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Using Herrmann Whole Brain Teaching Method To Enhance Students' Motivation Towards Science Learning

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ABSTRACT

The purpose of this study was to investigate the effect of Herrmann Whole Brain Teaching Method (HWBTM) to enhance eighth grade students' motivation towards science learning in Jordan. The randomly selected sample (N=357) including students within the Bani Kananah Directorate of Education-Jordan. One hundred eighty-three (Male = 98, Female = 85) students were instructed using HWBTM whereas hundred seventy-four (Male = 82, Female = 92) students were taught how to use the conventional teaching method (CTM). Two instruments were developed: 1) Thinking Preference Questionnaire to classify participants based on their preferred thinking styles; and 2) Student's Motivation towards Science Learning Questionnaire. Data were analyzed using a 2-way ANCOVA and Post Hoc with split file techniques and a significance threshold (α) of 0.05 using the SPSS software package. The results showed that HWBTM surpassed the CTM in enhancing students' motivation towards science learning. The results showed that there are no statistical significant differences amongst the students' preferred thinking styles across HWBTM on students' motivation towards science learning. However, there are differences across CTM. The results also showed that the main effect of students' gender on the post test score of students' motivation towards science learning were not found statistically significant.

Key Words: Students' Motivation; Brain Based Teaching Method; Students' Preferred Thinking Styles, Science Learning.

INTRODUCTION

Motivation has much to do with behavior stimulation, orientation and continuation to achieve targets of the teaching-learning process (Treagust & Duit, 2009; Lee & Brophy,

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1996). Educators, as a result, were greatly interested in identifying factors that increase students' motivation and lessen laziness, since low motivation is a major hindrance for learning (Kuyper, Werf & Lubbers, 2000; Wolters, 1999; Garcia, 1995).

Salim (1993) argue that motivation to learn is an important issue in explaining student behavior in classroom situations. Dropout rates, low achievement, problematic classroom behavior, and negative attitudes toward learning are amongst problems attributed to weak motivation to learn.

Tuckman (1999), and Brewster and Fager (2000) argue that enhancing motivation to learn in students is one of most challenging tasks even for the most professional and experienced teachers. Rogers, Ludington and Graham (1999) claim that every student has motivation to learn something, but unfortunately, many students do not have motivation to learn what is taught. The problem lies not only in creating motivation to learn in students, but also in making available attractive environment and conditions within which students feel motivated to learn, rather than being obliged to learn. Abu Mallouh (2001) agree with this argument explaining the observation of rejoice at the end of the school year and disloyalty to school by the gap between student wishes and needs from a hand and current status of the school on the other.

McCombs and Whisler (1997) viewed that focusing on learners and their needs as emphasizing on the learning process positively affects learner's motivation to learn and improves their achievement. This requires the educational system to meet students' individual needs such as emotional, physical, psychological, social and academic needs. The students' personality and thinking style need to be put into consideration, too. Students, when given equal opportunity to proceed in the learning process, will feel motivated and willing to stay in school, to learn, to be more productive, and to motivate to perform their duties and tasks.

Though Evans (2007) confirmed that the brain can be developed and changed based on previous experiences, many educators (Kaufman et al., 2008) insisted on the importance of employing research results related to brain and the way it processes information in the learning-teaching field. On the same note, Salmiza (2010) designed a teaching method that uses the brain data processing mechanism in enhancing motivation to physics learning among Malaysian students. The study's findings found positive effect on student motivation to learn physics. The result also receives support from Salamat (2010) in that learning based on brain approaches had a positive effect and improved students' motivation to learn science.

The present study also employs Herrmann Whole Brain Model (HWBM) to design electric concepts module that will be taught to students for the purpose of enhancing their motivation to learning physics. Herrmann (1989) argued that identification of student learning styles and developing instructional material accordingly would further integrate thinking styles of an individual student at an equilibrium level, Hence acquiring the so-called Whole Brain thinking that characterizes with elastic thinking and viewing a situation from multiple perspectives with greater creativity. This finally provides a positive affect and enhances students' motivation to learning (Felder, 1996; National Science Foundation, 2002). However, She (2005) also emphasized that students' attitudes towards learning science will improve when taught with a teaching method that matches their thinking styles as suggested by HWBM.

Many studies (Cole, 1997; Nowell & Hedges, 1998; Mills, Coffey-Corina & Neville, 1993; Fennema et al., 1998; Linn & Hyde, 1998; Shakeshaft, 1995; Sjoberg & Schreiner, 2005; Reiss & Zhang, 2006) have shown that boys and girls possess different learning methods due to the differences in the way they think and perceive their respective roles in the classroom. Therefore, teachers teaching boys and girls must make a distinction in the approach needed to handle the different gender. In terms of motivation in learning, boys and girls have many differences in terms of characteristics and individual preferences according to their gender (Taber, 1991; Thibert & Karsenti, 1996; Tindall & Hamil, 2004; Anderson, Hamilton & Hattie, 2003).

Tindall and Hamil (2004) held the same view that boys and girls have different preferences for learning certain topics in that boys are all for topics that involve the psychomotor coordination whilst girls opt for topics related to esthetic thinking and emotional relationships. However, there should be more detailed information in this area to allow policy makers, educators and education planners alike to distinguish the strengths and weaknesses for each gender in each of the specific area so as to plan for the most suitable curriculum, assessment and methodology to teach and assess each group of students effectively. Hence, more researches need to be conducted in the area of gender as an independent variable so as to unearth more information in this area.

Herrmann Whole Brain Model (HWBM)

Herrmann (1988) proposes that the brain is divided into an upper part and a lower part based on learning characteristics, both of which are further subdivided into right and left portions. The upper part deals with abstract and conceptual concepts whilst the lower part deals with emotional and intrinsic ideas. The left-upper part deals with logic and quantity whereas the left-lower parts deal with sequence and organization. On the other hand, the right-upper part deals with conceptual and visual notions, whereas the right-lower part deals with interpersonal and emotional concepts.

Many studies (Bawaneh, Zain & Salmiza, 2010; She, 2005) have described the four parts of brain in light of HWBM, and proposed the teaching methods to be fit for each part. For example, the left-upper part is logical and rational, depending on facts, quantitative and arithmetic analyses, and realistic thinking. In contrast, the left-lower part focuses on sequentially organized details, planned work, specific scheduled procedures and risk-avoidance. For Herrmann, the third part of the brain is the right-lower, which is emotional, intuitive, kinesthetic and sensational, enjoys reading and writing. This differs from the left-lower part because of the risk-taking consideration. Finally, the right-upper part uses a more comprehensive and integrated approach to thinking, with a preference for learning through pictures and drawings. Thus, this part of brain tends to be imaginative and innovative, often discovering facts and initiating performance assignments without demand (Bawaneh, Zain & Salmiza, 2011).

In light of the earlier discussion, this study suggests HWBTM to enhance students' motivation towards science learning (SMTSL), so that to match characteristics under each of the thinking styles (each of brain four quadrants) one fourth of time during single class time. Similarly, the remaining three thinking styles will be considered during three fourths left of class time. In other words, classroom events include different kinds of activities and skills that consider individual differences among students and their learning styles.This was suggested by HWBM i.e. external style (QA) that prefers lecture, discussion and learning from a textbook, (QB) prefers learning by manual work individually, (QC) learn by experimentation in small cooperative learning groups, and finally (QD) learn better through practical displays by the teacher (She, 2005).

Herrmann Whole Brain Teaching Method (HWBTM)

HWBTM stresses on providing equal learning opportunities for different learners, where each of the four learning styles (A, B, C, and D) fulfilled in a single lesson, so that a student's preferable learning style will be utilized in one quarter of the classroom time, while the remaining three quarter of total classroom time assigned will be for learning with other learning styles. Lessons were designed based on HWBM, so that at the beginning a brain storming (QA) session will be undertaken first by asking some questions about the new topic, associating the newly learned knowledge with previous knowledge related to the subject, and listening to the students' responses and comments without introducing the correct answer to the students in order to keep their attention attracted and perpetuate their interest to seek the correct answer (QD). Then, the teacher would direct students to recognize correct answers by experimentation and getting involved in activities, whether in group (QC) or individually (QB). The experimentation process involves data collection, device installations, jotting down results, graphing interrelations between variables, reporting (QB, QC). HWBTM requires teachers to perform some experiments themselves and present practical demonstrations (QD) which are preceded by questioning and learning situations (QA) without giving students the correct answers (QD). To attract students' attention to demonstration there will be no comment or talk by either the teacher or the students until the learners finally succeed in guessing the correct answer themselves through their concentration, thinking, and contemplation based on the practical demonstration they have seen (QD).

When the assigned time has ended, a group discussion (QA, QB, QC and QD) for both student-student and student-teacher will be carried out in order to reach the correct answers, which will then be written on the whiteboard. Application questions are then asked in order to help the students to find the solutions. This step can be done through individual (QA) or group (QB) worksheets, followed by instructing each student to find the solutions for some problems listed on the whiteboard (QA). Students will then be given homework assignments (QA, QB, QC, and QD). In other words this strategy implies that each student will be given the opportunity to practice his preferable learning style during every lesson time (She, 2005), so as to acquire the accurate scientific concepts, which would be less probable to take place in most schools that practiced conventional teaching (McCarthy, 1997).

Statement of The Problem

Numerous studies (Gibson & Chase, 2002; Westat, Frierson, Hood & Hughes, 2002; Masnick et al., 2010) reported students' motivation towards science learning, and indicated less probability of having a career related to science. Similarly, Osborn, Simon and Collins (2003) demonstrated that science is the least popular among other subjects such as English, Math and Technology. This attitude was found to be influenced by such variables as gender, physical conditions in the classroom, cultural factors in the community where they live, science curriculum, and their perceptions regarding how difficult science is i.e. undesirability of science due to the pre-conceived difficulty. It is also found that students study science as a last resort, and there is a need to find out the basic features that would make science a more desirable choice for students. The review of earlier results revealed that one can easily recognize that the reason for the lack of interest in science can be attributed to the student's decreased motivation in science learning; whether intrinsic or extrinsic. As many educators (Lister, 2004; Dunn, 2000; She, 2005; Salmiza, 2010) indicate that teaching students in ways that comply with differing learning styles during class time would result in student's improved motivation and attitudes towards science learning, and thus reduce efforts that need to be exerted. Herein, Watanabe and Ischinger (2009) in The Program for International Student Assessment: PISA of (2006) indicated a close relationship between achievement and motivation. In general, emphasizing that motivation resides behind every achievement and excellence. In the same context, Salili (1996) describes a highly motivated person as one who is also developing high levels of internal achievement and excellence. PISA of (2006) interest in students' motivation and attitudes towards science learning; constitutes the main objective of teaching science (Watanabe & Ischinger, 2009). Therefore the current study aims to investigate the effect of HWBTM on enhancing SMTSL in Jordan.

Operational Definitions

▪ Thinking style: Learning method most preferred by learner and serves as a cognitive, emotional and psychological indication, consisting of procedural sequences within the cognitive scheme of the individual and behaviourally noticed in a wide range of situations.

▪ Students' motivation towards science learning (SMTSL): Personal academic motivation will be approached through the perspectives of the participants in the study and what motivates them individually in science learning.

This study seeks to investigate the effect of a proposed HWBTM on SMTSL amongst eighth grade students in comparison to conventional teaching method CTM. Specifically, this study aims to examine the effect of HWBTM, students' thinking styles and gender on the post test scores of SMTSL, while controlling the effect of the pre-test results of SMTSL.

The main purpose of the present study is to investigate the effect of a proposed HWBTM regarding SMTSL amongst eighth grade students. The significance of studying this issue is multifaceted, as the success of this study would promote SMTSL. In using the proposed HWBTM, teachers would pay greater attention to students' thinking style during the class to enhance SMTSL. The study further intends to assist curriculum developers use the proposed HWBM when designing their curricula, text books, and teachers' manuals to improve the teaching and learning process at various schools levels. Specifically, this study seeks to answer the following questions:

▪ Is there any significant main effect of teaching methods and students' thinking styles and the interaction effects of teaching methods and students' thinking styles on the post test score of SMTSL when the effect of the pre test results of SMTSL is controlled?

▪ Is there any significant main effect of teaching methods and students' gender and the interaction effect of teaching methods and students' gender on the post test score of SMTSL when the effect of the pre test results of SMTSL is controlled?

METHODOLOGY

a) Population and Sample

The population of the study was students' enrolment (boys and girls) that include primary eighth grade level within the Bani Kenanah Directorate of Education during the second semester of the 2009-2010 academic year. The sample consisted of 357 eighth grade students from randomly chosen seven schools in the Bani Kananeh Educational Directorate in Jordan. One hundred eighty-three (Male = 98, Female = 85) eighth grade students adopted the HWBTM whereas one hundred seventy-four (Male = 82, Female = 92) eight grade students adopted the CTM. Students were taught in their normal classrooms.

Teachers with approximately equal educational levels and teaching experience at the eighth grade level were chosen to teach the classrooms at their respective schools. Teachers were trained on how to teach using HWBTM over three four-hour sessions and those from randomly selected schools served as the experimental group.

b) Study Design

This quasi-experimental factorial design included two groups: the experimental group taught using the proposed HWBTM, and the control group taught using CTM. Both groups were assigned a pre test and later a post test.

c) Variables

This study addresses the following variables:

Independent variable: represented by:

- Two types ofteaching methods:
  - a. Herrmann Whole Brain Teaching Method (HWBTM)
  - b. Conventional teaching method (CTM)

- Students' preferred thinking styles
  - a. QA: external learners   b. QB: procedural learners
  - c. QC: interactive learners   d. QD: internal learners

- Students' gender
  - a. Male   b. Female

Dependent variable: defined as students' motivation towards science learning (SMTSL) that took place with eighth grade students in Jordan.

d) Instrumentation

Thinking Preference Questionnaire (TPQ)

To classify participants according to their thinking styles, a questionnaire developed by Nawafleh (2008) to accommodate the Jordanian environment was used. Nawafleh (2008) instrument was an adaptation of a 60-items questionnaire already developed by She (2003), which primarily was primarily based on Herrmann Brain Dominance Instrument (HBDI) that in its original version had (120) items based on the Whole Brain Theory.

Nawafleh (2008) translated the Chinese version of She's instrument into Arabic and tested its validity by showing it to a panel of 12 experts with Ph.Ds. in psychology and teaching methods. In light of their feedback, necessary adjustments were made to some items, but the final version included 60-items as in the original version. To test for reliability, the instrument was administered to primary 9th grade students in Jordan and re-administered two weeks later. Cronbach alpha coefficients were computed for the first test (QA=0.78; QB=0.79; QC=0.76; and QD=0.77). Comparatively, such coefficients for the Chinese version as computed by She (2005) were (QA=0.73; QB=0.78; QC=0.76; and QD=0.78). Once again reliability coefficients were tested using test-retest method (QA=0.79; QB=0.76; QC=0.8; QD=0.75) (Nawafleh, 2008). Drawing on reliability indications and based on Odeh (1993) the instrument was considered appropriate for the Jordanian environment (Nawafleh, 2008).

Identification of Student's thinking Style

Student's thinking style will be identified depending on the aggregate response to the instrument items, where each student will select the learning activity which, from his /her view, is easy and enjoyable for learning. The aggregate response score will be computed for each respondent. The percentage will then be computed for each quadrant by dividing the number of items chosen within that quadrant by the aggregate number of items chosen across quadrants. Students, as a result, will be assigned to one of the four thinking styles depending on which quadrant had the highest percentage. If two or three quadrants had the same percentage, the student will be considered to have two or three thinking styles respectively if three quadrants had equal percentages, then the student will be considered as having three thinking styles. However, students with two thinking styles or more will be excluded from this study.

Student's Motivation Towards Science Learning Questionnaire (SMTSLQ)

Based on the literature reviewed in the relevant field and the way in which questionnaires on SMTSL are typically built, the instrument used in this study was adopted from Tuan, Chin and Shieh (2005). The instrument was developed to measure SMTSL that fits the Jordanian environment. The following steps were adopted:

- For the purpose of translating the instruments from English to Arabic, and Arabic to English word-by-word translation was avoided. Initially, The Arabic translation of the questionnaire was prepared by three translators holding Ph.Ds. in Science Teaching Methods, English Teaching Methods, and Educational Psychology who were graduates from English speaking countries, mainly UK and USA and arecurrently teaching in Jordanian universities.
- However, there were some differences in the generated versions, especially those related to the words used among the translators in translating the instruments. The researcher, then, compared and contrasted these translations, and formulated initial items that serve the aims of this study. The translators concurred decided and agreed on the final instrument, which is the translation format, that which was prepared professionally. This process resulted in 35-items based on *Likert-type 5-point scale* with [1=strongly disagree; 5=strongly agree]. Some items were written assertively, for example "When learning new science concepts, I attempt to understand them", whereas others were worded passively like "When I find the science content difficult, I do not try learning it". See appendix A.
- To test for validity, the questionnaire was shown to a panel consisting of eight experts holding Ph.Ds. in science teaching methods and educational psychology. The experts were invited to give their opinions regarding the appropriateness of individual items in terms of language wording, and suitability for measuring goals designed to measure. In light of their feedback, necessary adjustments were made to three items.The instrument in its final version included 35 items.
- To test for reliability, the test-retest method was employed and the instrument was administered to four male classes of 8th grade students (N=127); during 2009-2010 academic year. The instrument was administered two weeks later. The reliability coefficient using the test-retest method for the instrument overall was 0.84. This reliability coefficient based on Odeh (1993) which was considered suitable for the purpose of this study was accepted.

Instructional Content

The electricity chapter of the eighth science textbook used in the 2009-2010 academic year was selected for this study. The researchers designed twenty instructional booklets for the lessons in accordance with the HWBTM, whereas no instructions were presented to the conventional group of teachers. Teachers taught the instructional content to both groups four times a week over six weeks, resulting in a total of 24 classes. To follow up, regular classroom visits and phone calls were made to the groups at their respective schools.

e) Data Analysis

Mean and standard deviation were computed in order to test group differences. A 2-way ANCOVA and post hoc with split file techniques analysis were applied with a significance level of ($\alpha = 0.05$).

FINDINGS

Before a 2-way ANCOVA was conducted, several analyses were done to check the assumption associated with normality, linearity and homogeneity of regression. In designing the study, it was ensured that the covariate (the pre test of SMTSL) was measured prior to the treatment, or teaching method (Pallant, 2007). This was done to avoid scores on the covariate being influenced by the treatment. Based on the range of the value suggested by George and Mallery (2000), it was found that the skewness and kurtosis values were close to zero, which led to the conclusion that the distribution of the pre test and post test scores of the SMTSL approached a normal shape. The scatter plot appeared to show a linear (straight-line) relationship for each group. Thus, the findings of this study did not violate the assumption of a linear relationship between the dependent variable and the covariate. The final assumption of ANCOVA relates to the homogeneity of regression slopes (Pallant, 2007). The findings of this study did not violate the assumption of homogeneity of regression slopes.

To answer the first research question, which related to the independent variables (teaching methods and students' preferred thinking styles), mean and standard deviation were calculated for students' scores in the SMTSLQ Table 2.

Table 2. *The Mean score and Standard Deviation of the post test scores by thinking styles in various teaching methods*

Group	Thinking styles	Mean	SD	N
Control	Quadrant A	4.02	.514	31
CTM	Quadrant B	3.46	.559	38
	Quadrant C	3.60	.517	60
	Quadrant D	3.79	.593	45
Experimental	Quadrant A	4.12	.555	36
HWBTM	Quadrant B	4.22	.419	33
	Quadrant C	4.28	.421	63
	Quadrant D	4.26	.512	51
Total	Quadrant A	4.07	.535	67
	Quadrant B	3.82	.625	71
	Quadrant C	3.95	.582	123
	Quadrant D	4.04	.597	96

Table 2 presents the overall means and standard deviations of each post test score between the teaching methods and students' preferred thinking styles. The mean scores of the control group CTM reported QA (M = 4.02), QB (M = 3.46), QC (M = 3.60) and QD (M = 3.79). The mean scores for the Experimental group HWBTM reported QA (M = 4.12), QB (M = 4.22), QC (M = 4.28) and QD (M = 4.26).

In order to verify that these differences are statistically significant, and after adjusting for pretest scores on SMTSL, the results showed that the main effect of teaching method was statistically significant, $F(1, 348) = 75.319$, $p < 0.05$, with a large size effect (partial eta squared= 0.178) {.01= small effect, .06= moderate effect and .14= large effect} (Cohen, 1988), and observed power which is equal to 1.00 Table 3. It can be interpreted that teaching methods has main effect on students' performance of motivation towards science learning.

Table 3. ANCOVA *for thinking style by interaction group*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[b]
Corrected Model	40.492[a]	8	5.062	20.983	.000	.325	1.000
Intercept	51.184	1	51.184	212.193	.000	.379	1.000
pre_s3	7.535	1	7.535	31.238	.000	.082	1.000
Group	18.168	1	18.168	75.319	.000*	.178	1.000
Thinking styles	1.630	3	.543	2.253	.082	.019	.568
group * Thinking styles	5.469	3	1.823	7.557	.000*	.061	.987
Error	83.943	348	.241				
Total	5764.037	357					
Corrected Total	124.435	356					

a. R Squared = .325 (Adjusted R Squared = .310) *sig. at p < .05

The results from Table 3 showed that the main effect of preferred thinking style on the post test scores of SMTSL is not statistically significant, $F(3, 348) = 2.253$, $p = 0.082$ after the pre test scores of SMTSL were controlled. It can be interpreted that types of preferred thinking styles has no effect on the post test results of SMTSL. After adjusting for pre test scores of SMTSL, the result revealed that there is a significant interaction effect between teaching methods and preferred thinking style on the post test scores of SMTSL, $F(3, 348) = 7.557$, $p < .05$ as shown in Table 3. The interpretation of the significant interaction effect was made based on the collective results of the main effect of teaching methods and students' preferred thinking styles. Figure 1 shows the interaction effect between the teaching methods and students' preferred thinking styles across the four levels (QA, QB, QC, and QD) on SMTSL.

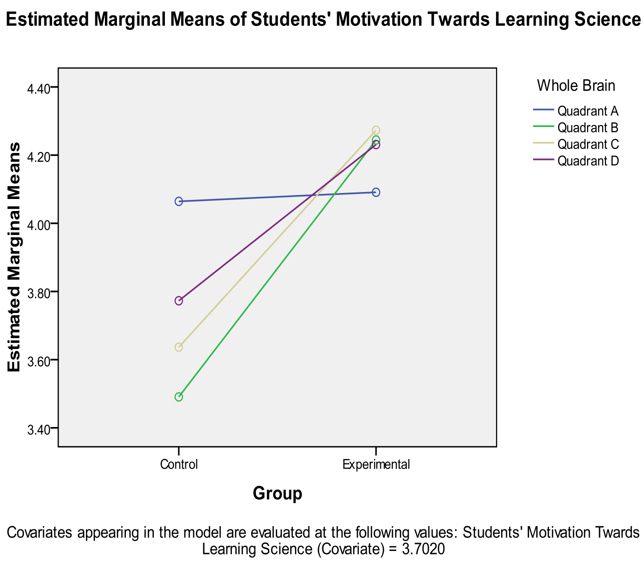

Figure 1. *Interaction effects between the teaching methods and the students' preferred thinking styles on SMTSL*

Figure 1 show that there is an interaction effect between the teaching methods and the students' preferred thinking styles across the four levels (QA, QB, QC, and QD) on SMTSL. In other words, students have different thinking styles taught via HWBTM, and CTM are not equally in SMTSL. Therefore, the effect of the teaching methods on SMTSL depends on the students' thinking styles.

Further analysis was done to investigate the univariate statistics results (analysis of variance ANOVA) by performing a Post Hoc pair wise comparison with split file technique using the Tukey HSD command for dependent variable in order to identify significantly where the differences in the means reside. Table 4 is a summary of the Post Hoc pair wise comparisons between SMTSL across the CTM and HWBTM.

Table 4. *Summary of Post Hoc pair wise Comparisons*

Group	(I) Thinking Styles	(J) Thinking styles	Mean Difference (I-J)	Std. Error	Sig.
Control	Quadrant A	Quadrant B	.5558*	.13238	.000
		Quadrant C	.4247*	.12098	.003
		Quadrant D	.2310*	.12767	.043
	Quadrant B	Quadrant A	-.5558-*	.13238	.000
		Quadrant C	-.1310-	.11340	.656
		Quadrant D	-.3248-*	.12051	.038
	Quadrant C	Quadrant A	-.4247-*	.12098	.003
		Quadrant B	.1310	.11340	.656
		Quadrant D	-.1937-	.10786	.279
	Quadrant D	Quadrant A	-.2310-*	.12767	.043
		Quadrant B	.3248*	.12051	.038
		Quadrant C	.1937	.10786	.279
Experimental	Quadrant A	Quadrant B	-.1048-	.11480	.798
		Quadrant C	-.1656-	.09952	.346
		Quadrant D	-.1384-	.10369	.542
	Quadrant B	Quadrant A	.1048	.11480	.798
		Quadrant C	-.0608-	.10236	.934
		Quadrant D	-.0336-	.10642	.989
	Quadrant C	Quadrant A	.1656	.09952	.346
		Quadrant B	.0608	.10236	.934
		Quadrant D	.0272	.08973	.990
	Quadrant D	Quadrant A	.1384	.10369	.542
		Quadrant B	.0336	.10642	.989
		Quadrant C	-.0272-	.08973	.990

Table 4 shows that there are no statistical significant differences among students' preferred thinking styles across HWBTM on SMTSL. However, there are statistical significant differences amongst students' preferred thinking styles across the CTM on SMTSL. These differences are presented below.

The QA (*M* = 4.02, SD = .514) group of students' thinking style on SMTSL has significantly outperformed the QB (*M* = 3.46, SD = .559), QC (*M* = 3.60, SD = .517) and QD (M = 3.79, SD = .593) thinking styles ($P < 0.05$). The QB (*M* = 3.46, SD = .559) group of students' thinking style on SMTSL has significantly outperformed QD (*M* = 3.79, SD = .593) thinking style ($P < 0.05$). There were no significant differences on SMTSL between QB (*M* = 3.46, SD = .559) group of thinking style on SMTSL and QC (*M* = 3.60, SD = .517), (p = .656). Finally, there were no significant differences on SMTSL between QC (*M* = 3.60, SD = .517) group of thinking style on SMTSL and QD (*M* = 3.79, SD = .593), (p = .279). In summary, students' preferred thinking styles on SMTSL among CTM can be arranged as follows: QA: external thinking style > QD: internal thinking style > QC: interactive thinking style > QB: procedural thinking style.

To answer the second question related to the independent variables (teaching methods and students' gender), mean and standard deviation were calculated for students' scores on SMTSLQ Table 5.

Table 5 presents the overall means and standard deviations of each post test score between the teaching methods and students' gender. The mean scores of the control group reported male (M = 3.75) and female (M = 3.65). The mean scores for the Experimental group reported male (M = 4.21) and female (M = 4.26). The results show that the differences between the means of male and female were negligible.

Table 5. *The Mean Score and Standard Deviation of the post test Scores by gender in various teaching methods*

Group	Gender	Mean	SD	N
Control	M	3.75	.607	82
CTM	F	3.65	.542	92
Experimental	M	4.21	.460	98
HWBTM	F	4.26	.495	85
Total	M	4.00	.578	180
	F	3.94	.603	177

In order to verify that these differences are statistically significant, and after adjusting pre test scores of SMTSL, the results showed that the main effect of teaching methods was statistically significant, $F(1, 352) = 86.762$, $p < 0.05$, with a large effect size (partial eta squared= 0.20) (Cohen, 1988) and observed power which is equal to 1.00 Table 6. It can be interpreted that teaching methods has a main effects on students' performance of students' motivation towards science learning.

Table 6. ANCOVA *for Gender by Interaction Group*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[b]
Corrected Model	33.974[a]	4	8.494	33.050	.000	.273	1.000
Intercept	52.639	1	52.639	204.830	.000	.368	1.000
pre_s3	7.410	1	7.410	28.832	.000	.076	1.000
Group	22.297	1	22.297	86.762	.000*	.198	1.000
Gender	.013	1	.013	.049	.825	.000	.056
group * Gender	.488	1	.488	1.897	.169	.005	.279
Error	90.460	352	.257				
Total	5764.037	357					
Corrected Total	124.435	356					

a. R Squared = .273 (Adjusted R Squared = .265)

Table 6 also showed that the main effect of students' gender on the post test score of SMTSL is not statistically significant, $F(1, 352) = 0.049$, $p = .825$ after pre test score of SMTSL was controlled. It can be interpreted that students' gender does not have any effect to the post test results of SMTSL. After adjusting for pre test scores on SMTSL, the result also revealed that there is no significant interaction effect between types of teaching methods and students' gender on the post test scores of SMTSL, $F(1, 352) = 1.897$, $p = 0.169$ as shown in Table 6. The interpretation of the non-significant interaction effect was made based on the collective results of the main effect of teaching methods and students' gender. It was discovered that HWBTM are effective in enhancing the SMTSL whereas the findings revealed that different types of gender has no effect to the post test results of SMTSL. Figure 2 shows the interaction effect between the teaching methods and students' gender across the two groups on SMTSL.

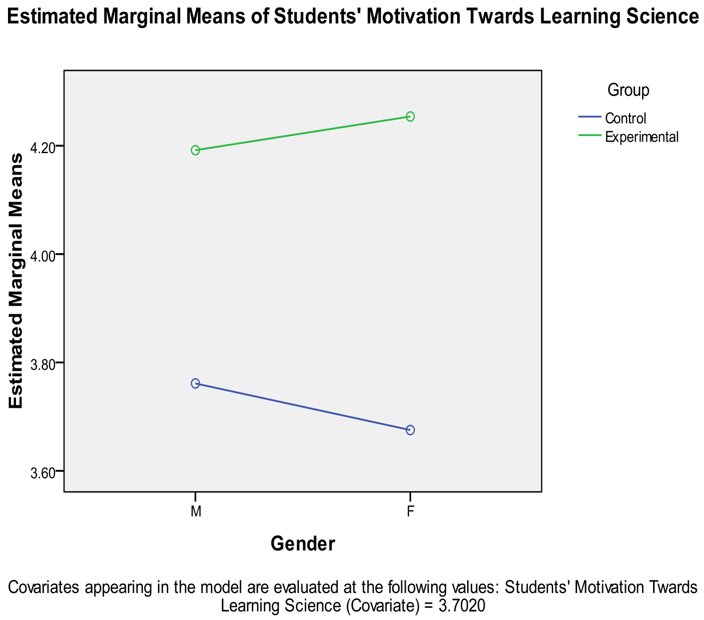

Figure 2. *Interaction effects between the teaching methods and students' gender on SMTSL*

Figure 2 show that there is no interaction effect between the teaching methods and the students' gender across the two groups on SMTSL. In other words, students' gender taught via HWBTM and CTM benefited equally in SMTSL. Therefore, the effect of the teaching methods on SMTSL was not dependent on the students' gender.

DISSCUSION

The discussion of teaching methods, students' preferred thinking styles and the interaction effect on SMTSL.The results showed statistically significant differences in SMTSL with the experimental group that was taught via HWBTM compared with the control students who were taught via CTM. The implication is that HWBTM was effective in enhancing SMTSL. The reason would be that HWBTM was designed based on HWBM in which the focus is essentially given to students' preferred thinking styles as related to the right and left parts of the brain, and to the upper and lower parts of brain.This result is consistent with results from many other studies that investigated the effectiveness of brain-oriented teaching methods to bring about motivation towards science learning (She, 2005; Salmiza, 2010; Bawaneh et al., 2010; Bawaneh, Zain & Salmiza, 2011). A number of factors can explain why HWBTM surpassed CTM in SMTSL.

1. HWBTM accommodates brain functionality. As discussed earlier, HWBTM is designed based on HWBM, which increased its effectiveness at a statistical level in improving SMTSL. Salmiza (2010) argues that learning designed based on the brain provides positive environment within which student-student relations become stronger and an emotional climate that enhances student learning will be created. Students under such environment will feel confident when they exchange ideas and data, which will improve their motivation towards science learning (Jensen, 1996). Shamsun Nisa (2005) argued that teaching methods that are designed based on brain processes stimulates students' motivation towards learning. This is contrary to the CTM that takes linear orientation in content delivery paying little or no attention to social and emotional aspects of learners. It also disregards their needs and does little to strengthen their positive interrelations, and ignores psychological spectra of students. She (2005) also demonstrated that students who were taught with teaching methods that consider brain processes had better attitudes and motivation towards learning science and outperformed students exposed to conventional methods.

2. HWBTM that is designed based on HWBM considers individual differences because it is essentially designed to respond to student's preferred thinking styles. Sultan and Jones (1995) stressed that teaching methods that take into account individual differences among students and varies the methods in which scientific content is being delivered stimulate higher levels of motivation in students and improve their attitudes to learning. This result is supported by the findings of Salmiza (2010) and She (2005) emphasized on the importance of taking individual differences into consideration due to their role in reinforcing SMTSL.

3. As a teaching method, HWBTM stresses on experiments and activities in the classroom, which enhances positive interaction and participation during lessons, thus improving the motivation for learning. Obeidat and Abu Assamid (2007) argued that action in learning is essential to stimulate the brain and helps to release Brain-derived neurotrophic factor (BDNF) agent that feeds the brain, thereby enhances thinking, reduce tension and boring during lessons which finally will positively reflects upon students' motivation to learning as a whole.

4. Cooperative learning is implied in HWBTM, which positively reflects upon student learning and interaction with the cognitive content. Ormrad (1995) emphasized that cooperative learning creates happiness in students, enhances self-confidence, cultivates social relations with classmates, encourages effective discussions thus stimulating the students' internal motivation, and they will have the desire to participate in experiments and activities with the intention of learning. Vygotsky (1978) emphasized that an individual learns more effectively when interacting with peers who are older in age and more skilled. Salmiza (2010) also argued that learning that encourages friendly student-student relationships reinforces their motivation to learn physics.

5. Compared with the CTM, the improved of SMTSL exposed to HWBTM can be attributed to the fact that HWBTM associates content with learner's experiences and surrounding environment. Ormord (1995) stressed that learning motivation is enhanced by linking topics with student's current and future needs. Many studies (Sousa, 1995; Salmiza, 2010) concluded that linking content with living examples from student's daily life and environment provokes student's interest and motivation in learning.

The fact that there are no interactions between HWBTM and the students' preferred thinking styles (A, B, C, and D) as suggested by HWBM on SMTSL, would imply that participants were affected by the teaching method at the same level. This is because HWBTM as suggested responded to the four learning styles equally. Specifically, this teaching method complies with one thinking style with one quarter of classroom time, while students employ the other three quarters of classroom time in developing the other thinking styles. In other words; activities, experiments, and exercises were assigned equally, and there was no bias toward one style or another. As a result, each student interacted by his thinking style almost in the same amount of time with the integrated teaching method (HWBTM). Their scores on the SMTSLQ, therefore, were approximately similar. On the contrary, the CTM suits certain style without consideration for the other learning styles. The explanation could be that the CTM is delivered linearly emphasizing on discussion, and direct argumentation flow from teacher to students with the students assuming a passive role seeking only to pass their test. The teacher however dominates a major part of classroom time for the purpose of completing the syllabus or the required textbook content. It can be argued that activities and other classroom practices were assigned differently, and biased towards one thinking style over the other styles. Consequently, students interact differently with the CTM thereby results were unequal for all thinking styles.

The discussion of students' gender and the interaction effects on SMTSL. Results related to the second question indicate no statistically significant effect on students' motivation towards science learning based on gender. This result is consistent with Bawaneh, Zain and Salmiza (2011), Baz and Bawaneh (2008), Nawafleh (2008) and Obeidat (2000). This result can be accounted for by social, economic, and cultural conditions, which were similar for students and parents. Place and time conditions were also similar for male and female students, with both having equal opportunity to learn within the same time period. There were nearly equal technical and academic types of male and female science teachers because teachers involved in the present study held similar academic and teaching backgrounds. Moreover, Jordanian parents no longer differentiate whether male and female students should have an equal opportunity to learn due to conscious promotion programs emphasizing the need to provide education for girls at higher levels. The trend is reflected by the male-female ratio among the university student body as well as the workforce in various sectors in Jordan. Results indicated that there were no interaction effects between teaching methods and gender, indicating that both male and female students were influenced by the teaching method at the same level. This shows a positive effect in favor of the HWBTM, as described by this study, because it takes into account brain characteristics in the HWBM in developing instructional content. Results indicated that there are no interaction effects between students' gender and teaching methods on enhancing SMTSL. This illustrated that the effect of the experimental method did not vary by gender, indicating students both males and females were influenced by the teaching methods at the same level. This shows positive effect in favor of the HWBTM as suggested by this study, because it takes into account brain characteristics in HWBM in developing the instructional content. This result is also consistent with Obeido (2009), Mallak (2008), Simpson (2004), King (2003) and Alaouneh (2005).

SUGGESTIONS

Based on the results, curriculum developers and textbook authors are advised to take into account characteristics of parts of the brain as illustrated by the HWBM in the curricula and textbooks they develop. Teachers are also encouraged to focus on students' type of learning process in their science lessons. In addition, workshops providing training for teachers on employing these teaching methods related to brain-based learning are also recommended.

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APPENDIX A

Students' Motivation Towards Science Learning Questionnaire (SMTSLQ)

Modified from Tuan, Chin, and Shieh (2005) Students' Motivation Towards Science Learning Questionnaire.

The following statements are about science. Please listen to, and read, each statement carefully. Use the scale to show how much you agree or disagree with each statement.

Item statement	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Section A: Self efficiency					
1. Whether the science content is difficult or easy, I am sure that I can understand it.					
2. I am not confidant about understanding difficult science concepts. (-).					
3. I am sure that I can do well on science test.					
4. No matter how much effort I put in, I cannot learn science (-).					
5. When science activities are too difficult, I give up or only do the easy parts (-).					
6. During science activities, I prefer to ask other people for the answer rather than think for myself (-).					
7. When I find the science content difficult, I do not try learning it (-).					
Section B: Active learning strategies	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
8. When learning new science concepts, I attempt to understand them.					
9. When learning new science concepts, I connect them to my previous experiences.					
10. When I do not understand a science concept, I fined relevant resources that well help me.					
11. When I do not understand a science concept, I would discuss with the teacher or other students to clarify my understanding.					
12. During the learning process, I attempt to make connections between the concepts that I learn.					
13. When I make a mistake, I try to find out why.					
14. When I meet science concepts that I do not understand, I still try to learn them.					
15. When new science concepts that I have learned conflict with my previous understanding, I try to understand why.					
Section C: Science learning value	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
16. I think that learning science is important because I can use it in my daily life.					
17. I think that learning science is important because I stimulate my thinking.					
18. In science, I think that it is important to learn to solve problems.					
19. In science, I think it is important to participate in inquiry activities.					

20. It is important to have the opportunity to satisfy my own curiosity when learning science.					
Section D: Performance Goal	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
21. I participate in science courses to get a good grade **(-)**.					
22. I participate in science courses to perform better than other students **(-)**.					
23. I participate in science courses so that other students think that I am smart **(-)**.					
24. I participate in science courses so that the teacher pays attention to me **(-)**.					
Section E: Achievement Goal	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
25. During a science course, I feel most fulfilled when I attain a good score in a test.					
26. I feel most fulfilled when I feel confident about the content in a science course.					
27. During a science course, I feel most fulfilled when I am able to solve a difficult problem.					
28. During a science course, I feel most fulfilled when the teacher accept my ideas.					
29. During a science course, I feel most fulfilled when other students accept my ideas.					
Section F: Learning Environment Stimulation	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
30. I am willing to participate in science course because the content is exciting and changeable.					
31. I am willing to participate in science course because the teacher uses a variety of teaching methods.					
32. I am willing to participate in science course because the teacher does not put a lot of pressure on me.					
33. I am willing to participate in science course because the teacher pays attention to me.					
34. I am willing to participate in science course because it is challenging.					
35. I am willing to participate in science course because students are involved in discussions.					

Note: (-) represents reverse items**.**