JPII 8 (1) (2019) 12-21

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

THE EFFECTS OF BRAIN-BASED TEACHING WITH I-THINK MAPS AND BRAIN GYM APPROACH TOWARDS PHYSICS UNDERSTANDING

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DOI: 10.15294/jpii.v8i1.16022

Accepted: October 8th, 2018. Approved: March 25th, 2019. Published: March 28th, 2019

ABSTRACT

The purpose of this study was to assess the effects of Brain-Based Teaching with i-Think Maps and the Brain Gym Approach (BBT-iTBA) compared to the conventional teaching approach (CTA) towards Physics' conceptual understanding amongst male and female matriculation students in the north of Peninsular Malaysia. 180 students (83 were male and 97 were female), aged around 19 years old, from two Matriculation Colleges, were involved as research sample for the targeted population. The effects of the BBT-iTBA compared to the CTA towards Physics' conceptual understanding amongst students were determined using a quasi-experimental non-equivalent group design, involving an experimental group of students (exposed to BBT-iTBA) and a control group of students (received CTA). Data gathered from the Physics Conceptual Understanding Test (PCUT), administered on the sample before and after the intervention of both teaching approaches, were then analyzed statistically. The two way ANOVA analysis results indicated that after the intervention, students' Physics conceptual understanding differ significantly due to the implementation of the different teaching approaches, with a great size effect. Students who were exposed to BBT-iTBA performed significantly better in the PCUT than students who received CTA. Although gender alone did not affect students' Physics conceptual understanding, the results obtained revealed that the effects of the interaction between the implementation of the teaching approaches and gender on the attainment of students' Physics conceptual understanding were significant, with a simple size effect. The main features of the BBT-iTBA, which are: focusing on the optimum function of the brain; promoting and enhancing the skills of thinking; and creating a relaxed and fun learning environment; are found to be the significant triggers for students to better understand Physics conceptually and excel in the subject.

Keywords: Physicsconceptual understanding, Brain-based Teaching, i-Think Maps, Brain Gym, matriculation students

INTRODUCTION

Although Physics has played an enormous part in improving the lives of human beings, it is, however, more well known as one of the most disliked and difficult subjects to be learned (Checkley, 2010; Lasry et al., 2009; Kapucu, 2014). Due to this fact, schools and educational institutions around the globe have started to report chillingly low enrolment numbers into the science streams, particularly into Physics (Abd. Karim, 2005; Ben, 2010; KPM, 2012; Laad, 2011). Studies have now revealed that the major cause of this alarming decline is due to poor teaching strategies at school and preparatory class levels (Mekonnen, 2014; Oladejo et al., 2011). The conventional teaching approach, which is commonly practiced worldwide, has been deemed as inadequate

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in providing better conceptual understanding of Physics for students (Oladejo et al., 2011; Karamustafaoglu, 2009).

Conceptual understanding can generally be defined as the understanding of a web of knowledge that is rich in relationships. It is extremely important as it facilitates students to remember, retain and recall concepts in Physics and also its interconnectedness to the world around us. Conceptual understanding can be best demonstrated when students are able to grasp ideas in a transferable way, which allows them to then apply the knowledge into new situations, and across new domains. A proper conceptual understanding in Physics helps students to solve problems theoretically and contextually, without the need to memorize formulas (Saswika, 2014). Conceptual understanding is vital to ensure students' overall achievement in Physics (Saswika, 2014). However, over the past few decades, studies have revealed that most students have failed to understand Physics conceptually, especially when it comes to the concept of 'Force and Motion' (Bani-Salameh, 2017; Costu et al., 2010; Graham et al., 2013). In the context of Malaysia, the situation is quite perturbing, as studies have shown that the level of conceptual understanding of 'Force and Motion' among students is critically low (Halim et al., 2002; Kamarudin & Isa, 2010; Saleh, 2011; Salleh & Phang, 2012). Studies have also shown that most Malaysian students, on numerous occasions, have not been able to solve problems that require a deep conceptual understanding of Physics (Phang et al., 2010; Saleh, 2011).

Literature review has also revealed that Physics achievement among female students has been very predictable, whereby their achievement level is usually lower than that of their male counterparts (Ceci et al., 2009, 2014; Kost et al., 2009; Koul 2012). There is also evidence to suggest that female students are less attracted to Physics compared to their male colleagues (Cassidy et al., 2018; Eilam & Barry, 2016). Similar findings have also been documented in terms of the level of conceptual understanding of 'Force and Motion'. Studies have found that male students overtook female students in understanding concepts related to 'Force and Motion' in more than a few occasions (Birch & Walet, 2012; Bates et al., 2013). Female students seem to face difficulties in understanding the concepts related to 'Force and Motion', compared to male students (Sahin & Yorek, 2009; Li & Singh, 2012). The reason for that, according to Coletta et al. (2012), is that the understanding of this concept requires a strong scientific reasoning ability, which is related to a deep conceptual understanding, normally possessed at a higher rate by male students. Since the brain structures of male and female students are relatively quite different, the way their thinking affects learning, as well as conceptual understanding, is also relatively different. Female students have been found to think more critically than their male counterparts, whereby they tend to use more of their left brain rather than the right (Piaw, 2014). Male students, who are more likely to use the right brain, have been observed to possess higher creativity than their female colleagues (Piaw, 2014). This explains why male students have been seen to perform better in Physics than female students (Wilson et al., 2016).

As 'Force and Motion' is one of the fundamental concepts in Physics, the difficulty in understanding the ideas conceptually has led to the insights into why Physics has been considered as a tough subject, as a whole, by most of the students in this country. Many students, especially females, avoid choosing Physics-related courses (Abd. Karim, 2005; Cassidy et al., 2018; Laad, 2011) at the higher level. Matriculation students in Malaysia (who are considered as excellent students), are also not an exception. Studies have shown that most of these students perceived Physics as a demanding, boring and unattractive subject to study (Veloo et al., 2015). They have also been found to be less motivated to learn Physics than any other science subjects (Abdul Kadir et al., 2016; Veloo et al., 2015). Although the current findings show that, in certain situations, female students do perform better than male students, a gender gap still exists in this subject on the whole.

In Matriculation colleges in Malaysia, the concepts of 'Force and Motion' form nearly half of the Physics syllabus that must be studied during the first semester. Students ought to do well in this topic in order to ace in Physics. However, a majority of Physics educators at the local matriculation colleges have been found to be more comfortable in using and maintaining a conventional teacher-centered approach. This approach has been found to be ineffective in enhancing students' conceptual understanding of Physics, which is an important component of proficiency that entails the ability to use the knowledge flexibly and applying it into another setting appropriately (Granger et al., 2012; Tebabal & Kahssay, 2011).

Recent studies related to Brain-Based Teaching have confirmed that this approach has been able to stimulate students' conceptual understanding, improve attainment, and decrease the gender gap that exists in Physics (Akyurek

& Afacan, 2013; Saleh & Subramaniam, 2018). Research has also shown that the use of thinking tools and brain gym activities can stimulate students' thinking processes, improve focus and increase their long-term memory (Dennison & Dennison, 2010; Long & Carlson, 2011; McNerney & Radvansky, 2015). Since research related to the potential of Brain-Based Teaching with i-Think Maps and Brain Gym Approach (BBT-iTBA) towards students' conceptual understanding on Physics is limited, this study can be considered as significant. Hence, the purpose of this study was to assess the effects of BBT-iTBA as compared to the conventional teaching approach (CTA) towards Physics conceptual understanding amongst matriculation students in the north of Peninsular Malaysia.

Brain-Based Teaching is an approach that centers on neuroscientific findings on how the brain learns and its potential in maximizing human learning capabilities (Caine et al., 2015). It is an approach that emphasizes on the student learning process through habit, structure and the development of the brain. The assumption is that the learning process will happen naturally, if there are no restrictions imposed on the learner's brain. Educators have been encouraged to use a variety of strategies so as to help the construction of synaptic networks within the brain that can lead to better understanding and the retention of information, in a manner designed to be naturally consistent with the brain's way of functioning (Jensen, 2008; Madsen et al., 2015). BBTA focuses on learning through meaningful experiences, which is tailor-made to the students' needs, regardless of their age. It also respects the differences in students and appreciate each student's uniqueness (Jensen, 2008). The implementation of this approach could create a more interesting and meaningful learning experience, and help improve the overall academic achievement of the learners (Jensen, 2008).

Research on the brain has contributed towards a paradigm shift in the teaching and learning practices, from the conventional to a more student-centered approach. Caine et al. (2015) are among the pioneers in this area, and have been known for their contribution on the framework of the twelve brain learning principles to help humans learn better. These twelve principles are divided into three basic elements of effective teaching and learning strategies, namely relaxed alertness, orchestrated immersion and active processing (Caine et al., 2015). Relaxed alertness is related to providing a challenging learning (calm surroundings with minimal threat) environment for the students so that they are always open to learning. Orchestrated immersion is related to immersing the students in a variety of meaningful experiences physically, psychologically, and emotionally, in order for them to consolidate what is being experienced and relate it to what is already known. Active processing is related to providing students with the opportunities to actively process information internally, make appreciation, unification, and generate relevant ideas or decisions.

The i-Think Maps (innovative thinking map), is a set of graphic techniques recommended for use in the schooling system in Malaysia. It is adapted from the systematic thinking tools proposed by Hyerle & Yeager (2007), commonly used to promote and enhance the skills of thinking among students. Compared to common thinking tools, the i-Think Maps encourage students to be more creative in organizing the knowledge they are dealing with. The i-Think Maps represent students' visual thinking, where information or content is depicted visually to show the correlation between concepts (Hall & Strangman, 2002; Rosen & Tager, 2014). The cognitive process involved during the creation of i-Think Maps allows students to store the knowledge/information gained in a much more efficient manner (Long & Carlson, 2011). Through i-Think Maps strategy, students' minds are stimulated to continuously explore information (Maneval et al., 2011), as long as they are engaged in learning activities. Creative i-Think Maps with colors, surprises and humor have demonstrated the ability to evoke emotions and generate a better learning atmosphere for students in general (Banas et al., 2011; Lucas, 2003). The use of i-Think Maps has been widely advocated by educators to help students understand lessons better (Hassan et al., 2016; Long & Carlson, 2011).

The Brain Gym technique is a set of specific physical activities, which involve the coordination of the movements of hands, eyes, ears, with the whole body, designed to improve various outcomes of human skills such as attention, retention and individual performance (Watson & Kelso, 2014). Introduced by Paul and Gail Dennison in the 1970s, it was then further improvised by Dennison and Dennison (2010) and promoted by Brain Gym® International as an educational philosophy, that has been claimed to result in the improvement of learners' performance (Kariuki & Kent, 2014; Watson & Kelso, 2014). The physical activities included in the Brain Gym technique are able to activate both hemispheres of the brain through neurological re-patterning process which encourages whole brain learning in students (Dennison & Dennison, 2010). By practicing this kind of approach, learning problems, including emotional and psychological stress, will be eliminated, thus allowing students to process the knowledge/information gained efficiently (Dennison & Dennison, in Watson & Kelso, 2014). Simple exercises that take place before, during and immediately after the learning process have been said to improve students' memory for a relatively longer period of time (McNerney & Radvansky, 2015). Studies have revealed that the Brain Gym technique can be successfully applied to improve learning as well as to enhance students' overall cognitive and affective performance (Jecinth & Velayudhan, 2007; Kariuki & Kent, 2014; Watson & Kelso, 2014).

By combining Brain-Based Teaching with i-Think Maps and Brain Gym techniques, it is expected that the conceptual understanding of Physics amongst students can be enhanced across gender. The outcomes of this study are expected to offer a significant contribution towards the development of Physics education at the matriculation or A-level study in general.

METHODS

The effects of BBT-iTBA compared to CTA towards Physics conceptual understanding amongst male and female matriculation students in the north of Peninsular of Malaysia were evaluated via a quasi-experimental non-equivalent group research design. A random cluster sampling technique has been used to randomly select a class from two matriculation colleges situated in the north of Malaysia. One of the colleges served as the experimental group, while the other college served as the control group. The sample consisted of 180 matriculation college students, with 95 of them being in the experimental group while the other 85 students made up the control group. The experimental group consisted of 41 male and 54 female students, while the control group consisted of 42 male and 43 female students. The study involved one lecturer who taught the experimental group, and another lecturer who taught the control group. Both lecturers are female, received a similar level of Physics education and have a similar background in teaching experience.

Before the intervention, the lecturer who would be teaching BBT-iTBA was exposed to a series of workshops organized by the researchers. Several micro-teaching practices were carried out using the BBT-iTBA to help the lecturer to familiarize with this teaching approach. The lecturer was also provided with the BBT-iTBA lesson plans, which have been validated by two experts (senior lecturers with more than seven years' experience teaching Physics at matriculation college), to assist her in implementing the intervention on the experimental group. In contrast, the lecturer in the control group would conduct her class using the common lesson plans, via only the conventional teaching approach (CTA).

The Physics Conceptual Understanding Test (PCUT) related to the topic of 'Force and Motion' was used as the main instrument to collect the required data. The PCUT was adapted and modified from the Force Concept Inventory (FCI) developed by Hestenes et al. (1992) to suit the Physics syllabus outlined by the Matriculation Division of the Malaysian Ministry of Education. The final version of the test consisted of 20 multiple-choice items in which each question has five answer options. The instrument was also validated by two experts who have validated BBT-iTBA lesson plans, and the reliability value gained from a pilot study conducted was at 0.91 (KR-20), which indicated that the instrument was suitable to be carried out in the study.

A week before the implementation was conducted, both groups were given the PCUT as a pre-test to acquire an early-stage score for their conceptual understanding of 'Force and Motion'. The experimental group was then exposed to BBT-iTBA (refer to Figure 1), while the students in the control group received the conventional teaching approach (CTA). The intervention lasted for eight weeks (three hours per week) to cover the all targeted topics, including Kinematics Linear Motion, Linear Momentum and Impulse, Forces, Work, Energy and Power. A post-test of the PCUT was then administered after the intervention period to identify the resulting effects between the independent variables (teaching approaches and student gender) and the dependent variables (Physics conceptual understanding). Both pre-test and post-test data obtained were analyzed descriptively and inferentially to determine the effects of the intervention.

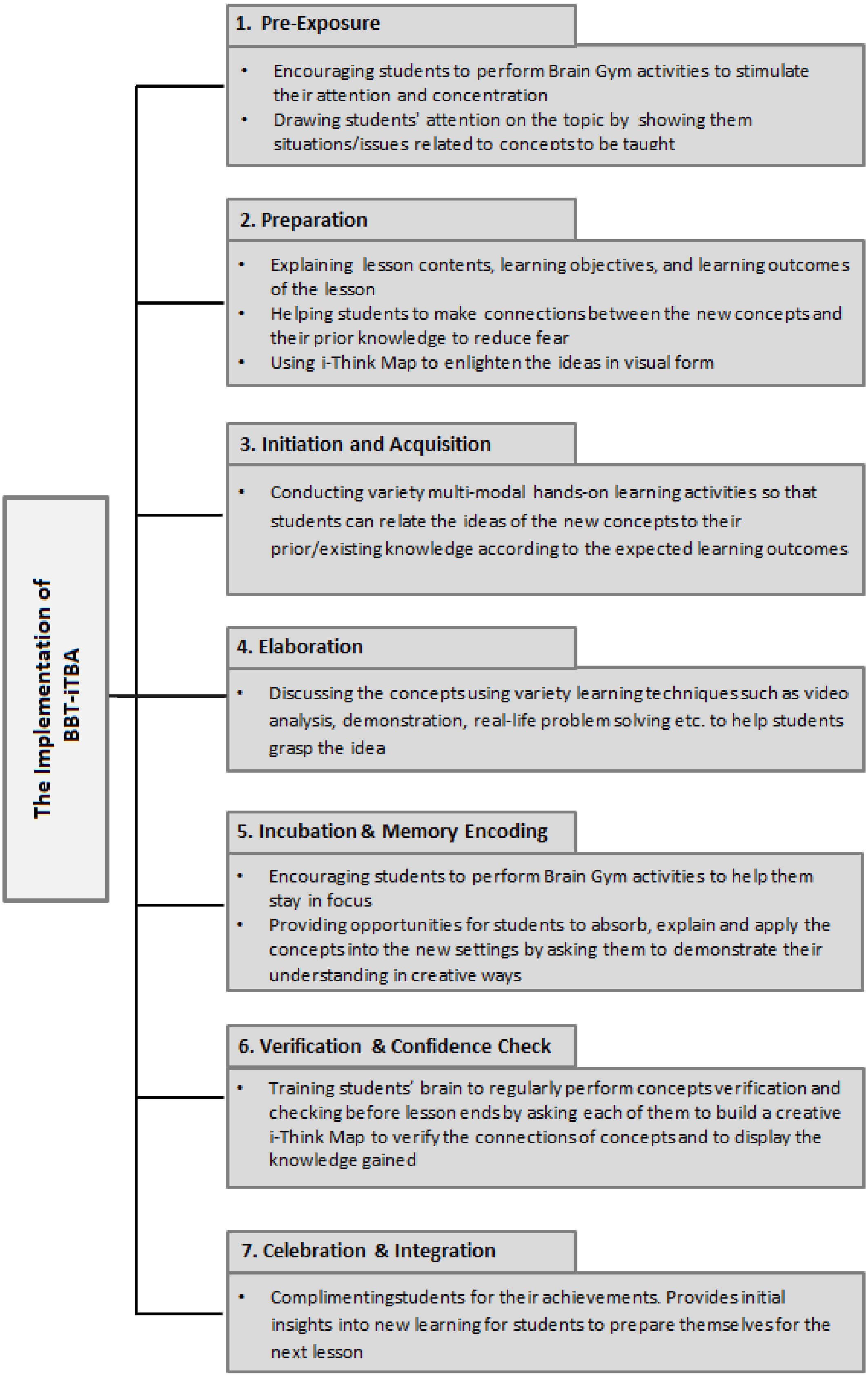

Figure 1. The implementation of Brain-Based Teaching with i-Think Maps and Brain Gym Approach (BBT-iTBA)

RESULTS AND DISCUSSION

Table 1 presents the descriptive and inferential statistics analysis of the pre-test scores, based on gender differences, for both the experimental and the control groups, prior to the intervention of BBT-iTBA and CTA.

Table 1. Descriptive and Inferential Statistics (Two-way ANOVA) Analysis of the Pre-Test Scores Based on Gender for Both Experimental (BBT-iTBA) and Control Groups (CTA)

Group	Gender	Mean	SD	Source	Type III Sum of Squares	Df	Mean Square	F	Sig. (p)	Partial Eta Squared
Experimental (BBT-iTBA)	Male (N=41)	22.85	4.932	Group (Teaching Approach)	38.097	1	38.097	.792	.375	.004
	Female (N=54)	20.98	6.683	Gender	.008	1	.008	.000	.990	.000
Control (CTA)	Male (N=44)	21.91	8.106	Group (Teaching Approach) *Gender	157.393	1	157.393	3.272	.072	.018
	Female (N=45)	23.76	7.526	Error	8658.051	180	48.100			

Table 1 shows that for the experimental group, the mean score for Physics conceptual understanding of male students is 22.85, while the mean score of female students is 20.98. For the control group, the mean score for Physics conceptual understanding of male students is 21.95, while the mean score of female students is 23.76.

The results of the Two-way ANOVA analysis regarding the effects of the teaching approaches, gender and interaction between the teaching approaches, and gender on students' Physics conceptual understanding in the pre-test indicated that prior to the intervention, teaching approaches and gender, have no effect on students' Physics conceptual understanding [see Table 2: F (1, 180) = 0.792, p = 0. 375 and F (1, 180) = 0.00, p = 0.990]. Furthermore, the interaction effect between the teaching approaches and gender on students' Physics conceptual understanding was also not significant [see Table 2: F (1, 180) = 3.272, p = 0.072]. This means that the levels of Physics conceptual understanding of male and female students are the same, and have not been influenced by the teaching approaches before the intervention.

After conducting the intervention for both the experimental (exposed to BBT-iTBA) and the control groups (received CTA), the post-tests were conducted. Table 2 presents the descriptive and inferential statistics analysis of the pre-test scores based on gender difference for both the experimental and control groups after the intervention of BBT-iTBA and CTA.

Table 2. Descriptive and Inferential Statistics (Two-way ANOVA) Analysis of the Post-test Scores Based on Gender for Both the Experimental (BBT-iTBA) and the Control groups (CTA).

Group	Gender	Mean	SD	Source	Type III Sum of Squares	Df	Mean Square	F	Sig. (p)	Partial Eta Squared
Experimental (BBT-iTBA)	Male (N=41)	32.22	4.613	Group (Teaching Approach)	2383.73	1	2383.783	57.521	.000*	.242

	Female (N=54)	30.07	5.801	Gender	.881	1	.881	.021	.884	.000
Control (CTA)	Male (N=44)	22.08	8.231	Group (Teaching Approach) *Gender	183.262	1	183.262	4.422	.037*	.024
	Female (N=45)	24.84	6.592	Error	7459.616	180	41.442			

Table 2 shows that the mean score for male students from the experimental group is M = 32.22, while female students scored M = 30.07. However, the mean score for male students from the control group is M = 22.98, while female students scored M = 24.84. The findings also show that the post-test scores for male and female students from the experimental group are significantly higher than that of their counterparts in the control group. Compared to the pre-test scores, it is found that the increment of the male and female scores in the experimental group is distributed almost equally and is vastly higher than those in the control group.

The results of the Two-way ANOVA analysis regarding the effects of the teaching approaches, gender and interaction between the teaching approaches and gender on students' Physics conceptual understanding in the post-test indicated that after the intervention, students' Physics conceptual understanding differs significantly, due to the implementation of the different teaching approaches [F (1, 180) = 57.521, p=0.000] with great size effect (Partial Eta Squared = 0.242). Although gender alone does not affect students' Physics conceptual understanding [F (1, 180) = 0.21, p = 0.884], the results revealed that the interaction effect between the implementation of the teaching approaches and gender on the attainment of students' Physics conceptual understanding is rather significant [F (1, 180) = 4.422, p = 0.037], with a simple size effect (Partial Eta Squared = 0.024). This means that the levels of Physics conceptual understanding of male and female students after the intervention are different and are mainly influenced by the teaching approaches used and also by the interaction effects between the teaching approaches and gender. Male and female students in the BBT-iTBA group performed significantly better in the PCUT compared to male and female students in the CTA group.

The findings of this study are consistent with the results of previous studies which revealed that the Brain-Based Teaching Approach could lead to a remarkable improvement in student academic achievement (Bawaneh et al., 2012; Banchonhattakit et al., 2012; Fazil & Saleh, 2016; binti Mazlan, 2017; Saleh & Subramaniam, 2018). The findings are also consistent with the results of previous studies (Coletta et al., 2012; Kost et al., 2009), which show that male students outperform female students in Physics conceptual understanding, particularly in Force and Motion related topics. The improved test scores proved that the BBT-iTBA has managed to improve the Physics conceptual understanding among students across gender. The BBT-iTBA, which was designed with an emphasis on the optimum function of the human brain, equipped with the i-Think Maps to promote and enhance the skills of thinking, and Brain Gym activities to create a relaxed and fun learning environment, has helped students to better understand Physics conceptually. Due to the fact that the BBT-iTBA appreciates students' differences and uniqueness, the implementation of this approach also has proved to increase male and female students' attainment of Physics conceptual understanding, on an almost equal basis.

This is because at the early stages of the implementation of the BBT-iTBA, students were provided with the ideas of the lesson contents, learning objectives and learning outcomes expected from the lessons. The phase was to ensure that the students were always ready to learn and can devote full attention towards the lessons. The relevance of past experiences and existing knowledge with the learning concepts was also emphasized, to help students build the required new knowledge. Various learning experiences within a conducive learning environment during the initial, acquisition phases, as well as elaboration phases, have helped empower students to manage their emotions and entire physiology to make a richer connection to the information obtained, in order to conceptually understand the learning concepts. The understanding gained was again further strengthened during the following phase of elaboration, whereby in-depth discussions of the learning concept took place between the students and the lecturer.

The phases of incubation and memory encoding in the BBT-iTBA encouraged students to integrate the learning concepts into a new setting, and was found to also be effective in promoting and enhancing Physics conceptual understanding. Throughout this phase, students were given opportunities to absorb, explain and apply the concepts into the new settings by asking them to demonstrate their understanding in their own creative ways. These include debate, issues analysis, solving real-life problems and etcetera. The Brain Gym activities have also helped ease the tension that may arise during this phase. The background music played has helped calm students' emotions during the time when they were dealing with the information. This type of learning environment had led towards a better acquisition of the conceptual understanding of Physics amongst students, which were again strengthened during the phases of verification and confidence check. During this phase, the use of i-Think Maps was significant for students, to help them structure the ideas gained appropriately and more systematically. This strategic thinking approach which allowed students to think critically and creatively was helpful in ensuring the establishment of appropriate conceptual understanding. The compliments given during the last phase of this approach left the students with a positive emotion from the learning process, which helped ease the transferring process of the information to their long term memory.

The overall results of the implementation of BBT-iTBA have shown a rise in student activity in an optimum learning environment (relaxed alertness, orchestrated immersion and active processing), which required students to engage in various learning experiences while enhancing their thinking skills, as well as improving other learning skills such as focusing, reasoning and retention (Caine et al., 2015; Tokuhama-Espinosa, 2015; Watson & Kelso, 2014). The structured learning activities planned according to how the brain works, implemented through BBT-iTBA, have helped students' brains to work more effectively (Jensen, 2008). These activities have also enabled both hemispheres of the students' brain to function in a more optimal manner, in order to grasp the ideas conceptually (Dennison & Dennison, 2010; Jensen, 2008). These are in line with the Neuro Linguistic Programming study, which discloses that the implementation of teaching approaches through various sensory inputs such as visualization, auditory and kinesthetic in the learning process, can enhance the acquisition of knowledge/information of the students.

CONCLUSION

This study has revealed that the combination of three powerful techniques (BBT, i-Think Maps and Brain Gym) through the implementation of BBT-iTBA has vastly improved the Physics conceptual understanding amongst matriculation students across gender, as compared to the CTA. The main features of the BBT-iTBA, which are: focusing on the optimum function of the brain; promoting and enhancing the skills of thinking; and creating a relaxed and fun learning environment; are found to be the significant triggers for students to better understand Physics conceptually and excel in the subject.

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