

Dealing with the Problem of the Differences in Students' Learning Styles in Physics Education via the Brain Based Teaching Approach

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Received: 1 Mar. 2012, Revised 21 Jun. 2012; Accepted 03 Aug. 2012

Abstract: The aim of this study was to assess the effectiveness of the Brain Based Teaching Approach (BBTA) in dealing with the problem of the differences in students' learning styles concerning the subject of Physics education, at the Form Four secondary school level in Malaysia. The assessment technique employed was based on the Brain Based Learning Principles, a brain compatible strategy. This strategy focuses its attention and consideration on seven major steps: (i) *Activation*, (ii) *Clarify the outcome and paint big picture of the lesson*, (iii) *Making connection*, (iv) *Doing the learning activity*, (v) *Demonstrate student understanding*, (vi) *Review for student recall and retention / Closure* and (vii) *Preview the new topic*. The effectiveness of the teaching approach via BBTA, within the targeted context, was then assessed in a quasi-experimental research approach involving 200 students from two Science Secondary Schools in the northern states of peninsular Malaysia. Students' preferred learning styles were then determined via the Student's Learning Style Questionnaire, while their Physics understanding achievement were assessed through the Test of Newtonian Physics Conceptual Understanding. The findings of this research showed that this teaching approach was effective in dealing with the problems aforementioned. It concludes that more students from the group that provided with the Brain Based Teaching Approach possessed a better conceptual understanding Physics, compared to the group that was taught using the conventional method.

Keywords: Brain Based Teaching Approach, learning styles, individual differences, Physics learning and instruction, Newtonian Physics.

Introduction

In Malaysia, studies have found that students, in general, lack interest towards the subject of Physics taught at either schools or higher learning institutions (Abd. Karim et al., 2006; Lee et al., 1996). They generally tend to avoid this subject because Physics, in contrast to other science subjects, is often perceived to be more difficult (Abd. Karim et al., 2006; Lee et al., 1996;). This negative view, according to Mohd. Salleh (2004), Sidin (2003) as well as Syed Zin & Lewin (1993) is due to ineffective traditional instructional methods, which are seen as being too mechanistic, too passive and too academic. Ideas in the subject of Physics are delivered as isolated, abstract concepts from the student's world and interests (Mohd. Salleh, 2004; Syed Zin, 2003; Sidin, 2003; Syed Zin & Lewin, 1993; Hestenes, 1992) and are taught with more focus on calculations and less on conceptual understanding (Campbell, 2006).

In most of the cases, studies have shown that students have developed the lack of interest and oftentimes, find it difficult to follow certain subject matters taught in schools, due to the inability of the current teaching process and methods to adapt to their now rather specialized learning techniques (Cahyadi, 2007; Mohd. Salleh, 2004; Sidin, 2003; Bacok et.al, , [Online]; Mc Carthy ,1997). This phenomenon is probably due to certain defects in the current teaching and learning methods employed by educators. The *teacher-centered* and *one-way approach* still seem to be the dominant pedagogical method in the classroom, especially in schools in the rural areas of Malaysia (Mohd. Salleh, 2004; Sidin, 2003; Cahyadi, 2007; Mladenovic, 2000; Ngah Razali et al., 1996; Habib et al., 1996; Agness, 1996; Syed Zin & Lewin, 1993, 1993; Nik Pa, 1992). From a pedagogical standpoint, it has been found that present teaching practices still focus on memorizing techniques, simple subject focus, and note-taking techniques (Cahyadi, 2007; Syed Zin, 2003; Mladenovic, 2000; Syed Zin & Lewin, 1993, Nik Pa, 1992), whereas active student

involvement in the learning process have been very limited (Cahyadi, 2007; Syed Zin, 2003; Nik Pa, 1992). Other aspects such as comprehension, practice and personal experience have not been fully capitalized. The current teaching methods have also failed to assist students in making the necessary connections between subject matters learned with students' real-life/real-world experiences, and also learning situations within the classroom context and students' real-life/real-world experiences (Gabbin, 2002). These methods have not only resulted in the lack of interest amongst students, but also have been severely ineffective in augmenting students' academic results (Gabbin, 2002).

In addition, the currently employed teaching and learning approach has also been seen as ineffective in generating the optimum potential of students' learning capabilities, as each student has a different learning style (Bacok et al. [Online]; Salleh, [Online]; Ngah, [Online]). This is because the teaching method currently practiced is seen to be giving priority to only a few groups of students. By and large, teaching methods in current classrooms seem to typically stress on linear information processing approach (Syed Zin, 2003; Mok, 1997; Lourdusamy, 1994; McCarthy, 1987). This approach seems to only benefit students who are left-brain dominated and is rather unable to entice the interest of right-brain dominated students (Sousa, 1998; 1995). As a result, only students with a certain type of learning inclination are able to benefit from this type of teaching process. The rest of the students generally fall out of interest in the taught subject. Inadvertently, this situation may well be the cause of the unbalanced learning opportunities currently detected amongst students and therefore could well be the major cause of the high disparity of achievements amongst students with different learning capabilities.

Learning styles are important because they have been identified as one of the determining factors of students' academic achievement (Terregrosa, Englander & Englander, 2009; Rasyid, 2003; Dunn & Griggs, 2000), in addition to the ability to boost student motivation and learning productivity (Dunn, 1995; Price, Dunn & Dunn, 1990). The results of this entire research will illustrate that there is, in fact, a real relationship between learning styles and students' academic achievements (Terregrosa, Englander & Englander, 2009; Abd. Aziz, 2004; Ghani, 2004; Habib & Azizan, 1997, 1993; Baba & Chong 1992).

Theoretically, it can be stated that a teaching and learning process can be optimized if the factor of the differences in a student's learning style is given top priority (Terregrosa, Englander & Englander, 2009; Geiser, Dunn, Denig, Beasley, 2001; Honey & Mumford, 2000, 1986; Dunn, 1995; Mc Carthy, 1987; Kolb, 1984). Research has shown that different students require different teaching/learning approaches in order to improve their learning capabilities (Meehan, 2005; Dunn, Thies, & Honigsfeld, 2001; Honey & Mumford, 2000, 1986; Dunn & DeBello, 1999; Montgomery, 1995; Kolb, 1984). Furthermore, according to Hyland (1993), to improve students' achievement, teaching styles and also learning styles need to complement each other. However, issues arise when, in general, research conducted show that these matters have been severely neglected in the teaching and learning processes in the classroom. The majority of the teaching and learning processes nowadays undergo teaching style conditions that do not match students' learning styles (Bacok et al., [Online]; Salleh, [Online]; Ngah, [Online]; Lawrence, 1997; Robitaille, 1993; Anderson, 1989). Research results have shown that "*teacher-directed*" teaching style is still very dominant amongst educators (Cahyadi, 2007; Syed Zin, 2003, Robitaille, 1993; Nik Pa, 1992; Anderson, 1989; Crosswhite, 1987). This has resulted in student boredom, lack of attention in class, unsatisfactory test results and lack of interest in the subjects presented (Bacok et al., [Online]; Dunn, 1995).

Jensen (1996) quoted that students' interest towards subjects taught is actually related to the tendencies in their learning styles. They will learn effectively if the teacher's teaching style corresponds to their own learning styles (Jensen, 1996). However, it is found that most of the teaching processes occur without the consideration of students learning styles (Bacok et al. [Online]; Salleh, [Online]; Ngah, [Online]; Lawrence, 1997; Robitaille, 1993; Anderson, 1989). As a result, students find themselves unable to catch up the lesson and at the end give up and turn down the subject. Research has also concluded that students' learning styles play an important role in determining their academic achievement in the subjects learned (Abd. Aziz, 2004; Ghani, 2004; Geiser et al., 2001; Habib & Azizan, 1997; Baba & Chong, 1992). The

trend shows that if the teacher's teaching style concurred with the student's learning style, the results will be surprisingly amazing (Klavas, 1993; Smith & Renzulli, 1984; Spires, 1983). Hence the need for a more effective teaching method, in order to not only stimulate student interest, but also to boost student learning capacities, particularly in science subjects such as Physics.

In this context, the Brain Based Teaching Approach (BBTA) can be seen as a potential solution to these issues. In general, the Brain Based Teaching Approach is a strategy implemented based on the Brain Based Learning Principles developed by Caine & Caine (2003, 1997, 1991), Jensen (1996) and Sousa (1995) through related brain research. This rather unique teaching approach was designed in such a way that is compatible to the structure, tendency and optimum function of the human brain, to ensure the effectiveness of the individual learning process (Caine & Caine, 2003, 1997, 1991; Jensen, 1996; Sousa, 1995). Although all teaching processes are essentially brain based, compared to other methods, the BBTA is a strategy specifically created to value the true potential of the human brain in a learning process (Caine & Caine, 2003, 1997, 1991). It is based on the fact that the human brain is an organ of extremely high potential and that every student is able to learn effectively, if their brain is given the opportunity to function in an optimum manner. The integration of these optimum learning state elements, involving Orchestrated Immersion – which creates a learning environment that fully immerses students in many educational experiences; Relaxed Alertness – which eliminates fear in the learners while maintaining highly challenging environments; and, Active Processing – which allows the learner to consolidate and internalize information by actively processing it (Caine & Caine, 2003, 1997, 1991), is believed to be able to fulfill various learning requirements, whilst fostering interest among students.

Brain Based Learning Principles

According to this theory, each education should integrate all of these elements:

(a) *Relaxed Alertness – emotional climate:*

1. The brain learns best in its optimal state
2. The brain's bio-cognitive cycle influences the learning process
3. Emotions are critical to the brain's patterning process
4. Learning is enhanced by challenge and inhibited by threat.
5. Positive climate stimulates brain function
6. Appropriate environment, music and aroma excite brain activity

(b) *Orchestrated Immersion – instruction:*

7. The brain is unique and is a parallel processor (able to perform several activities at the same time).
8. Search for meaning comes through brain patterning process.
9. The brain processor works in wholes and parts simultaneously
10. Complex and active experiences involving movements stimulate the brain development
11. Learning engages the whole physiology

(c) *Active Processing – strengthening:*

12. Learning involves both focused attention and peripheral perception
13. Learning involves both conscious and unconscious processes
14. Learning always takes place in two memory approaches - to retain facts, skills and procedures; and/or making sense of experience
15. The brain can easily grasp and remember facts and skills embedded in its memory space.
16. Rehearsal is necessary to retain information in the brain

Brain Based Learning Principles

Source: Saleh (2011)

Implementation Strategy of the Brain Based Teaching Approach

The Brain Based Teaching Approach in this research was generally implemented based on the integration of 'Brain Based Learning Principles' (Caine & Caine, 2003, 1997, 1991; Jensen, 1996; Sousa, 1995) through seven brain compatible instructional phases (Sousa, 1995; Smith 2003): (i) *Activation*; (ii) *Clarification of the outcome and painting the big picture of the lesson*; (iii) *Making the connection*; (iv) *Doing the learning activity*; (v) *Demonstration of student understanding*; (vi) *Review of student recall and retention / Closure*; and (vii) *Previewing the new topic*. Optimal learning state is the main feature of this approach.

Implementation of the Brain Based Teaching Approach

A. Instructional Phases

Phase	Features	Brain Based Learning Principles
<i>Activation</i>	Activate the memory processor system and student's prior knowledge to stimulate the transfer process.	(i) Brain learns best in its optimal state (ii) Learning is enhanced by challenge and inhibited by threat. (iii) Brain processor works in wholes and parts simultaneously
<i>Clarify the outcomes and paint the big picture</i>	- Have the students affirm for themselves personal performance target (Smith, 2003). - Activate the right brain processor prior to the left brain (Sousa, 1995,1998) - Alleviate anxieties over the accessibility and relevance of the material (Smith, 2003; Sousa, 1995, 1998).	(i) The brain is unique and a parallel processor (able to perform several activities at the same time). (ii) Brain processor works in wholes and parts simultaneously
<i>Making connection and develop meaning</i>	- The stage where the topic or unit of work about to be completed is connected with what has gone before and what is to come (Smith, 2003). - It builds on what the learners already know and understand and helps them assimilate and integrate new information (Caine & Caine, 1991, 2003; Smith, 2003).	(i) Learning involves both focused attention and peripheral perception (ii) Learning involves both conscious and unconscious processes. (iii) Learning always takes place in two memory approaches, to retain facts, skills and procedures or making sense of experience (iv) Brain can easily grasp and remember facts and skills embedded in its memory space.
<i>Doing the learning activity</i>	- The stage for digesting, thinking about, reflecting on and making sense of experience utilizing visualization, auditory, kinesthetic in multiple contexts. - Access all of the multiple intelligences. (Jensen, 1996; Smith, 2003).	(i) The brain is unique and a parallel processor (able to perform several activities at the same time). (ii) The search for meaning comes through brain patterning process. (iii) Brain processor works in wholes and parts simultaneously (iv) Learning involves both conscious and unconscious processes. (v) Complex and active experience involving movement stimulate brain development (vi) Learning engages whole physiology
<i>Application and</i>	The stage for brain active processing	(i) The brain is unique and a parallel

<i>integration / Demonstrate student's understanding</i>	(Caine & Caine, 1991, 2003; Smith, 2003).	processor (able to perform several activities at the same time).
	(ii)	Learning always takes place in two memory approaches, to retain facts, skills and procedures or making sense of experience
<i>Review for students retention / Closure</i>	The activity stimulates working memory to summarize the lesson (Sousa, 1995, 1998).	Learning involves both conscious and unconscious processes.
<i>Preview the next topic</i>	The experience helps brain pre-processor and reptilian brain to focus on the new lesson (Shaw & Hawes, 1998).	Learning involves both focused attention and peripheral perception

Table 1: Brain Based Teaching Approach Instructional Phases
Source: Saleh (2011)

In general, in the Brain Based Teaching Approach classroom, students were assured to; (i) be actively involved in all the seven brain compatible instructional phases listed above, (ii) have fun learning (multiple representations such as slide shows, videos, group discussions, minds on and hands on activities), and, (iii) learn in their context and related to their existing knowledge (learning activities organized based on the students' everyday experiences, such as students' own experience on the concept of inertia, force, action and reaction, et cetera) to explore the idea of Newtonian Physics concepts (Saleh, 2011).

Research Objectives

The aim of this study was to assess the effectiveness of the Brain Based Teaching Approach in dealing with problem of the differences in students' learning styles concerning the subject of Physics education, at the Form Four secondary school level. In particular, this study was conducted to determine whether there is a different pattern of Newtonian Physics conceptual understanding score among the students with different learning styles enrolled in the Brain Based Teaching Approach (BBTA) classroom, compared to those who were taught using the conventional teaching method (CTM).

Research Methodology

The research was conducted using the design of quasi-experimental approach. Research samples consisted of 200 students: 100 in an experimental group, and the other 100 in a control group. These students were randomly selected from two equivalent schools and involved Form Four students to represent the population of Science Secondary School students in the northern peninsular states of Malaysia. Prior to the intervention, two teachers with approximately equal educational levels and teaching experience were chosen to teach each group. One of them was trained on how to teach using the Brain Based Teaching Approach over a six hour session, whereas the other one was only told to conduct the Physics teaching as usual. After the training process completed, the Student's Learning Style Questionnaire (Honey & Mumford, 2000, 1986) was distributed to the students in order to identify the samples' learning styles. This questionnaire classified students into four basic types of learning styles preferable, namely: (i) Theorists - detailed learner, think problems through step-by-step; (ii) Activists - experiential learner, enthusiastic about new ideas; (iii) Pragmatists - independent learner, eager to try things out; and (iv) Reflectors - conscientious but hard to get started learner (Honey & Mumford, 2000, 1986). The experimental group was then given the Brain Based Teaching Approach (BBTA) by the trained teacher while the control group followed the Conventional Teaching Method (CTM), in learning the topic of "*Force and Motion*", according to the current Form Four Physics syllabus. The implementation of these teaching methods took about three months to be completed. Students' physics achievement was measured through the Test of Newtonian Physics Conceptual Understanding before (pre-test) and after (post-test) the intervention, to determine the effectiveness of the implemented BBTA. The development of the test was done by adopting the required items from the relevant reference materials such as Force Concept Inventory (*Hestenes*,

Wells, Swackhamer, 1992), ConcepTests (Mazur, 1997), text books and reference books. (The reliability of this instrument had been tested in a pilot test conducted on a different sample before the intervention). Data collected were then analyzed descriptively and inferentially using the technique of ANOVA analysis.

Findings

From the Table 2, pre test results obtained show that for both the samples in experiment (exposed to BBTA) and control (followed CTM) groups, students inclined to a certain learning style portrayed a slightly better result than other students.

A substantial difference in the gain scores can be noticed between students in the experiment group and those in the control group. Gain scores of the students within the experiment group are seen to be higher than the gain scores of the students within the control group. This result indirectly shows that exposure to the BBTA is significant in generating students' conceptual understanding of Newtonian Physics than that of CTM.

Table 2: Student's mean score, standard deviation and gain score in pre and post test of Newtonian Physics conceptual understanding between experimental and control groups.

Students' Understanding of Physics	Conceptual of Newtonian	No. of Students	Pre test mean score	Post test mean score	Gain Score
Experiment Group (Exposed to BBTA)	Reflectors	23	6.20	19.60	13.40
	Activists	25	6.40	19.90	13.50
	Theorists	28	6.60	19.67	13.07
	Pragmatists	24	6.40	19.40	13.00
Overall		100	6.42	19.62	13.20
Control Group (Followed CTM)	Reflectors	24	6.40	12.20	5.80
	Activists	24	6.55	14.82	8.27
	Theorists	27	6.64	16.14	9.50
	Pragmatists	25	6.47	14.20	7.73
Overall		100	6.52	14.48	7.96

Results obtained also show that for the experiment group, relatively similar/constant gain scores were obtained by the different groups of students with different learning styles (reflective, activist, theoretical and pragmatic). Due to the implementation of the BBTA, which takes into account various aspects of enriched experiences that are in-line with the different student learning inclinations, results show that it is able to reduce the existing gap difference and further develop optimum student potential. For the control group, gain scores obtained by students with different learning styles greatly differ, whereby the highest gains scores were obtained by theorists students, followed by the activists, pragmatists and reflectors. This result indirectly shows that conventional teaching methods (CTM) seem to focus more on the theoretical student group and is less effective in the context of generating the optimum potential of students with different learning style inclinations.

The following is the ANOVA analysis conducted to determine whether or not there is a significant difference in achievement between student groups with different learning styles in both the experiment and the control groups, in terms of their conceptual understanding of Newtonian Physics.

Table 3: One-Way ANOVA analysis for min score of Newtonian Physics conceptual understanding post test between different groups of students with different learning styles in the BBTA group.

	Sum of Squares	df	Mean squares	F	Significance
Experiment Group	1.547	3	0.516	0.033	0.99
Control Group	93.129	3	31.043	3.804	0.02

Significance Level, $p = 0.05$

Results acquired in Table 3 show that there is no significant difference in min score of Newtonian Physics conceptual understanding ($F=0.033$; $p=0.99$, $p>0.05$) in the *post test* between different groups of students with different learning styles in the experiment group. However, for the control group, results show a significant difference in min score of Newtonian Physics Conceptual Understanding ($F=3.804$; $p=0.02$, $p<0.05$) between different groups of students with different learning styles involved.

In relation to the results obtained from the control group, a *Post Hoc* test was conducted to determine which group exhibits the most significant difference. Results of this test are shown in Table 4:

Table 4: *Post Hoc* test results for the difference in min scores of Newtonian Physics conceptual understanding post test between different groups of students with different learning styles in the CTM group.

Learning Style (a)	Learning Style (b)	Min Difference (a-b)	Std. Deviation	Significance	95 % Confidence Interval of Difference	
					Lower Boundary	Upper Boundary
Conceptual understanding						
1	2	-2.618	1.248	0.169	-5.945	0.709
	3	-3.943*	1.183	0.009*	-7.095	-0.790
	4	-2.000	1.166	0.328	-5.108	1.108
2	1	2.618	1.248	0.169	-0.709	5.945
	3	-1.325	1.151	1.660	-4.393	1.743
	4	0.618	1.134	0.947	-2.404	3.641
3	1	3.943*	1.183	0.009*	0.790	7.095
	2	1.325	1.151	0.660	-1.743	4.393
	4	1.943	1.062	0.273	-0.887	4.772
4	1	2.000	1.166	0.328	-1.108	5.108
	2	-0.618	1.134	0.947	-3.641	2.404
	3	-1.943	1.062	0.273	-4.772	0.887

Significant Level, $p = 0.05$

* Difference is significant at Level 0.05

Guide: Learning Style: 1 – Reflectors, 2 – Activists, 3 – Theorists, 4 – Pragmatists

Results obtained from the *Post Hoc* test show that a significant difference exists in the Newtonian Physics conceptual understanding between students in the reflectors group and theorists group, with the min difference of 3.943 and $p=0.009$, $p<0.05$.

Discussion and Conclusion

Results from the research conducted show that there is no significant difference in the Newtonian Physics conceptual understanding score between different student groups with different learning styles within the experimented groups (following the BBTA). Overall, consistent scores of Newtonian Physics conceptual understanding were obtained between the groups of students who are inclined to reflectors, activist, theorists and pragmatists learning styles, within the groups. The implications of this result show that the BBTA is effective in achieving optimum learning potential of students with different learning styles.

In relation to the intervention of the performed BBTA, optimal learning potential of students inclined to different learning styles was successfully generated because of the implementation of brain compatible teaching and learning strategies. Following the principle that the brain is unique and that each student is different from one another (Caine & Caine, 2003, 1997; 1991; Jensen, 1996; Sousa, 1995), the implementation of this approach emphasizes the variation of input, contexts and students processing ability. Presentation of information using different sensory inputs, specifically that of visualization, auditory and kinesthetic, can ensure that no group of students will be left out of the teaching and learning process involved. A variety of student contexts, exposed to a variety of different real-world based learning activities, along with the use of selected media in a structured yet flexible environment to the individual or groups of students, allows for a variety of approach choices that are more likable to the students (Jensen, 1996). Emphasis on a variety of student information processing strategies, especially via the comprehensive information presentation technique, followed by a detailed concept discussion, as well as 'minds on' technique via texts, books, discussion activities and problem solving, and 'hands on' technique based on the concept of 'learning by doing', can ensure that each and every student is able to grasp the concepts learned (Jensen, 1996).

Exposure to a variety of different learning experiences using an approach based on learning in a comfortable environment style is also seen as capable of rendering students more flexible, in the context of adapting their learning style to a strategy that is of lesser choice (Felder, 1993). Based on a more open teaching method, students are free to explore their study materials using a variety of approaches, and are also be able to directly participate in each activity conducted. This unconscious process not only increases the brain's efficiency in processing information but also stimulates the development of cognitive and affective skills sought after by the students. Therefore, this practice is found to guarantee beneficial gains to all students involved and thus, is effective in the generation of their optimum learning potential.

Consequently, a different result is obtained by the group of students who received CTM. Research result show that there is a significant difference in scores obtained in Newtonian Physics Conceptual Understanding between students with different learning style inclinations within the group. It is found that the highest scores were obtained by the theorists group, followed by the activists, pragmatists and reflectors groups. This is probably due to the fact that the conventional teaching strategy is unable to take into account the aspect of students' various individual differences. The approach based on student learning style is less emphasized in each and every learning and teaching activity conducted. Teachers generally conduct teaching based on their learning style inclinations without knowing that student are actually 'multi-processors' (Jensen, 1996). The strategy employed seems to concentrate on linear information processing technique, which theoretically emphasizes the theoretical student group as compared to others. The inclusion of emotional elements (especially that of feelings), to which the reflective group of students are more inclined to, are only minimally inserted. As a result, students from the reflective group are seen to be less interested in the teaching and learning strategy practiced, thus resulting in the lowest scores in the conceptual understanding of Newtonian Physics test.

Therefore, in conclusion, it is found that the Brain Based Teaching Approach is effective in dealing with the problems of the differences in learning styles amongst students.

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