OmniaScience

Journal of Technology and Science Education
JOTSE, 2023 – 13(1): 276-287 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349
https://doi.org/10.3926/jotse.1629

EFFECT OF BRAIN-BASED TEACHING METHOD ON SECONDARY SCHOOL PHYSICS STUDENTS' RETENTION AND SELF-EFFICACY

Abiodun Bada, Loyiso Jita

Faculty of Education, School of Mathematics Natural Science and Technology Education, University of the Free State (RSA) (South Africa)

Bada.AA@ufs.ac.za, JitaLC@ufs.ac.za

Received February 2022
Accepted November 2022

Abstract

Inequality in education is a challenge that have persisted and still likely to persist for a long time in the field of education because students come into the classroom with different characteristics thus posing a great concern to the realization of classroom objectives. The use of adequate teaching strategy might break this limitation thereby making every student to engage in meaning learning. The two objectives of this study include i) to investigate the effect of brain-based teaching (BBT) method on students' retention on the topic, heat energy (ii) to investigate if self-efficacy influence physics students' retention on the topic, heat energy, when taught using brain-based teaching method. We adopt the design, pre-test post-test control group quasi experimental design for the investigation. The participants were 99 (experimental group, n= 46; control group, n=53) students and were selected from two schools in Ondo using random sampling technique. A researcher designed data collection tool titled heat energy test (HET) was used to collect data in this study. HET's validity was achieved by giving the draft to three science education experts and two secondary school physics teachers for validation. Both descriptive and inferential statistics (Mean, t-test. ANCOVA) were used for analysis. Brain-based teaching method significantly improved the retention of students in physics (heat energy) and also, self-efficacy did not influence physics students' retention in physics (heat energy). In conclusion, brain-based teaching method enhanced the retention of physics (heat energy) thus breaking the limitation posed by differences in the characteristics of the students.

Keywords – Brain-based teaching method, Heat energy, Inequality in education, Retention, Self-efficacy.

To cite this article:

Bada, A., & Jita, L. (2023). Effect of brain-based teaching method on secondary school physics students' retention and self-efficacy. *Journal of Technology and Science Education,* 13(1), 276-287. https://doi.org/10.3926/jotse.1629

---

1. Introduction

One major challenge that has persisted in the field of education is the continuous search for the best teaching method that can be used for instruction in schools. This situation is as a result of the demerits that comes with the already identify teaching methods, which makes none of this method perfect for instruction in secondary schools. This situation is also not different in the field of natural science world over, because the array of the different teaching methods used for instruction in secondary school physics,

have either revealed little or no significance difference over the conventional lecture method (Aderounmu & Obafemi, 2015; Anyafulude, 2014; Bigozzi, Tarchi, Fiorentini, Falsini & Stefanelli, 2018; Hursen & Asiksoy, 2015; Njoroge, Changeiywo & Ndirangu, 2014; Olaniyan, Omosewo & Nwankwo, 2015; Suleman, Hussain, Din & Igbal, 2017; Ugwuanyi, Nduji, Elejere & Omeke, 2020: Uwizeyimana, Yadav, Musengimana & Uwamahoro, 2018). Physics, an integral aspect of the natural science and technology curriculum play an active role in contributing to the meaningful learning of science in the secondary schools. The use of adequate teaching method is therefore crucial to the realization of classroom objectives because meaningful learning is said to take place when there is a relative lifelong change in the attitudes of the learners. Varghese and Pandya (2016) opine that the teaching method and resources used by teachers contribute significantly to meaningful learning in the classroom. This implies that the type of teaching method(s) used for instruction in the classroom can make or mar the achievement of classroom objectives and the realization of the goals of teaching. The use of inadequate teaching method(s) can therefore pose a great threat to effective teaching and meaningful learning. Secondary school students come into the classroom with different characteristics hence, the inability for a teaching method to effectively accommodate all the differences in the learners. One major method that is novel and also has the capacity to alleviate this challenge in the field of education is to employ brain-based teaching method. This instructional method perhaps, can be useful in reducing the inequality currently experienced in the field of education as a result of the different characteristics brought to the classroom by the students.

Brain-based teaching (BBT) method is an approach that stems out from brain-based theory. The theory relies on the findings from the field of neuroscience to provide instruction that complies with teaching in the 21st century. Findings from brain-based theory indicate that it is an approach that can be used to overcome the shortcomings associated with the other teaching methods (Caine & Caine, 2001; Jensen, 2008). Also, it is a method to instruction that emphasize the student-centred approach, thus, changing the role of the teacher to that of a facilitator. This method tends to make the students more active during the teaching-learning process by increasing students' engagement in the classroom. Kahveci and Ay (2008) opine that BBT method is closely related to constructivism because it shares common principles with the constructivism theory. Prominent among this principles include 'meaningful learning, individual differences in learning, multiple representations in learning, personal and environmental factors in learning and effective components in learning' (Kahveci & Ay, 2008: page 126).

BBT leverages on how the brain is designed to learn. Caine and Caine (1994) views the brain as a biological organ whose major job is to learn. The goal of every teaching-learning process is for students to have a relative permanent change in behaviour hence, the use of a method that considers how the brain learns might provide the necessary succour posed by the different characteristics in the learners. BBT method relies on the principles of brain-based theory for its integration in the classroom. Varghese and Pandya (2016) define brain-based learning "as a comprehensive approach to instruction using current research from neuroscience to determine how human actually learns" (p. 104). Neuroscience is the "scientific study of the brain which deals with the structure and functions of the brain" (Arun & Singaravelu, 2018: page 766). Sani, Rochintaniawati and Winarno (2019a) views brain-based learning as a student focussed and instructor encouraged methodology that uses students' intellectual gifts and underscore important learning. Jensen (2008) define brain-based learning as "a way of thinking about the learning process which provides a set of principles and a base for knowledge and skills upon which better decisions about the learning process" (page 22) can be made. Dunman (2010) opine that BBT was not originally meant to be a teaching method, but its principles can be conveniently used to alleviate the demerits prevalent in the other teaching methods. The integration of brain-based learning is majorly done using three techniques which include relaxed alertness, orchestrated immersion, and active processing (Caine & Caine, 1997; Jensen, 2008; Sousa, 2011). Relaxed alertness involves eliminating fear and threat from the classroom environment thus, promoting the internalisation of information optimally (Saleh & Subramanlam, 2019). Orchestrated immersion has to do with providing a learning environment rich in activities that encourage meaningful learning (Varghese & Pandya, 2016). Active processing deals with examining phenomenon from different perspectives with the aim of promoting meaningful learning (Varghese & Pandya, 2016). For this study, we adopt relaxed alertness

as the intervention to investigate the effects of BBT method on the retention of students in heat energy. For relaxed alertness, each lesson is divided into three phases (Prime time 1, down time, prime time 2). During prime time 1, instructions on heat energy were introduced to the students. Students are allowed to relax, and their activities are not controlled during the second phase (down time). This is to allow the brain cool off and reset for the next phase of instructions (Jensen, 2008). The last phase (prime time 2) allows the teacher to make conclusion on the instruction. Sousa (2011) posited that students remember best instructions learnt during the first phase (prime time 1), followed by instructions that comes during the last phase (prime time 2), while students remember least instruction during down time. Self-efficacy as used in this investigation refers to physics students' conviction to accomplish and surpass predictions in physics task (heat energy). This present study therefore investigated the effect of BBT method on students' retention and the influence of self-efficacy on physics students' retention when taught using brain-based teaching method.

2. Literature Review

Several constructs have been used in the literature to integrate BBT method in the classroom even though all of these constructs emerge from the brain-based theory. This implies that these constructs relies on brain-based theory principles for their integration in the classroom. Some of these construct include brain-based learning (Al-Tarawneh et al., 2021; Alanazi, 2020; Al-Balushi & Al-Balushi, 2018; Riskiningtyas & Wangid, 2019; Sani et al., 2019; Wijayanti, Khasanah, Rizkiana, Mashuri, Dewi & Budhiati, 2021), brain-based learning approach (Akyürek & Afacan, 2013) brain-based teaching (BBT) (Saleh, 2012a; Saleh, 2012b), brain-based teaching approach (Saleh, 2012c) and brain-based teaching methods (Saleh & Subramaniam, 2019).

A number of researchers have conducted investigations on the effect of BBT strategy on science students' achievement in secondary schools. While many of these studies have focussed on secondary school mathematics (Al-Tarawneh, Altarawneh & Karaki, 2021; Kartikaningtyas, Kusmayadi & Riyadi, 2018; Mastoni, Sumantri & Ibrahim, 2019; Mekarina & Ningsih, 2017; Noureen, Awan & Fatima, 2017; Priatna, 2017; Riskiningtyas & Wangid, 2019; Triana, Zubainur & Bahrun, 2019), others have focussed on finding the effect of BBT strategy on biology and chemistry secondary school students' achievement (Alanazi, 2020; Shabatat & Al-Tarawneh, 2016; Akyurek & Afacan, 2013; Varghese & Pandya, 2016).

In the area of secondary school physics, previous studies (Saleh, 2012a,b,c; Saleh & Subramaniam, 2019; Sani et al., 2019a,b) showed that students' achievement was positive when taught the different contents areas in physics. Saleh (2012a) used BBT as an approach to deal with the challenges that comes with the differences that exist among secondary school form four student's learning manner in Newtonian physics conceptual understanding and found out that the method was efficient with respect to the identified challenges. Saleh (2012b) also investigated the effectiveness of using this same approach in dealing with the challenges of understanding Newtonian physics and its motivation towards learning physics among form four students. The researcher found out that the use of the approach (brain-based teaching) was effective in handling the already identified challenges.

Another investigation completed by Saleh (2012c) showed that students motivation increased positively when taught using BBT method especially in coping with students conceptual understanding in relation to their counterparts taught using the lecture method. Jack, Danjuma and Gbademosi (2018) in Nigeria inquiry into the effectiveness BBT strategy was explored on colleges of education physics student's and the researchers found out that BBT method improved students' achievement in current electricity when compared to their peers taught using the normal method.

Saleh and Subramaniam (2019) in their study in Malaysia discovered that BBT method improved the achievement of form two physics students when compared to the group of students taught using the conventional teaching method. Sani et al. (2019a) investigation revealed that brain-based learning have more impact on secondary school students' motivation in learning physics. The researchers conclude that the use of brain-based learning improved students' motivation to learning electric circuit. This implies that brain-based leaning method is not only effective in improving secondary school students' achievement in physics, but it can also be used to improve students' motivation to learning physics.

Sani et al. (2019b) investigated the effect of brain-based learning on secondary school students' mastery of electric circuits and found out that brain-based learning improved students' mastery on electric circuit, a component of the topics in the secondary school physics curriculum. The review of literature reveals that BBT method improves students' achievement, mastery and motivation on secondary school physics students but not much has been conducted on its effectiveness on students' retention in heat energy and how self-efficacy influenced students' retention in heat energy when taught using BBT. Previous studies on brain-based reported that the method and its effectiveness have focussed on Newtonian physics, electric circuits, forces, and motion while little or no study has been conducted on heat energy.

This present study differs from the previous studies that have been carried out on secondary school physics in the area of the content covered and in the use of samples because most of the already completed research were done outside Nigeria. One of the few study carried out in Nigeria used college of education students as its sample and the physics topic used was current electricity (see Jack et al., 2018). Apart from this study, there is little or no study available to the researchers on the effectiveness of brain-based approach in secondary schools with a focus of physics student's retention. The objectives of this study are in two folds: (i) to find out the effect of brain-based teaching method on students' retention in the topic heat energy (ii) to investigate if self-efficacy influence the retention of students in the topic, heat energy when taught physics (heat energy) using brain-based teaching method.

3. Research Questions

1. What is the effect of brain-based teaching method on physics student's retention in heat energy?
2. Is there any influence of self-efficacy on the retention of students when taught physics energy using brain-based teaching method?

3.1. Research Hypothesis

H_{01}: There is no significant effect of brain-based teaching method on the retention of physics students in heat energy.

H_{02}: There is no significant influence of self-efficacy on the retention of physics students taught using brain-based teaching method.

4. Methodology

4.1. Research Design

For this study, quasi-experimental research design of the pre-test post-test control group design was adopted. Fokides and Papoutsi (2020) opine that the design is good for answering scientific questions because it deals with cause and effects, which allows for the manipulation of at least one independent variable and also allows for the use of intact class as participants. Studies by Al-Balushi and Al-Balushi (2018); Al-Tarawneh et al (2021); Bada (2022); Kartikaningtyas et al (2018); Saleh & Subramaniam (2019) have used the design and found it adequate for isolating, controlling, and manipulating independent variables.

4.2. Participants

This investigation involved two equivalent schools located in Ondo, Nigeria. Simple random sampling technique was adopted to select one intact science class each from the two schools used for this research. The participants used in this study include 99 secondary school two students (SS2) (Table 1). The justification for using SS2 students was because the students were not preparing for any certificate examination and also, the physics topic used in this study (heat energy) is usually taught at the secondary school two (SS2) level with reference to the secondary school physics curriculum in Nigeria. The students used in this study were yet to be taught the components of heat energy in their schools. One school each, was used as the experimental and control group respectively. The experimental group consist of 46 students and the control group was made up 53 students. We conducted t-test analysis, using the pre-test scores of the two groups to confirm that the two groups were not significantly difference before treatment, hence the two groups are homogenous (Table 2).

Group	Levels		Number
Teaching Method	Brain-based Teaching Method		46
	Conventional Lecture Method		53
Self-efficacy	Brain-based Teaching Method	Low	17
		Average	24
		High	5
	Conventional Lecture Method	Low	23
		Average	25
		High	5

Table 1. Demographic representation of participants

Group	Number (N)	Mean (X)	Std. Dev. (S.D)	Df	t	Significance (Sig.)	Remarks
BTS	46	4.89	2.73				
				97	0.44	.66	NS
CLM	53	4.62	3.28				

P < 0.05; BTS: Brain-based teaching method; CLM: Conventional lecture method.

Table 2. T-test analysis of the Pre-test Scores

4.3. Instrument

We used three researcher designed instruments to obtain data in this study. The first is the lesson teaching package (LTP) on BBT method and lecture method on the topic, heat energy. Lesson teaching package was deliberately created on the topic, heat energy using the principles guiding BBT method and lecture method respectively. The second instrument was heat energy test (HET), which comprised of forty multiple choice items designed on the topic, heat energy. The items in HET have three distractors and one right answer. HET was used to adjudge all the test (pre-test, post-test, and retention test) scored by the participant students in heat energy. The maximum score obtainable by any student is 80 marks while the minimum score obtainable is zero. The two instruments (LTP and HET) were both checked by five experts (three lecturers in the field of Physics education and two secondary school physics teachers) for face and content validities. HET was also validated by carefully preparing a table of specification on the content of heat energy. Item analysis was conducted on HET to determine its discriminating power (57.2%) and difficulty index (52.3%). The reliability of HET was obtained after administering it to a non-partisan secondary school students. A coefficient of 0.84 achieved using Kuder Richardson's formular 21 confirmed that the test was reliable for use. The third instrument was an adapted version of the self-efficacy scale. The scale was developed and validated by Schwarzer and Jerusalem (see Schwarzer & Jerusalem, 1995). This self-efficacy scale has been used and cited in over 3500 scholarly journals and its version has been translated into several languages. It has been used and adjusted to test specific task where it yielded between 0.75 and 0.91 internal consistency. The scale titled physics student's self-efficacy scale (PSSS) was used to determine physics student's self-efficacy. The scale consist of ten statements relating to statements on student's self-efficacy to physics. Students reacted to the items indicating whether they Strongly Agree (SA), Agree (A), Neutral (N), Disagreed (D), Strongly Disagree (SD). The minimum score obtainable by any student is 10 marks while the maximum obtainable score is 50.

4.4. Data Collection

The ethical clearance for this research was obtained from the University of Ilorin, Nigeria (UERC/ASN/2017/1077). This study involved two equivalent secondary schools in Ondo, Nigeria. We allocated one entire class each, to complete this study. We used one of the classes as the experimental group and the other class was used as the control group. The teacher (research assistant one) of the experimental group taught heat energy using the lesson teaching package on BBT method while the other group was taught the same content using lecture method by the second researcher assistant . We used heat energy test (HET) to conduct all the test (pre-test, post-test, retention). The only difference among the three test (pre-test, post-test, retention) was that they were reshuffled in each case before usage. We

divided the participants into three self-efficacy levels (low, average, high) using their pre-test scores from the self-efficacy scale instrument. Students who had a score lower than quartile (Q1) were grouped as low self-efficacy students while those students who scored above upper quartile (Q3) were grouped as high self-efficacy students. Students whose scores in the self-efficacy scale fell amidst the lower quartile (Q1) and upper quartile (Q3) were grouped as average self-efficacy students. This research took place under four phases, and it lasted a period of seven weeks before its completion.

Stage	Week of Research	Number of week(s) used	Activity
Stage 1	1st Week	1 week	1. Training of the two research assistants (secondary school physics teachers) by the researchers using the lesson teaching package. 2. Heat energy test (HET) was administered on the two groups. The test was graded and recorded using the marking scheme. The scores of students in the test was used as the pre-test scores. 3. Physics self-efficacy scale test was administered on the two groups by the research assistants. The scores of students in the test was graded and used to divide students into the three self-efficacy levels (low, average, high).
Stage 2	2nd and 3rd Week	2 Weeks	The teaching of the content on heat energy commenced in the two groups. The group labelled as the experimental group was taught physics using BBT method. In similar manner, the group labelled control was taught similar content but with the conventional lecture method. Four lessons were completed in each of the groups.
Stage 3	4th Week	1 week	A reshuffled version of heat energy test (HET) was administered on the two groups after the intervention. The test took place after pre-informing the students on the date and time for the test. The test was marked and recorded using the marking scheme. The scores of students in the test was used as the post-test scores.
Stage 4	7th week	1 Week	Another reshuffled version of heat energy test (HET) was administered on the two groups. The two groups were not pre-informed that the test would take place. The test was marked and recorded using the marking scheme. The scores of students in the test was used as the retention-test scores.

Table 3. Research Phase

Phase 1 (1 week): Research assistants for the two groups were trained by the researchers. The teacher of the experimental group was trained using the lesson teaching package on BBT method. We also trained the teacher of the control group using the conventional lecture method teaching package. Also, the administration of the self-efficacy test was carried out on the two groups. Pre-test administration of HET was carried out on the two groups. The scores of students in all these tests were objectively marked and recorded using the marking scheme.

Phase 2 (2 weeks): The teaching of the concepts of heat energy in the two groups took place. The research assistant in charge of the experimental group taught heat energy using BBT method and the research assistant in charge of the control group taught heat energy using the conventional lecture method. In each of the two groups, four lessons were taught in accordance with the Nigerian secondary school physics curriculum.

Phase 3 (1 week): The research assistants administered the post-test (HET) on the two separate groups. The post-test was objectively marked using the marking scheme. The scores of students in the test were recorded and stored.

Phase 4 (After 3 weeks): The research assistants administered the retention test on the two groups three weeks after from the administration of post-test. The students were not pre-informed about the test. The time for the test was also not mentioned to the students. The test was objectively marked using the marking scheme. The scores of students in the test were recorded and stored. The researchers monitored

and supervised the research to ensure that the research assistants sticked to the plan throughout the experiment. The summary of the data collection activities is shown in Table 3.

4.5. Data Analysis

The data obtained from this investigation was analysed using descriptive and inferential statistics. The data include all the scores of the students in the three test (pre-test, post-test, retention test). The research questions were answered using mean and standard deviation. Hypothesis one was analysed using t-test statistics while analysis of covariance (ANCOVA) was used to analyse hypothesis two.

5. Result and Discussion

Question 1: What is the effect of brain-based teaching method on physics student's retention in heat energy?

Group	Statistics	Post-Test	Retention Test	Mean Gain (Loss)
Brain-based Teaching Strategy	N	46	46	
	Mean	53.28	57.96	5.68
	Std Dev.	1.82	1.91	
Conventional Lecturer Method	N	53	53	
	Mean	51.72	49.81	(1.91)
	Std Dev.	1.72	1.89	

Table 4. Effect of brain-based teaching strategy on retention

Group	N	Mean	Std Dev.	Df	T	Sig.	Remarks
BTS	46	57.96	1.91				
				97	4.29	.00	*S
CLM	53	49.81	1.89				

Table 5. T-test Analysis of BBT method on Student's Retention

Table 4 shows the effect of BBT method on student's retention in heat energy. Table 4 reveals that there is difference in the retention of students taught physics (heat energy) using BBT strategy compared to the other group (lecture method). The retention mean score of students taught heat energy using BBT strategy was 57.96 while those students taught heat energy using the conventional lecture method was 49.81. Table 4 shows that the group taught physics (heat energy) using BBT method has a higher mean gain (5.68) when compared to the mean (loss) of students taught heat energy using the lecture method (1.91). This implies that the use of this method has effect on the retention of students' retention on heat energy. This result is not different from the findings of Jack et al. (2018) and Sani et al. (2019b) who found a difference in the retention and achievement of students taught physics using brain-based teaching strategy.

> *Hypothesis 1: There is no significant effect of brain-based teaching method on the retention of physics students in heat energy.*

Table 5 reveals the independent sampled t-test of the effect of BBT method on students' retention in heat energy. Table 5 shows that a t-test value of 4.29 was achieved at a significant level of 0.00. The significant value of 0.00 is less than the alpha value of 0.05, hence, there is significant impact of BBT method on physics students' performance in physics (heat energy). This implies that there is positive effect of the use of BBT method on students' retention in physics (heat energy) when compared to those taught physics using lecture method. The result of this investigation agrees with that of Bada (2022) who found out that the teaching method significantly improved students' achievement in physics. The findings from this study also agrees with Saleh (2012a, b, c), Saleh and Subramanian (2019) and Sani et al. (2019b) who found out

BBT method significantly improved secondary school students' achievement in the different components of physics concepts.

Question 2: Is there any influence of self-efficacy on the retention of students when taught physics energy using brain-based teaching method?

Self-efficacy group	Statistics	Post-test	Retention test	Mean gain (Loss)
Low	N Mean Std Dev.	17 25.18 8.46	17 59.06 9.57	33.88
Average	N Mean Std Dev.	24 26.42 10.89	24 59.58 11.38	33.16
High	N Mean Std Dev.	5 25.60 7.93	5 60.40 9.63	34.80

Table 6. Influence of self-efficacy on students' retention

Table 6 shows students' self-efficacy and its influence on physics students' retention in the subject when taught with BBT method. Table 6 reveals that the retention scores of the low, average, and high self-efficacy students were 59.06, 59.58 and 60.40 respectively. Even though the high self-efficacy physics students had the highest retention score and mean gain, the low and average self-efficacy students also had 33.88 and 33.16 mean gain respectively.

Hypothesis 2: There is no significant influence of self-efficacy on the retention of physics students taught using brain-based teaching method.

Source	Type III sum of squares	df	Mean square	f	sig.
Corrected model	4293.143a	3	1431.048	114.193	.000
Intercept	5768.513	1	5768.513	460.311	.000
Pretest	4285.640	1	4285.640	341.982	.000
Brain-based Teaching Method	13.450	2	6.725	.537	.589
Error	526.335	42	12.532		
Total	167552.000	46			
Corrected Total	4819.478	45			

Table 7. Influence of Self-efficacy on Students Retention

Table 7 shows the analysis of the influence of student's self-efficacy towards the retention of physics concept (heat energy) when taught using BBT method. Table 7 reveals that the calculated f-value of 0.537 was obtained at 0.589 level of significance. The calculated level of significance of 0.589 is greater than the alpha significant level of 0.00. This implies that hypothesis two is not significant. Hence, there is no significant influence of self-efficacy on the retention of students when taught heat energy using brain-based teaching strategy. This means that the use of BBT method is not biased along student's self-efficacy towards physics. The result of this study agrees with Adeyemo and Agokei (2009) who also found out that student's self-efficacy is not the only determinant of behaviour even though it might mediate between knowledge and action.

6. Conclusion

This paper investigated the effect of using BBT method to teach secondary school physics students and how it affects students' retention and self-efficacy. We found out that the use of this method improved physics students' ability to retain concept learnt for a fairly longer time (3 weeks interval). This result

further revealed that the teaching method used in this study (brain-based method) was not selective along student's self-efficacy towards physics. Based on the finding from this research, we can therefore conclude that BBT method improved students' retention ability in the concepts learnt better than the students taught using the conventional lecture method irrespective of the differences in the characteristics of the students. This study also revealed that physics students' self-efficacy did not significantly influence students' ability to retain the concept learnt. We therefore conclude that the use of BBT method is not biased along physics students' self-efficacy. This teaching method (brain-based method) breaks through the limit by adequately accommodating the challenge imposed by the different characteristics' students bring to the classrooms. Even though there was difference among the retention scores of the three self-efficacy groups, the difference was not significant with respect to the use of BBT method. What must be responsible for this was the effectiveness of the use of BBT method irrespective of student's conviction to excel in secondary school physics task (self-efficacy). This result would go a long way to further reduce the inequality currently experienced in the field of education as a result of the different characteristics brought into the classroom by the students. We consider the following recommendations appropriate based on the results from this study. First, BBT method should be used for classroom instruction during secondary school physics lessons especially in the teaching of heat energy. Second, workshop and seminars should be organised for practising physics teachers on how to use BBT method during instruction. Lastly, curriculum developers and educational policy makers should work on introducing BBT method into the curriculum for preparing physics teachers in the various faculties of education and colleges of education especially in the modules/courses covering physics teaching methods.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

Aderounmu, S.B., & Obafemi, T.A. (2015). Ordeals of physics instruction in Nigerian secondary schools: Way forward for the attainment of global competitiveness. *Journal of Education & Practice*, 6(20), 87-96.

Adeyemo, D.A., & Agokei, R.C. (2009). The effects of circadian typology, emotional intelligence and creativity on the academic self-efficacy of secondary school students in Delta State, Nigeria. *African Journal of Educational Research,* 13(1/2), 203-213.

Akyürek, E., & Afacan, Ö. (2013). Effects of brain based learning approach on students' motivation and attitudes levels in science class. *Mevlana International Journal of Education,* 3(1), 104-119. https://doi.org/10.13054/mije.13.08.3.1

Alanazi, F.H. (2020). Brain-based learning as perceived by Saudi teachers and its effect on chemistry achievement of 7th graders. *Journal of Baltic Science Education,* 19(6), 864-874. https://doi.org/10.33225/jbse/20.19.864

Al-Balushi, K.A., & Al-Balushi, S.M. (2018). Effectiveness of brain based learning for grade eight students' direct and postponed retention in science. *International Journal of Instruction,* 11(3), 525-538. https://doi.org/10.12973/iji.2018.11336a

Al-Tarawneh, A., Altarawneh, A.F., & Karaki, W.K. (2021). Effect of brain-based learning in developing spatial ability of ninth grade students with low achievement in mathematics. *Journal of Educational and Social Research,* 11(5), 141-150. https://doi.org/10.36941/jesr-2021-0112

Anyafulude, J.C. (2014). Impact of discovery-based learning method on senior secondary school physics. *Journal of Teacher Perspective,* 8(3), 1-9.

Arun, A., & Singaravelu, G. (2018). Brain-based learning: A tool for meaningful learning in the classroom. *International Journal of Research,* 7(IX), 766-771.

Bada, A.A. (2022). Effectiveness of brain-based teaching strategy on students' achievement and score levels in heat energy. *Journal of Innovation in Educational and Cultural Research*, 3(1), 20-29. https://doi.org/10.46843/jiecr.v3i1.45

Bigozzi, L., Tarchi, C., Fiorentini, C., Falsini, P., & Stefanelli, F. (2018). The influence of teaching approach on students' conceptual learning in physics. *Frontiers in Psychology,* 9, 2472. https://doi.org/10.3389/fpsyg.2018.02474

Caine, R.N., & Caine, G. (1994). *Making connections: Teaching and the human brain*. Menlo Park, CA: Addison-Wesley.

Caine, G., & Caine, R.N. (1997). *Education on the edge of possibility.* Association for Supervision and Curriculum Development.

Caine, G., & Caine, R.N. (2001). *The brain, education, and the competitive edge*. R&L Education. Available at: https://www.amazon.com/Brain-Education-Competitive-Edge/dp/0810840618

Duman, B. (2010). The effects of brain-based learning on the academic achievement of students with different learning styles. *Educational Sciences: Theory & Practice Educational Sciences: Theory & Practice,* 10(4), 2077-2103. https://files.eric.ed.gov/fulltext/EJ919873.pdf

Fokides, J.E., & Papoutsi, A. (2020). Using makey-makey for teaching electricity to primary school students. A pilot study. *Education and Information Technologies,* 25, 1193-1215. https://doi.org/10.1007/s10639-019-10013-5

Hursen, C., & Asiksoy, G. (2015). The effect of simulation methods in teaching physics on students' academic success. *World Journal on Educational Technology,* 7(1), 87-98. https://doi.org/10.18844/wjet.v7i1.26

Jensen, E.P. (2008). *Brain-based learning*: *The new paradigm of teaching* (2nd ed.). Corwin Press.

Jack, U.G., Danjuma, G.S., & Gbademosi, B.O. (2018). Effects of brain based learning model on colleges of education students' retention and attitude in "current electricity" in Taraba State, Nigeria. *Journal of Education, Society and Behavioural Science,* 25(2), 1-15. https://doi.org/10.9734/JESBS/2018/40519

Kahveci, A., & Ay, S. (2008). Different approaches- Common implications: Brain-based and constructivist learning from a paradigms and integral model perspective. *Journal of Turkish Science Education,* 5(3), 124-129. http://biologydiva.pbworks.com/f/Different+Approaches+-+Common+Implications.pdf

Kartikaningtyas, V., Kusmayadi, T.A., & Riyadi, R. (2018). The effect of brain based learning with contextual approach viewed from adversity quotient. *Journal of Physics: Conference series,* 1022, 1-7. https://doi.org/10.1088/1742-6596/1022/1/012014

Mastoni, E., Sumantri, M.S., & Ibrahim, N. (2019). A preliminary study of brain-based learning and intrapersonal intelligence in junior high school mathematics learning. *Universal Journal of Educational Research,* 7(9A), 147-154. https://doi.org/10.13189/ujer.2019.071617

Mekarina, M., & Ningsih, Y.P. (2017). The effects of brain based learning approach on motivation and students achievement in mathematics learning. *Journal of Physics: Conference Series,* 895, 1-6. https://doi.org/10.1088/1742-6596/895/1/012057

Njoroge, G.N., Changeiywo, J.M., & Ndirangu, M. (2014). Effects of inquiry-based teaching approach on secondary school students' achievement and motivation in physics in Nyeri County, Kenya. *International Journal of Research in Education and Review,* 2(1), 1-16. https://doi.org/10.14662/IJARER2013.010

Noureen, G., Awan, R.N., & Fatima, H. (2017). Effect of brain-based learning on academic achievement of VII graders in mathematics. *Journal of Elementary Education,* 27(2), 85-97

Olaniyan, A.O., Omosewo, E.O., & Nwankwo, L.J. (2015). Effect of polya problem solving model on senior secondary school student performance in current electricity. *European Journal of Science and Mathematics Education,* 3(1), 97-104.

Priatna, N. (2017). The application of brain-based learning principles aided by geogebra to improve mathematical representation ability. *AIP Conference Proceedings,* 1868, 1-6. https://doi.org/10.1063/1.4995157

Riskiningtyas, I., & Wangid, M.N. (2019). Students' self-efficacy of mathematics through brain based learning. *Journal of Physics: Conference Series,* 1157. https://doi.org/10.1088/1742-6596/1157/4/042067

Saleh, S. (2012a). Dealing with the problem of the differences in students' learning styles in physics education via the brain based teaching approach. *International Review of Contemporary Learning Research,* 1(1), 47-56. https://doi.org/10.12785/IRCLR/010104

Saleh, S. (2012b). The effectiveness of brain-based teaching approach in dealing with the problems of students' conceptual understanding and learning motivation towards physics. *Educational Studies,* 38(1), 19-29. https://doi.org/10.1080/03055698.2011.570004

Saleh, S. (2012c). The effectiveness of the brain-based teaching approach in enhancing scientific understanding of Newtonian physics among form four students. *International Journal of Environmental and Science Education,* 7(1), 107-122. https://files.eric.ed.gov/fulltext/EJ972447.pdf

Saleh, S., & Subramaniam, L. (2019). Effects of brain-based teaching method on physics achievement among ordinary school students. *Kasetsart Journal of Social Sciences*, 40(3), 580-584. https://doi.org/10.1016/j.kjss.2017.12.025

Sani, A., Rochintaniawati, D., & Winarno, N. (2019a). Enhancing students' motivation through brain-based learning. *Journal of Physics: Conference Series,* 1157, 1-5. https://doi.org/10.1088/1742-6596/1157/2/022059

Sani, A., Rochintaniawati, D., & Winarno, N. (2019b). Using brain-based learning to promote students' concept mastery in learning electric circuit. *Journal of Science Learning,* 2(2), 42-49. Available at: https://files.eric.ed.gov/fulltext/EJ1226178.pdf https://doi.org/10.17509/jsl.v2i2.13262

Schwarzer, R., & Jerusalem, M. (1995). Generalized self-efficacy scale. In Weinman, J., Wright, S. & Johnston, M. (Eds.), *Measures in health psychology: A user's portfolio. Causal and control beliefs* (35-37). Windsor, UK: NFER-Nelson. https://doi.org/10.1037/t00393-000

Shabatat, K., & Al-Tarawneh, M. (2016). The impact of a teaching learning program based on a brain-based learning on the achievement of the female students of 9th grade in chemistry. *Higher Education Studies,* 6(2), 162. https://doi.org/10.5539/hes.v6n2p162

Sousa, D.A. (2011). *David A. Sousa's How the Brain Learns*. Corwin Press. https://doi.org/10.4135/9781452219684

Suleman, Q., Hussain, I., Din, M.N., & Igbal, K. (2017). Effects of computer-assisted instruction on students' academic achievement in physics at secondary level. *Computer Engineering and Intelligent Systems,* 8(7), 9-17.

Triana, M., Zubainur, C.M., & Bahrun (2019). Students' mathematical communication ability through the brain-based learning approach using autograph. *Journal of Research and Advances in Mathematics Education,* 4(1), 1-10. https://doi.org/10.23917/jramathedu.v4i1.6972

Ugwuanyi, C.S., Nduji, C.C., Elejere, U.C., & Omeke, N.E. (2020). Effect of flipped classroom and think pair share strategy on achievement and retention among secondary school physics students. *International Journal of Sciences: Basic and Applied Research,* 52(2), 136-148.

Uwizeyimana, D., Yadav, L., Musengimana, T., & Uwamahoro, J. (2018). The impact of teaching approaches on effective physics learning: An investigation conducted in five secondary schools in Rusizi District, Rwanda. *Rwandan Journal of Education,* 4(2), 1-14.

Varghese, M.G., & Pandya, S. (2016). A study on the effectiveness of brain-based learning of students of secondary level on their academic achievement in biology, study habits and stress. *International Journal of Humanities and Social Sciences,* 5(2), 103-122.

Wijayanti, K., Khasanah, A.F., Rizkiana, T., Mashuri, Dewi, N.R., & Budhiati, R. (2021). Mathematical creative thinking ability of students in treffinger and brain-based learning at junior high school. *Journal of Physics: Conference Series*, 1918, 1-5. https://doi.org/10.1088/1742-6596/1918/4/042085

Published by OmniaScience (www.omniascience.com)

Journal of Technology and Science Education, 2023 (www.jotse.org)