Kasetsart Journal of Social Sciences 40 (2019) 580–584

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

Effects of Brain-Based Teaching Method on Physics achievement among ordinary school students

Salmiza Saleh*, Lechimi Subramaniam

School of Educational Studies, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia

Article Info

Article history:
Received 1 August 2017
Revised 14 November 2017
Accepted 28 December 2017
Available online 17 January 2018

Keywords:
Brain-Based Teaching Method,
gender,
physics,
school,
science learning

Abstract

This study was conducted to determine whether or not there is a significant difference in Physics achievement of ordinary school students (i) between those who were exposed to the Brain-Based Teaching Method (BBTM) versus those who followed the conventional teaching method (CTM), and (ii) between males and females who were exposed to the BBTM. The effects of the BBTM within the targeted context were assessed using a quasi-experimental research approach involving 90 students from two ordinary schools in Penang, Malaysia. Data collected through the Physics Achievement Test (PAT) were then analyzed descriptively and inferentially. The results showed that students who were exposed to the BBTM obtained a significantly higher mean score in the PAT compared to those who followed the CTM. It was also found that there was no significant difference in the PAT mean scores between male and female students in the BBTM group. These findings indicate that BBTM was effective in improving Physics achievement as well as in reducing the gender gap in Physics achievement among ordinary school students.

Introduction

Physics is a science subject that deals with matter, energy, motion, and force. Learning Physics is important as it is one of the fields of knowledge that underlies the physical universe and applies constantly to people's everyday lives (O'Keefe, 1997). Nevertheless, many people are afraid to learn Physics because it has a reputation of being a difficult subject (Clement, 1993; O'Keefe, 1997) due to the fact that it deals with a lot of different representations such as experiments, formulas, numbers and calculations, graphs, and conceptual explanations (Angell, Guttersrud, Henriksen, & Isnes, 2004; Seth, Fatin, & Marlina, 2007). Students' performance in Physics has been generally lower compared to Chemistry and Biology (Lavonen, Meisano, Byman, Uiito, & Juiit, 2005). Gender-related differences also exist within Physics. Known as a more 'masculine' subject, the content and context of Physics are more favorable to male students (Murphy & Whitelegg, 2006). Hence, there are more male students in most Physics classrooms than female students (McCullough, 2011, pp. 1–10; Zhen, 2007). Besides, numerous studies have also confirmed that male students do typically outperform female students in Physics (Gwen & Gita, 2013).

Current studies also show that there is an alarmingly low number of students enrolling in Physics-related courses around the globe, particularly at the higher level of studies (Checkley, 2010). The reasons for the declining student interest in Physics have also been widely observed and noted. Among them are the passive teaching methods that are widely employed by the teachers in the Physics classrooms (Owen, Dickson, Stanisstreet, & Boyes, 2008). The traditional Physics instruction, which is normally

* Corresponding author.
E-mail addresses: salmiza@usm.my (S. Saleh), s_lech28@yahoo.com (L. Subramaniam).
Peer review under responsibility of Kasetsart University.

https://doi.org/10.1016/j.kjss.2017.12.025
2452-3151/

conducted based on a theoretical basis, together with the teacher-centered approach, has been shown to heighten the dislike of studying Physics amongst students, which in turn causes a lack of impact on their understanding of Physics (Hake, 1998; Sidin, 2003).

For effective Physics education to occur, students have to actively process the knowledge by making sense of the concepts by themselves. The information cannot merely be transferred from the teacher to the students. Diversified teaching and learning techniques of Physics can yield students who really want to learn Physics. Hence, Physics teachers can utilize the recently developed Brain-Based Teaching Method (BBTM) in their classrooms. Equipped with a range of diverse teaching approaches and students' active learning activities to cater students' diverse needs, Physics teachers can now tap into the best of brain-compatible learning and neurodevelopmental applications, to provide new and innovative ways to reach students (Caine & Caine, 1994). Therefore, this study was conducted to determine whether or not there is a significant difference in Physics achievement by ordinary school students: (i) between those who were exposed to the Brain-Based Teaching Method (BBTM) versus those who followed the conventional teaching method (CTM), and (ii) between males and females who were exposed to the BBTM.

Literature Review

Through the literature review, a number of sets of principles were identified that had been developed by different researchers (Caine & Caine, 1994; Jensen, 2000; Kagan, 2001; Lackney, 1998; Sousa, 1995). The principles are just slightly different from one another, but with a similar basic theme behind them all, due to the fact that all of them are concerned with the function and structure of the different parts of brain. The fundamental principles stated by Caine and Caine (1994) in their ground-breaking research work are: (i) the brain is a parallel processor; (ii) learning engages the entire physiology; (iii) the search for meaning is innate; (iv) the search for meaning occurs through patterning; (v) emotions are critical to patterning; (vi) every brain simultaneously perceives and creates parts and wholes; (vii) learning involves both focused attention and peripheral perception; (viii) learning always involves conscious and unconscious processes; (ix) humans have (at least) two types of memory systems: spatial and rote learning; (x) the brain understands and remembers best when facts and skills are embedded in the natural, spatial memory; (xi) learning is enhanced by challenge and inhibited by threat; and (xii) every brain is unique.

All 12 principles can be classified into three brain-based teaching techniques as follows (Caine & Caine, 1994): (i) Orchestrated Immersion—the instruction phase that includes a variety of teaching and learning activities (related to real-life situations) that generates a conducive learning environment; (ii) Active Processing—the continuous strengthening process for further deep understanding; and (iii) Relaxed Alertness—the state of the brain (emotional) which is free of threat or negative stress but highly challenged that enables the learner to internalize information optimally.

Saleh (2012) conducted a study to investigate the effectiveness of Brain Based Teaching Approach in enhancing Physics learning among 100 high-achieving school students in the northern states of Peninsular Malaysia. The results showed that the Brain Based Teaching Approach, implemented by integrating brain-based teaching techniques through the seven brain compatible instructional phases, is effective in increasing Physics conceptual understanding and learning motivation among the research samples.

A study by Rehman and Bokhari (2011) to explore the effectiveness of the BBTM on ninth-grade students in Mathematics achievement also found similar results. The Brain-Based Learning Principles applied through a enriched environment and cognitive practices such as playing soft tones, using appropriate words, praising, using soothing colors, generating a safe and friendly environment, exploring real life problems, cracking jokes, encouraging smiles and laughter, promoting critical thinking, and giving nutritional tips were found helpful in assisting students to learn effectively.

Duman (2010) conducted a study on 34 third-year university students in Turkey to investigate the effects of the Brain-Based Learning Approach on the academic achievement of students with different learning styles. The researcher designed a brain-based integrated learning-teaching model based on the Brain-Based Learning Principles. Lessons started with the playing of music, group activities, and cooperation among group members to enhance emotional awareness and relaxation. Students were also advised to drink water and were reminded to remove stress and challenge themselves. During the orchestrated immersion phase, the measurement and evaluation processes were associated with daily problems. Posters, pictures, graphics, and multimedia related to the topic were displayed. Lastly, for the active process phase, students were encouraged to ask questions and do deep thinking. The researcher concluded that Brain-Based Learning had significantly increased students' academic achievement overall, compared to the Traditional Teaching Method.

Avaci and Yagbasani (2005) applied the Brain-Based Learning Approach to seventh graders, to measure the impact of the method on their achievement in science subjects. A quasi-experimental research design was used in the study. Data collected through the Work-Energy Achievement Test revealed that there was a significant difference on the impact of the Brain-Based Learning Approach, in favor of the experimental group compared to the control group. Hence, based on the abovementioned literature review, it can be concluded that the BBTM has the potential to be implemented as an alternative instructional approach in order to improve students' performance.

Methods

A quasi-experimental design with control and experimental groups was used in this study. Prior to the intervention, a teacher for the experimental group was trained to use the BBTM for about a week. A pre-test using the Physics Achievement Test (PAT) was then administered to both the control and experimental groups, followed by the intervention. The control group was taught using the

conventional teaching method (CTM—a lecture followed by demonstration and/or lab activities, and discussion—without paying any attention to brain-compatible strategies), whilst the experimental group was taught using the BBTM via brain-compatible instructional phases (activation, clarify outcomes and paint the big picture, making connection and develop meaning, doing the learning activities, and demonstrating understanding, review the lesson and preview new topic) (Saleh, 2012; Smith, 2003; Sousa, 1995). The teaching and learning activities of the experimental group were diversified according to the principles summarized in Table 1.

Both groups were taught the same Physics topic (Forces and Motion) for about six weeks. The PAT post-test was then administered to measure the effectiveness of the intervention.

Participants

The research sample consisted of 90 students, selected from two ordinary schools (similar background) from a fourth form students' population in Penang, Malaysia. The purposive cluster sampling technique was used to select the samples. This technique allowed the researcher to pick two intact groups from the science classes in the district so that an almost equal number of males (46 students) and females (44 students) were involved in the study. The first group (2 classes—45 male and female students) was elected as the control group, whilst the second group (another 2 classes—45 male and female students) became the experimental group.

Data Collection

The PAT used as pre-test and post-test in this study focuses on the topic of Forces and Motion. The PAT comprises 20 multiple-choice questions and two structured questions. The questions are based on the Malaysian Certificate of Education level and are in accordance with the curriculum specifications articulated by the Malaysian Ministry of Education. The PAT was validated by three experienced Physics teachers and was piloted on 30 students. The reliability value of Kuder-Richardson (KR-20) obtained for the PAT was 0.73, indicating that it was reliable for the purpose of the study.

Data Analysis

The pre-test and post-test PAT data were analyzed descriptively and inferentially. A one-way ANCOVA test was used to determine the differences in Physics achievement between students who were exposed to the BBTM versus students who followed the CTM, whereas an independent samples t-test was used to determine the differences in Physics achievement of male and female students who were exposed to the BBTM.

Results

Physics Achievement of Students Who Were Exposed to the BBTM versus Students Who Followed the CTM

Table 2 below shows the descriptive statistics for the pre-test and post-test scores of the PAT for both the BBTM (experimental) and control (CTM) groups. The BBTM group had a pre-test mean score of $M = 6.00$, $SD = 3.69$ whereas the CTM group had a pre-test mean score of $M = 7.67$, $SD = 5.31$. The post-test mean score of the BBTM group ($M = 22.30$, $SD = 4.96$) was relatively higher than that of the CTM group ($M = 17.97$, $SD = 5.38$).

Table 3 shows the one-way ANCOVA analysis for the post-test score of the PAT and the pre-test score as the

Table 1
Application of Brain-Based Learning Principles on the experimental group

Brain-Based Learning Principle	Teaching and learning activities
Principle 1 (Parallel processing)	Diagrams, figures, re-corrections, pinpointing mistakes, filling blanks in the incomplete simplifications
Principle 2 (Learning engages the physiology)	Displaying balanced diet chart in the classroom, encouraging students to bring water bottles with them, giving hygienic tips off and so on
Principle 3 (Search for meaning)	Familiarity and novelty in content, innovative problems, reflecting previous knowledge
Principle 4 (Patterning)	Self-concept, location of patterns, generation of new patterns
Principle 5 (Emotions and patterning)	Creating cheerful environment through brain energizers and jokes; Using soothing colors (green, blue, and brown), playing soft tones on a few occasions, reflecting students' interests in content, and using praising words only for all the students
Principle 6 (Parts and whole)	Assembling parts into a meaningful whole, dividing whole into small inter-related parts
Principle 7 (Learning and focused attention)	Group discussions, assuring students of having their say in the classroom and solving problems related to real-life situations
Principle 8 (Learning and conscious and unconscious processes)	Providing pauses and adequate time during lessons to process information, displaying assignments of each group in classrooms, encouraging students to ask questions and encouraging other students to answer them, appreciating innovation, and acknowledging ambiguities of students
Principle 9 (Spatial and rote learning memory)	Generation of a safe and friendly environment, presenting meaningful content, fitting new ideas into already relevant existing ideas, encouraging students to form their own patterns, acknowledging individual differences of students, encouraging smiles, laughter, and promoting critical thinking
Principle 10 (Building spatial memory)	
Principle 11 (Challenge and threat)	Physical activities, sarcasm-free jokes, teacher's friendly attitude towards students, generation of a challenging atmosphere through individual tasks, exploration of ideas, unfolding riddles, exploring real-life problems, and appreciation of innovative thinking of students
Principle 12 (Uniqueness of brain)	Individual tasks, free choices to perform

Adapted from "Effectiveness of Brain-Based Learning Theory on secondary level students of urban areas", by U. R. Aziz, A. M. Mushtaq, H. Shafqat, I. Zafar, & M. Rauf, 2012, *Journal of Managerial Sciences, 6*(1), 114–122. Copyright 2012 by Journal of Managerial Sciences. Reprinted with permission

Table 2
Descriptive statistics for PAT pre-test and post-test scores

PAT	CTM (control) group					BBTM (experimental) group				
	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Pre-test	45	1.00	15.00	7.67	5.31	45	1.00	12.00	6.00	3.69
Post-test	45	11.00	28.00	17.97	5.38	45	15.00	30.00	22.30	4.96

Table 3
One-way ANCOVA for the PAT post-test score and the pre-test score as the covariates. (Dependent variable: PAT post-test score)

Source	Sum of squares	df	Mean square	F	Partial eta squared
Pre-test	.21	1	.21	.015*	.00
Method	271.91	1	271.91	9.98*	.15
Error	1,553.05	88	27.25		

*$p < .05$

covariates. The results with an F value $(1, 88) = 9.98$, Mean Square Error $= 27.25$ and $p < .05$ indicate that it can be concluded that there is a significant difference in the post-test score of the PAT between the BBTM and CTM groups. The partial eta squared value shows that the difference between the methods explains 15 percent of the post-test score variance.

Table 4 shows that the estimated marginal means produced by the ANCOVA post-test score of the PAT for the BBTM was 22.29, which is higher than the post-test score for the CTM of 17.98. Therefore, the study results show that the BBTM was more effective in enhancing students' achievement in Physics.

Physics Achievement of Male and Female Students Who Were Exposed to the BBTM

Table 5 shows the results of the t-test and the descriptive statistics for the PAT post test score of the male and female students in the BBTM group.

The result of the independent samples t-test showed that there was no significant difference in the PAT post-test mean score between male students (M = 22.53, SD = 4.97) and female students (M = 22.07, SD = 5.12) at the .05 level of significance (t = −.25, df = 89, $p > .05$, 95% CI for mean difference −4.24 to 3.31). On average, male and female students obtained quite similar scores in the PAT in this group. Therefore, it can be said that the achievement gap in Physics between these two groups of students was reduced in the BBTM group.

Table 4
Estimated marginal means for the PAT post-test score and the standard error for the BBTM and CTM groups. (Dependent variable: PAT post-test score)

Group	Mean	SE	95% CI	
			Lower bound	Upper bound
CTM	17.98[a]	.96	16.06	19.90
BBTM	22.29[a]	.96	20.37	24.21

[a] Covariates: Pre-test score

Discussion

Physics Achievement of Students Who Were Exposed to the BBTM versus Students Who Followed the CTM

The key findings of this research show that the Brain-Based Teaching Method (BBTM) is effective regarding Physics achievement compared to the conventional teaching method (CTM). These findings were similar to the studies conducted by Saleh (2012), and Duman (2010). In a CTM classroom, according to Novak (2010), the teacher becomes the controller of the learning environment and plays the role of instructor and decision maker. Students master the content delivered by the teacher through drill and practices known as rote learning. Rote learning inhibits meaningful learning and discourages the learner form consciously integrating the new knowledge with prior knowledge (Wandersee, Mintzes, & Novak, 1994).

In contrast, the BBTM employs meaningful learning by accepting the rules of how the brain processes and then organizing instruction to achieve meaningful learning (Caine & Caine, 1994). The main focus of the brain-based learning strategy is to encourage teachers to modify their teaching methods so that the knowledge can reach to all students and to create a safe and challenging emotional climate for the students. Apart from that, the Brain-Based Learning Strategy also incorporates a variety of aspects such as multiple intelligences, learning styles, and emotional intelligences (Lombardi, 2008). Each and every individual learns in different ways; hence a multi-dimensional teaching model should be used (Duman, 2010) to allow students to obtain knowledge in a variety of interesting and fun ways that leads to meaningful learning (Kolb & Kolb, 2005).

Table 5
Results of t-test and descriptive statistics for the PAT post-test mean score of male and female students in the BBTM group

	BBTM group						95% CI for	t	df
	Male			Female			Mean		
	N	Mean	SD	N	Mean	SD	Difference		
PAT (post-test)	46	22.53	4.97	44	22.07	5.12	−4.24, 3.31	−.25*	89

*$p > .05$

The diverse teaching approaches and multiple learning pathways such as auditory, visual and kinesthetic used in this study were able to tap into the best of brain-compatible learning and provide innovative ways to reach students (Lombardi, 2008). Through the implementation of the BBTM, students were actively involved either personally or in groups and could understand the scientific concepts. Experience formed by the students themselves increases academic achievement and understanding of scientific knowledge (Ozden & Gultekin, 2008).

Physics Achievement of Male and Female Students Who Were Exposed to the BBTM

In general, female students claim that Physics is difficult for them because the subject tends to favor the masculine nature. Based on a classic study done by Johnson (1987), Physics is said to be contrastive to the feminine nature. However, in the current study, it was found that the BBTM could reduce the gender gap in Physics achievement due to the fact that the BBTM puts forward some basic principles such as considering the left and right brain tendencies, practicing real life experiences in the learning environment, establishing an effective communication with learners and guiding learners through their learning processes. This is in line with the findings of Ozden and Gultekin (2008) and Saleh (2012) who concluded that the BBTM offers optimum learning opportunities for all students.

Conclusion and Recommendation

The findings proved that the Brain-Based Teaching Method (BBTM) is significantly more effective compared to the conventional teaching method (CTM) in improving Physics achievement as well as in reducing the gender gap in Physics achievement among ordinary school students. Therefore, it is suggested that teachers use the BBTM as one of the techniques to teach Physics in schools to tap into students' optimal potential.

Conflict of Interest

There is no conflict of interest in this research.

Acknowledgments

USM Research University Grant.

References

Angell, C., Guttersrud, O., Henriksen, E. K., & Isnes, A. (2004). Physics: Frightful, but fun. Pupils' and teachers' views of physics and physics teaching. *Science Education, 88*(5), 683–706.

Avaci, D. E., & Yagbasani, R. (2005). *A study on impact of brain based learning approach on students' achievement of knowledge about work-energy* (Unpublished doctoral dissertation). University of South Florida, St. Petersburg.

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

Checkley, D. (2010). *High school students' perceptions of physics*. Retrieved from https://www.uleth.ca/dspace/bitstream/handle/10133/2584/checkley%2C%20doug.pdf.

Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching, 30*(10), 1241–1257.

Duman, B. (2010). The effects of brain-based learning on the academic achievement of students with different learning styles. *Educational Sciences: Theory & Practice, 10*(4), 2077–2103.

Gwen, C. M., & Gita, T. (2013). Stereotype threat and women's performance in physics. *International Journal of Science Education, 35*(18), 3050–3061. https://doi.org/10.1080/09500693.2012.683461.

Hake, R. R. (1998). Interactive engagements versus traditional methods: A six thousand-student survey of mechanics test data for introductory physics course. *American Journal of Physics, 66*(1), 64–74.

Jensen, E. (2000). *Brain-based learning: The new science of teaching & training*. Thousand Oaks, CA: Corwin Press.

Johnson, S. (1987). Gender differences in science: Parallels in interest, experience and performance. *International Journal of Science Education, 9*(4), 467–481. https://doi.org/10.1080/0950069870090405.

Kagan, S. (2001). *Kagan structures are brain-based*. San Clemente, CA: Kagan Publishing.

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing learning in higher education. *The Academy of Management Learning and Education, 4*(2), 193–212.

Lackney, J. (1998). *12 design principles based on brain-based learning research*. Retrieved from http://www.designshare.com/Research/BrainBasedLearn98.htm.

Lavonen, J., Meisano, V., Byman, R., Uiito, A., & Juiit, K. (2005). Pupils' interest in physics: A survey in Finland. *NORDINA, 2*, 72–85.

Lombardi, J. (2008). Beyond learning styles: Brain-based research and English language learners. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 81*(5), 219–222.

McCullough, L. (2011). *Gender differences in student responses to physics conceptual questions based on question context*. Stout, WI: ASQ Advancing the STEM Agenda in Education, the Workplace and Society.

Murphy, P., & Whitelegg, E. (2006). *Girls in the physics classroom: A review of the research on the participation of girls in physics* (Technical Report). London, UK: Institute of Physics.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations* (2nd ed.). New York, NY: Routledge, Taylor-Francis.

Owen, S., Dickson, D., Stanisstreet, M., & Boyes, E. (2008). Teaching physics: Students' attitudes towards different learning activities. *Research in Science & Technological Education, 26*(2), 113–128.

Ozden, M., & Gultekin, M. (2008). The effects of brain-based learning on academic achievement and retention of knowledge in science course. *Electronic Journal of Science Education, 12*(1), 3–19.

O'Keefe, D. (1997). *Secondary physics population in Victoria, analysis of year 12 physics numbers*. Paper presented in the 1997 Science Teachers Association of Victoria Physics Teachers Conference, *Monash University, Victoria, Australia*

Rehman, A. U., & Bokhari, M. A. (2011). Effectiveness of brain-based learning theory at secondary level. *International Journal of Academic Research, 3*(4), 354–359.

Saleh, S. (2012). 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.

Seth, S., Fatin, A. P., & Marlina, A. (2007). *Kemahiran Metakognitif dalam Kalangan Pelajar Sekolah Menengah di Negeri Johor dalam Menyelesaikan Masalah Fizik. [Metacognitive skills among secondary school students in Johor in solving physics problems]* (Technical Report). Malaysia: Universiti Teknologi Malaysia. [in Malay]

Sidin, R. (2003). Pembudayaan Sains dan Teknologi: Satu Cadangan Piawai [Socialization of science and technology: A standard proposal]. *Jurnal Pendidikan (UKM)*, 47–63. [in Malay]

Smith, A. (2003). *Accelerated learning in practice: Brain-based method for accelerating motivation and achievement*. Stafford, UK: Network Educational Press.

Sousa, D. (1995). *How the brain learns: A classroom teacher's guide*. Reston, VA: National Associations of Secondary Schools Principals.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177–210). New York, NY: MacMillan.

Zhen, Z. (2007). Learning content, physics self-efficacy, and female students' physics course-taking. *International Educational Journal, 8*(2), 204–212.