each student. According to Caine & Caine (1991,1999), instruction becomes meaningful and effective when it is carried out in accordance with the principles of brain processing. An investigative study by Greenleaf (2005) indicated that Brain-based learning takes into account how the brain organizes and interprets data. Students who participate enthusiastically in teaching as a consequence of brain-based instruction are more likely to retain the information they have learned (Awolola, 2011). The identification of learners' unrealized potential is one of the fundamental objectives of education, according to Duruji et al. (2014). Unlocking pupils' potential is a goal of good educational planning. Teaching is a continuous process designed to affect the necessary changes in students' behaviour, according to Ayeni (2011). In the words of Ganyaupfu (2013), instruction is a collaborative activity in which the teacher and the learner are equally involved. Teaching promotes an attitude of interest regarding the environment and enhances the skills required to sustain a sense of the question, claim Duruji et al. (2014).

Methodology

The purpose of this study was to conduct an experiment to assess how Brain-based Teaching affects the learning outcomes of secondary school students in mathematics. The study focused on all public secondary schools in the district Kohat, and one school was selected using purposeful sampling. The sample for the study consisted of 90 male secondary school students who were studying mathematics.

Experts in the field of mathematics collaborated on the development of a test to measure students' growth between two points in time. The participants in the study were categorised into two groups: the experimental and the control. Each group consisted of 45 students. Each of the two groups was then subdivided into High Achievers (HAs), Average Achievers (AAs), and Low Achievers (LAs) based on their performance on the pretest.

Table 1

Selection of the Students as a Sample of the Study

Experimental group			Control group				Total
HAs	AAs	LAs	HAs	AAs	C16-C30	LAs	90
E1-E15	E16-E30	E31-E45	C1-C15			C31-C45	

Research tool: Five human cognitive abilities served as the foundation for developing a test of academic achievement. The research instrument's initial iteration contained 20 items. The developed test items were based on the intrinsic cognitive activities given below.

1. Perception through parts and wholes
2. Meaning seeking is inbuilt.
3. Creating patterns in perception using pieces and wholes
4. Concurrent processing

5. Each brain is distinct.

Items were sorted into three categories—difficult, moderate, and easy—after being matched with the appropriate tables of specification, pilot testing, and expert opinion. Things that were either too challenging or too simple were taken out. Only items of moderate difficulty were kept for the research tool's final iteration. The research tool's final version had 10 moderately tough items. Care was taken to ensure that the components of the study tool relate to each of the five basic brain functions stated above. This instrument served as both a pre-and post-testing tool. The purpose of the pretest was to learn more about the student's prior knowledge and skills. Pretesting also aided in distributing pupils equally between the experimental and control groups.

At the end of the study, both groups took a post-test using the same instrument, but with the objects switched around. The post-test was designed to ascertain whether or not there had been a significant shift in conduct or the influence of external factors on the dependent variable. Mathematical learning results were assessed by subtracting pre-test scores from post-test scores to evaluate the impact of the instructional method.

Table 2

Shows the Findings from Post hoc Tests using Tukey HSD to Compare the Mean Variations between the Three Categories of Achievement

(I)group	group	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Lower Bound
HAs	AAs		4.6667*	1.24548	.001	1.6950	7.6383
		LAs	11.4667*	1.24548	.000	8.4950	14.4383
AAs	HaS		-4.6667*	1.24548	.001	-7.6383	-1.6950
		LAs	6.8000*	1.24548	.000	3.8283	9.7717

Based on observed means.

**. The mean difference is significant at the .05 level.*

Differences in mean educational attainment between HAs, AAs, and LAs, as well as any two groups of students, are displayed in Table 2. Academically, HAs were found to have fared significantly better than AAs (p.05, SEM=1.24548). The results also reveal that HAs excel in the classroom more than LAs.

The table shows that there was a significant mean difference between HA and LA achievement levels (11.467). The average difference between AAs and LAs was found to be 6.8, while the difference between HAs and AAs was 4.667, a smaller value.

The p-values for the following comparisons may be found in Table No. 2

P value for HAs versus AAs = 4.667

Comparison of HAs and LAs; p = 11.46

The p-value for AAs against LAs is 6.8

The results in this table show a clear disparity between the educational accomplishments of high achievers and those of average and poor performers. The gap between the educational accomplishments of average and poor performers was also determined to be statistically significant.

Table 3

Result of an Analysis of Variance (ANOVA) demonstrating the effect of the Technique on the Educational Outcomes of Students in the Control and Experimental Groups

Source	Type III Sum of Squares	df	Mean	F	Sig.
Corrected Model	5473.022[a]	5	1094.604	47.043	.000
Intercept	168134.444	1	168134.444	7225.916	.000
Method	3216.044	1	3216.044	138.216	.000
group	1995.022	2	997.511	42.870	.000
Method group	261.956	2	130.978	5.629	.005
Error	1954.533	84	23.268		
Total	175562.000	90			
Corrected Total	7427.556	89			

a) R Squared = .737 (Adjusted R Squared .721) Main outcomes of the table are:

1. The model as a whole is important, F (5, 84) = 47.043, p<.05.
2. There is substantial variation between the academic outcomes of both categories. such as the control and experimental groups, F (2, 84) =138.216, p<.05.
3. The chart clearly shows that the approach has a substantial influence on trainees' academic accomplishments, F (1, 84), p<.05.
4. The impact of the contact is equally substantial., F (2, 84) = 5.629, p<.05

Conclusions

1. Because steps were taken to engage various cognitive abilities like parallel processing, innate pursuit for reality, and mindfulness through the simultaneous formation of parts, the accomplishment of the Experimental and Control groups reveal that BBT is far more successful than typical approaches for providing mathematics instruction at the secondary level.
2. The top performers in the experimental group outperformed those who performed well in the control group by a large margin. The student's involvement with pertinent information, peer instruction, group debates, the rapid emergence of structures, resolving problems, etc., contributed to this advantage.
3. Students who often struggled to learn outperformed when taught using the BBL teaching style compared to those who were instructed using the conventional approach. This difference in performance was attributed to a variety of variables, including working in small groups, individualized assignments that accounted for the differences in each student's brain, exploring concepts through real-world contexts, engaging in physical activities, and making connections between the subject and prior knowledge.
4. BBT pupils had greater mathematical problem-solving skills, and higher levels of self-assurance, towards learning mathematics than children who received instruction using the traditional teaching methodology. Considering this, it can be said that BBT greatly changed students' perspectives on learning mathematics.

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