The Effect of Herrmann Whole Brain Teaching Method on Students' Understanding of Simple Electric Circuits

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Abstract

The purpose of this study was to investigate the effect of Herrmann Whole Brain Teaching Method over conventional teaching method on eight graders in their understanding of simple electric circuits in Jordan. Participants (N= 273 students; M=139, F=134) were randomly selected from Bani Kenanah region-North of Jordan and randomly assigned to both teaching methods (Hermann Whole Brain Teaching Method =135, Conventional Teaching Method =138). A multiple choice concept test was developed measuring misconceptions commonly held by eight grade students on simple electric circuits. The results showed that Hermann Whole Brain Teaching Method was more successful than the conventional teaching method in fostering students' understanding of simple electric circuits. However, there was no significant differences attributed to gender or interaction between methods and gender on student' understanding of simple electric circuits. The results suggest that curriculum developers and textbook authors are advised to take into account students' learning styles and characteristics of brain parts as illustrated by Hermann Whole Brain Model in the curricula and textbooks they develop. Teachers are also recommended to focus on individual differences among students and respond to their learning styles during science lessons.

Key words: Herrmann Whole Brain Model, Herrmann Whole Brain Teaching Method, Learning Styles, Conceptual Understanding, Simple Electric Circuits.

Introduction

International studies on science education have been performed in many countries, including Jordan. These studies have indicated low performance of Jordanian participants compare to others. The results from the Second International Assessment of Educational Progress IAEP (1991) report indicated that the mean score of Jordanian student's responses was 57%, placing Jordan in the second-to-last rank among the 19 participating countries (Abulibdeh, 2008). Similarly, results from the Third International Mathematics and Science Study-Repeat (TIMSS-R, 1999) report revealed that among the 38 participating countries, Jordan was placed 30th (Martin et al., 2000). In 2003, Jordan occupied 26th place among the 46 participating countries (Martin et al., 2004). The last replication for the Trends in International Mathematics and Science study (TIMSS) was in 2007, which Jordan occupied 20th place among 51 participating countries (Martin et al., 2008). When the participating countries were grouped based on their mean scores, Jordan was ranked above the middle achievement group but lower than the high achievement group. Based on the rankings suggested by the TIMSS study, the characteristics of the countries in the category that including Jordan was that their students did not have enough understanding of scientific concepts, lack the skills necessary to apply such concepts in their daily life, lack proper understanding of the principles of physics, including concepts such as electricity, thermal extension, sound, material composition and properties, lack the skills needed to apply the physical principles to solve quantitative problems, did not produce scientific interpretations that could be communicated and shared; lacked the skills of scientific inquiry; had not achieved a level at which they could collect and interpret data from figures and tables; and lacked the ability to produce coherent demonstrations showing cause-effect relations (Martin et al., 2008).

More recently, the Program for International Student Assessment's (PISA, 2006) study on science showed that among 57 participating countries, Jordan was ranked 45th, having a score that was below the international mean score by 51 points (Watanabe and Ischinger, 2009).

More specifically, the Program for International Student Assessment, PISA (2006) report showed the varied rankings of Jordan's subscales. For the scientific phenomenon explanation subscale, Jordan took 42nd place when its mean score, 438, was compared with the international mean score of 475. On the scientific identification subscale, Jordan, which had a mean score of 409, was ranked 47th when this score was compared with the international mean score of 470. However, on the subscale of using scientific evidence, Jordan was placed in the 48th rank when its mean score of 405 was compared with the international mean score of 470. In summary, Jordan's mean performance scores on the three science subscales were below the international average (Watanabe and Ischinger, 2009).

The results also showed that one sixth of Jordanian students failed to reach the first level on the performance scale, which represents the lower performance level in science. Jordanian students also failed to reach the upper level on the performance scale in science (Watanabe and Ischinger, 2009).

In general, results from this study clearly demonstrate that the Jordanian Educational System has been ineffective in preparing Jordanian students to achieve at the targeted performance levels, despite the curriculum reforms adopted by the Jordanian Ministry of Education (Abulibdeh, 2008). In light of the results stated earlier, these reforms merit revisiting, and further reforms to the teacher qualifying and training programs and the scholastic environment in general should be considered. The purpose of this study is to suggest a teaching method based on students' preferred learning styles. This method is intended to be adapted to individual differences among students and make students the hub of the learning-teaching process, encouraging them to be effectively involved in class experiments, activities and interactions by cooperating with classmates in solving problems, participating in classroom discussions and answering teacher inquiries, all in an attempt to improve their achievement and understanding of scientific concepts and issues and enhance their motivation to learn (Bawaneh, Ahmad Nurulazam, and Salmiza, 2010b).

Herrmann's Whole Brain Model

Herrmann (2000) classified learning styles based on the functions controlled by each chamber of the brain. He identified four divisions within the brain, each of which was associated with a certain learning style (She, 2005; Steyn and Maree, 2003; Bawaneh, Ahmad Nurulazam, and Salmiza, 2010a), as shown in Fig. 1

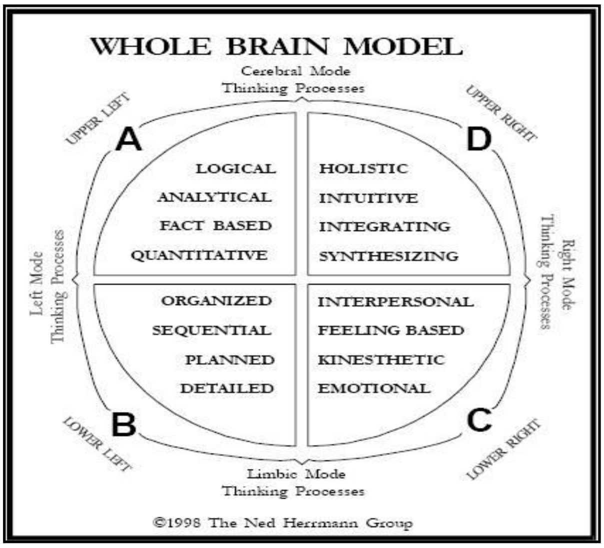


Figure 1 Brain Division by Herman's Taxonomy (Herrmann, 2000)

1. The upper left quarter (QA) represents external learning, which is logical, rational, realistic, analytical, critical, deductive, quantitative, and verbal. Learners within this category traditionally learn best through lectures, textbooks, and teachers who serve as knowledge dispensers and answerers of questions.
2. The lower left quarter (QB) refers to procedural learning. Procedural learners are characterized as being sequential, structured, organized, regulated, individualized, and needing verification. Their preferred learning style is the procedural, step-by-step approach, in which practice, repetition, hands-on activities, abstract cognition, and commonsense are most emphasized.
3. The lower right quarter (QC) describes interactive learning, in which interrelations and kinesthetic work are emphasized. Interactive learners are sensory, cooperative, emotional, intuitive and explorative. Their ideal learning

environment is created by experience, feedback, listening, physical experimentation, and shared thinking.

4. The upper right quarter (QD), which represents internal learning, incorporates much of what is required for comprehensive, creative, imaginative, conceptual, and inductive ways of learning. The ideal learning context for an internal learner is characterized by insightfulness, idea construction, and concept understanding that occur instantly, totally, comprehensively and intuitively.

Herrmann's Whole Brain Model is based on the Herrmann Brain Dominance theory, in which dominance is deemed natural and is regularly observed in organisms (Herrmann, 2000). From this approach, the form, structure, and functionality of many of the body's organs and appendages, whether external, such as hands, legs, feet, or eyes, or internal, such as lungs, kidneys, or the heart, mirror the dichotomous structure of brain. This structure was described by Herrmann (2000) as being composed of two large and two limbic hemispheres, all of which are closely associated. This association allows the four parts to function systematically, operating according to different ways of thinking and performing different mental tasks.

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) were fulfilled in a single lesson, so that a student's preferable learning style was utilized in one quarter of the classroom time, while the remaining three quarter of total classroom time assigned were for learning with other learning styles (Shorman, 2006; Qudah, 2009).

Lessons were designed based on HWBM, so that at the beginning a brain storming session were 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 attract their attention and perpetuate their interest to seek the correct answer. The teacher would then direct students to recognize correct answers by conducting experiments and getting involved in activities whether in group or individually. Students involved themselves in data collection, device installations, jotting down results, graphing interrelations between variables, and reporting while doing the experiment. Furthermore, HWBTM requires teachers to perform some experiments themselves or demonstrations which were preceded by questioning and learning situations without giving students the correct answers. To attract the students' attention to the demonstrations there were no comment or talk by either the teacher or the students until the students finally succeeded in giving the correct answer themselves through their thinking, and contemplation based on the demonstrations they saw.

When the assigned time ended, group discussions for both student-student and student-teacher were carried out in order to reach the correct answers, which will then be written on the whiteboard. Questions on applications were then being asked in order to help the students to find the solutions. This step was done through individual or group worksheets, followed by instructing each student to find the solutions for problems listed on the whiteboard. Students were then be given homework assignments.

Studies on students' understanding of electricity

Ashab (2001) conducted a study to identify the effect of using analogy as a teaching method, rather than the traditional method, to correct primary school tenth graders' misconceptions about constant electric current and circuits. The results indicated the superiority of using analogy, rather than the traditional method, to correct misconceptions about electric current and circuit.

A study by Tsai (2003) primarily investigated the effect of using Conflict Maps to change primary eighth graders' concepts of simple electric circuits. To achieve the study's goals, students were administered both a pretest and a posttest. The findings showed that the performance of the experimental group improved more than the performance of the control group. Results from this study emphasized the ability of Conflict Maps to bring about conceptual change in students studying simple electric circuits.

Mustafa (2006) researched the effects of simulations based on conceptual change conditions (CCS) and the traditional confirmatory simulation (TCS) on pre–service elementary school teachers' understanding of direct current and electrical circuits. Students, divided into two groups, where taught to create the same circuit simulations using free/open source software (Qucs). The main difference between the two modes of instruction was the design of the CCS simulations, which were based on CCS and were designed to address alternative student conceptions of direct current electricity. The TCS group, however, did the simulations to confirm a rule (or concept). The simulations were created by designing the subjects after Posner's model (1982) CCS. Data were collected from a sample consisting of 89 students: 48 students in the experimental group, who were taught simulations based on the CCS, and 41 students in the control group, who followed the TCS. All students were administered Electric Circuits Concepts Test (DIRECT), pretest and after completing 3 weeks treatment, all students received the DIRECT again as a post-test. Analysis of covariance was used. The results found that the students' understanding of direct current and electric circuits in the CCS group was significantly better than the TCS group understands of the same concepts. The results also found that the students in the CCS group significantly outperformed students in the TCS group on an 11-week delayed posttest that tested their understanding of direct current and electric concepts.

Afra, Osta, and Zoubeir (2007) conducted a study to investigate which alternative ideas about electricity were held by a group of 12 Lebanese ninth graders at an American school in Beirut. The sample comprised 7 girls and 5 boys, all 14 to 15 years old. They then evaluated the students' conceptual understanding after the implementation of an inquiry–based module about the basic principles of electricity. The instrument DIRECT (version 1.0), which measures conceptual understanding, was used as a posttest and instructional test to measure whether students' understanding had improved. The findings revealed that most of the alternative beliefs about the principles of electricity (conservation of currents model, unipolar model, electrical sinks model, attenuation model, and sharing model) were held by the participants. The results also showed that the inquiry–based approach implemented by the researchers successfully enhanced participants' conceptual understanding of the target (Direct Current: DC) circuit concepts.

A study conducted by Ipek and Calik (2008) presented a sample teaching design that used different conceptual change methods embedded within a four–step constructivist teaching model. The researchers focused on series and parallel circuits as well as the brightness of bulbs in a series and the parallel connection of circuits. The four steps in the study included the following: eliciting students' pre–existing ideas, focusing on the target concept, challenging students' ideas, and using analogy to reinforce students' newly structured knowledge. The results indicated that the activities included in the four–step constructivist teaching model not only increased student engagement and performance but also enhanced motivation.

Bawaneh, Ahmad Nurulazam, and Ghazali (2010) conducted a study to investigate the effectiveness of Conflict Maps and the V-Shape method in changing Jordanian primary eighth grade students' conceptions of scientific principles. A randomly selected sample (N=63) from the Bani Kenanah region in northern Jordan was randomly assigned to the two teaching methods (Conflict Maps, N=31; V-Shape, N=32). A conceptual multiple-choice test was developed to evaluate which common misconceptions regarding electricity were held by eighth grade students. Data gathered were statistically analyzed using SPSS software. The results indicated that both methods were successful in bringing about conceptual changes in the students. At the same time, the results did not prove either method to be superior in facilitating the students' conceptual shifts.

Problem Statement

Scientific concepts are essential tools for teaching science (Bawaneh, Ahmad Nurulazam, and Munirah, 2010; Demirci, Cirkinoglu, 2004; Afra, Osta, and Zoubeir, 2007; Cepni and Keles, 2006; Baz and Bawaneh, 2008; and Masad et al., 2002). However, other studies (American Association for the Advancement of Science, 1989; National Research Council, 1996) have emphasized that students come to school with many misconceptions. Literature by the Jordanian Ministry of Education clearly demonstrates that misconceptions about scientific principles are thoroughly pervasive among Jordanian students (Masad et al., 2002). This result is supported by findings from many of the international studies that were presented in the introduction: the Second IAEP (1991), (Abulibdeh, 2008), the TIMSS-R (1999)

(Martin et al., 2000), the TIMSS (2003) (Martin et al., 2004), the TIMSS (2007) (Martin et al., 2008), and the PISA (2006) (Watanabe and Ischinger, 2009). Jordan was a participant in these studies, which revealed the prevalence of scientific misconceptions, particularly of physical concepts, among primary eighth graders in Jordan.

The problems encountered in this study were the result of these widespread misconceptions among the students.

To identify the best teaching methods that would improve students' understanding of scientific concepts, this study, based on arguments by many educators (Cuthbert, 2005; Bell, 1998), was driven by the hypothesis that using teaching strategies that address student's individual learning styles would be the most effective. The present study, therefore, sought to investigate the effects of Herrmann Whole Brain Teaching Method (HWBTM) on student's understanding of the electrical circuits. Herrmann's Model, which is systematic and inclusive, theorizes that student's preferable learning style is inconstant that can be changed and developed. Because we used Herrmann's Model as a foundation, the instructional content we developed accommodates Herrmann's four learning styles (QA, QB, QC, and QD), which were inclusive of the learning styles we observed during a one-time observation in the classroom. The four learning styles were integrated into one teaching method that takes into account the characteristics of each learning style (Bawaneh, Ahmad Nurulazam, and Salmiza, 2010b). Referred to in this study as Herrmann Whole Brain Teaching Method (HWBTM), this teaching method supports and encourages students to develop their preferred learning styles by designing skills, events and activities that comply with more than one learning style. This process helps teachers and learners achieve the end goal of Herrmann's theory and emphasizes that learners have all learning styles in parallel. It also encourages students to have what Herrmann called the Whole Brain, development of which leads to a more elastic learning style and greater creativity (Bawaneh, Ahmad Nurulazam, and Salmiza, 2010b). Felder (1996) argues that Herrmann's Model helps learners form successful learning strategies and allows teachers to understand their students as well as the responses and comments they make in the context of their preferred learning styles. Teachers who learn to do this can deliver instructional content in a suitable and enjoyable way that increases student motivation to learn science.

Significance of the Study

The main purpose of the present study was to investigate the effect of Herrmann Whole Brain Teaching Method (HWBTM) on primary eighth grade students' conceptual understanding (CU) of Principles of "Electric Circuits". The significance of this study is multifaceted: results from this study would assist conceptual understanding in students and improve their accurate acquisition of scientific concepts, which is a basic goal of science education (Lewis and Linn, 2003). The study can also alert teachers to the misconceptions about electricity held by primary eighth graders. Using the proposed instructional model, teachers will also be able to rectify such mistakes. The study further intends to assist curriculum developers to take advantage of the proposed teaching method when designing their curricula, textbooks, and teacher manuals, which will improve the teaching and learning process at various grade levels. Specifically, this study seeks to answer the following questions:

Question One: Would students taught via HWBTM perform better than students taught via CTM on students' understanding electric circuits?

Question Two: Does students' understanding electric circuits for eighth grade students differ among students' gender (Male, Female)?

Question Three: Are there any interactional effects between the teaching methods and students' gender (Male, Female) on students' understanding electric circuits?

Study Objectives

This study primarily investigated the level of understanding about circuits among primary eighth grade students are able achieve when taught by the proposed HWBTM compared with the achievements of students taught by the CTM. Specifically, the aims of this study were as follows:

1. Identify HWBTM rectifying effect on eighth grade students' understanding circuits in comparison with the CTM.
2. Identify eighth grade students' understanding electric circuits among students' gender (Male, Female).
3. Identify the interaction effects of the teaching methods and students' gender (Male, Female) on students' understanding electric circuits.

Method and Procedures

Population and Sample

The population consisted of all-boy and all-girl schools, within the Bani Kenanah Provincial Directorate of Education, that included the primary eighth grade level. The sample was selected during the second semester of the 2009-2010 academic year. Four school buildings (two boy schools and two girl schools) were randomly selected to serve as the study sample. The sample schools were randomly assigned teaching methods (HWBTM, CTM). Table 1 shows the names of the schools that participated in the study, the number of students attending the school, and the teaching method assigned to each school.

Table 1. Participants by sample schools and respective teaching methods

Teaching Method	Gender		*Total*
	Male	Female	
HWBTM	Kharja Comprehensive boys' Secondary School (63)	Kofersoom Comprehensive girls' Secondary School (72)	*135*
CTM	Hareema Comprehensive boys' Secondary School (76)	Kharja Comprehensive girls' Secondary School (62)	*138*

Total	*139*	*134*	*273*

Teachers with similar educational levels and years of teaching experience at the primary eighth grade level were chosen to teach one classroom in their respective schools. Teachers in the experimental groups (one male and one female) received training on how to teach using HWBTM. There were two, one-hour sessions. Teachers in the randomly selected schools served as the experimental control group.

Study Design

This quasi-experimental, 2 x 2 factorial study included two groups: the experimental group, which was taught using the HWBTM, and the control group, which was taught via the CTM. Both groups were assigned a pretest and were later assigned a posttest.

Variables: This study addresses the following variables:

❖ *Independent variables*:
1. Represented by the teaching method with two levels:
    a. Herrmann Whole Brain Teaching Method (HWBTM).

    b. Conventional Teaching Method (CTM).

2. Students' Gender (Male and Female).

❖ *Dependent variable:*
1. Represented by conceptual understanding (CU) taking place in primary 8^{th} grade students regarding simple electric circuits.

Instruments

Conceptual Test: Prior building the conceptual test, a researcher conducted face-to-face interviews with a randomly selected sample from the study population to ascertain the current misconceptions about scientific principles commonly held by students. The principles investigated were limited to the concepts presented in the eighth science textbook during the 2009-2010 academic year. Major misconceptions identified in the sample students were as follows:

- The electric current passes through an open circuit until reaching the disconnection point, where it stops and ceases running.
- There is a reverse relationship between the potential difference and current intensity of an electric circuit.
- There is no relationship between the potential difference and current intensity of an electric circuit.
- The same current passes through lamps connected in parallel but with different potential difference in each parallel circuit path.
- Clashing current (two–component model): positive current leaves from the positive terminal and negative current leaves from the negative

terminal of the battery; when they meet, they produce energy in the bulb.

- Closed circuit model: electrical current flows in a given direction around a circuit. Each device in the circuit uses up some of the current, and the current weakens (sequentially-connected lamps consume the electric current).

Based on this survey of common misconceptions, a conceptual test was developed to explore the students' depth of conceptual understanding. The final version of the test was a multiple-choice fourteen-item scale measuring misconceptions commonly held by students, see appendix (A). Each item had four alternatives, among which only one was the correct answer. The test development process can be summarized as follows:

- Misconceptions about electric circuits were surveyed through interviews conducted by one researcher in studies conducted by Bawaneh, Ahmad Nurulazam and Ghazali (2010) and by Baz and Bawaneh (2008). Participants were only asked about misconceptions related to concepts found in the eighth science textbook used in Jordan during the 2009-2010 academic year. The items of the conceptual understanding test were then developed.
- Validation was secured by having the conceptual test reviewed by a panel of six experts, including a teacher, an educational supervisor and faculty members from Jordanian universities. They gave feedback, and some test items were modified accordingly.
- To verify reliability, the conceptual test was administered to a pilot sample comprising 39 students from the ninth grade level who had been exposed to the subject matter one year earlier. The reliability coefficient (0.87) was tested using Cronbach's alpha and was found suitable for the study's purposes (O'deh, 1993). Students' responses on the conceptual understanding pretest and posttest were scored by giving one mark for each item. Scores were then aggregated, tabulated and entered into a computer for statistical analysis using the Statistical Package for Social Sciences (SPSS, V17).

Instructional Content: The subject of electric circuit, taken from the first section of the final unit of the eighth science textbook used during the 2009-2010 academic year, was selected for this study. The researchers designed seven Instructional booklets for each electric circuit lesson in accordance with the Herrmann Whole Brain Model called (HWBTM) (Bawaneh, Ahmad Nurulazam, & Salmiza, 2010b). The instruction material was designed to be responsive to different types of learners and the characteristics of each of the four brain quadrants. This was achieved by preparing the instructional content to suit the various learning styles demonstrated by classroom students during class time and was done by integrating the four teaching methods preferred by each of the different types of learners into one teaching method that took into account the characteristics implied by each learning style. No special instructions were given to the group of conventional teachers. Teachers taught the instructional content to both groups for two weeks across four class periods. To follow up, regular classroom visits and phone calls were made to groups in their respective schools.

Statistical Analysis

The means and standard deviations were computed to test the mean differences. A t-test, ANCOVA and Post Hoc analysis were applied. The level of significance was set at $\alpha = 0.05$.

Findings

First, we tested the two groups' equivalence on the conceptual pretest. Table 2 shows the means and standard deviations of each group's performance on the conceptual pretest. The comparison between the estimated mean of the subjects' performances revealed a computational difference (0.22) in favor of the control group.

Table 2. Means, standard deviations of the study groups on the conceptual pre-test

group	N	Mean	S D	Std. Error of Mean
HWBTM	135	4.63	1.84	.15
CTM	138	4.86	1.60	.13
Total	273	4.75	1.73	.10

To ascertain whether this difference was statistically significant, a t-test was conducted, as shown in Table 3.

Table 3. T-test results of independent data comparing the estimated mean of the study groups (experimental and control) on the conceptual pre-test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
pretest	Equal variances assumed	3.45	.064	-1.075-	271	.283	-.225-	.2094
	Equal variances not assumed			-1.074-	264.3	.284	-.225-	.2098

Table 3 demonstrates that the mean difference between the study groups is insignificant, implying that both groups are equivalent. The results show that both groups performed low on the pretest. The mean of the experimental group performance was 4.6370 out of 14, and the mean of the control group performance was 4.8623, also out of 14. These scores confirm the prevalence of misconceptions among the students in the study sample.

Second: To answer the first question of the study which was related to the first independent variable, the means and standard deviations for students' scores on the conceptual test were calculated according to teaching method; the results are shown in Table 4.

Table 4. Means and standard deviations for students' scores based on teaching methods

group	N	Mean	SD	Std. Error of Mean
HWBTM	135	10.96	1.75	.15
CTM	138	8.31	2.26	.19
Total	273	9.62	2.42	.14

Table 4 shows that there are differences between the mean scores of students taught by the HWBTM and students taught by the CTM. To verify that these differences are significant, an ANCOVA test was conducted Table 5 using the pretest scores as covariate.

Table 5. ANCOVA test for the differences between means of students' scores on conceptual test based on different teaching methods.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	481.99[a]	2	240.99	58.40	.000
Intercept	3108.05	1	3108.05	753.19	.000
pre_test	2.26	1	2.26	.54	.459
group	473.40	1	473.40	114.72	.000
Error	1114.14	270	4.12		
Total	26875.00	273			
Corrected Total	1596.13	272			

a. R Squared = .302 (Adjusted R Squared = .297)

The results indicate that there is a statistically significant difference ($\alpha = 0.05$) between the two groups' means in favor of the HWBTM. $F_{(1,270)} = 114.72$, $P < .05$. The mean of the HWBTM students' scores was 10.96; the mean of the CM students' scores was 8.31. The difference between the two means was 2.65.

Third: Testing the equivalence between students' gender (male and female) on the conceptual pretest. Table 6 shows the means and standard deviations, according to gender, of student performances on the conceptual pretest. The comparison between these means and the estimated means reveals a computational difference (0.23) in favor of the males.

Table 6. Means, standard deviations of the study gender (Male and Female) on the conceptual pre-test

Gender	N	Mean	SD	Std. Error of Mean
Male	139	4.86	1.75	.149
Female	134	4.63	1.70	.146
Total	273	4.75	1.73	.104

To ascertain whether this difference was statistically significant, a t-test was conducted, as shown in Table 7.

Table 7. T-test results of independent data comparing the estimated mean of the study gender (Male and Female) on the conceptual pre-test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
pre_test	Equal variances assumed	.018	.894	1.093	271	.275	.22898	.20950
	Equal variances not assumed			1.094	270.995	.275	.22898	.20937

Table 7 demonstrates that the mean difference between the gender is insignificant, implying that both male and female students performed equivalently on the pretest. The results show that both male and female performed poorly on the pretest. The mean male performance score was 4.86 out of 14, and the mean female performance score was 4.63, also out of 14. This confirms the prevalence of misconceptions among the students in the study sample.

Fourth, to answer the second question of the study, which was related to the second independent variable, gender (male and female), the means and standard deviations of students' scores on the conceptual test were calculated according to the gender (male and female); the results are shown in Table 8.

Table 8. Means, standard deviations of the study groups on the conceptual post-test according to the gender (Male and Female)

Gender	N	Mean	SD	Std. Error of Mean
Male	139	9.48	2.42	.20
Female	134	9.76	2.42	.20
Total	273	9.62	2.42	.14

Table 8 shows that there were differences between the mean scores of the males and the females. To verify that these differences were significant, an ANCOVA test was conducted, using the pretest scores as covariates Table 9.

Table 9. ANCOVA test for the differences between means of students' scores on conceptual test based on gender (Male and Female).

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.33[a]	2	6.66	1.13	.322
Intercept	3235.84	1	3235.84	551.98	.000
pre_test	7.72	1	7.72	1.318	.252
Gender	4.74	1	4.74	.809	.369
Error	1582.80	270	5.86		
Total	26875.00	273			
Corrected Total	1596.13	272			

a. R Squared = .008 (Adjusted R Squared = .001)

The results shown in Table 9 indicate that there is no statistically significant difference ($\alpha = 0.05$) between the male and female students' mean scores, $F_{(1, 270)} = .809$, P=.369. The mean of the male students' scores was 9.4820; the mean of female students' scores was 9.7687. The difference between the two means (0.867) favored the females, but this difference was not statistically significant.

Fifth: To answer the third question of the study which related to the interaction effects between the independent variables; teaching methods (HWBTM, CTM) and the gender (Male, Female), means and standard deviations were calculated for students' scores in the conceptual test on the subject "electrical circuits" Table 10.

Table 10. Means and standard deviations by the interaction effect across group by gender.

group	Gender	Mean	SD	N
Herrmann Method	Male	10.80	1.97	63
	Female	11.09	1.53	72
	Total	10.96	1.75	135

Conventional Method	Male	8.38	2.20	76
	Female	8.22	2.34	62
	Total	8.31	2.26	138
Total	Male	9.48	2.42	139
	Female	9.76	2.42	134
	Total	9.62	2.42	273

Table 10 shows that there are differences between the means for students' scores according to teaching methods (HWBTM, CTM) and the gender (Male and Female). In order to verify that these differences are significant, ANCOVA test has been conducted Table 11 using the pretest scores as covariates.

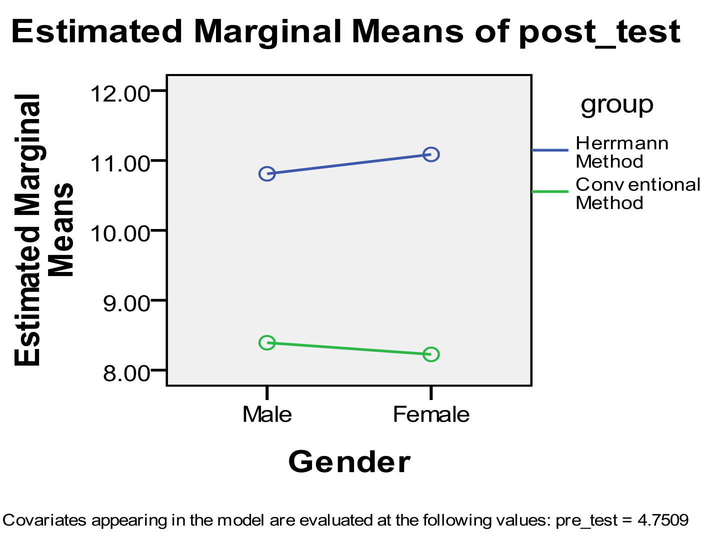
Table 11. Analysis of covariance (ANCOVA) results by the interaction effect across group * Gender.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	485.52[a]	4	121.38	29.290	.000
Intercept	3089.64	1	3089.64	745.554	.000
pre_test	2.19	1	2.19	.528	.468
group	470.03	1	470.03	113.422	.000
Gender	.20	1	.20	.049	.825
group * Gender	3.34	1	3.34	.806	.370
Error	1110.61	268	4.14		
Total	26875.00	273			
Corrected Total	1596.13	272			

a. R Squared = .304 (Adjusted R Squared = .294)

The results of the two-way univariate ANCOVA tests, which are represented in Table 11, indicated that there were not statistically significant interaction effects across the two groups in CU. The $F_{(1,268)}$ = .806, p = .370. This means that the interaction effects were not statistically significant on students' conceptual understanding CU.

The researchers further investigated the interaction effect results by plotting the interaction between the instructional method and the students' genders and its effect on conceptual understanding CU. Figure 2 shows the interaction effect between the



instructional method and students' gender across the two groups. Figure 2 shows that there are no interaction effects between the instructional methods and the students'

Figure 2 Interaction effects between the instructional method and the students' gender on CU

gender across the two groups on conceptual understanding CU. In other words, males and females, taught via HWBTM, and CTM benefited equally in conceptual understanding. Therefore, the effects of the instructional methods on CU did not depend on the students' gender.

Discussion

Discussion related to question one: The first question compared and contrasted the effect of Herrmann Whole Brain Teaching Method: HWBTM with the Conventional Teaching Method (CTM) on students' understanding of the electric circuits. Results showed that the HWBTM was significantly more effective than the CTM. A review of the related literature revealed no study addressing a comprehensive teaching method based on the Herrmann Whole Brain Model. Rather, these studies developed teaching methods to accommodate a single learning style. She (2005), for example, investigated the effect of four teaching methods, each based on the Herrmann Whole Brain Model. Each teaching method was designed to facilitate learning through a single learning style. The results revealed that the compatibility between teaching method and learning style varied by the learning style itself, and that students' ability to learn the principles of air pressure was affected more positively by the meaningful learning style. The results from the present study find support from other studies that developed teaching methods based on other brain models. Qudah (2009), for instance, investigated the effect on science achievement of a teaching method based on McCarthy model when compared with the effectiveness of the conventional method. Salmiza (2010) also conducted a study aimed to assess the effectiveness of the Brain Based Teaching Approach (BBTA) in dealing with the issues of the conceptual understanding of Newtonian Physics of Form Four students in Secondary Science Schools in the state of Kedah, Malaysia. It was found that students who received Physics education taught using the BBTA possessed a better conceptual understanding of Newtonian Physics, compared to students who received Physics education taught using conventional teaching method.

Results from this study were consistent with Sung-Young and Chang (2005), in which the authors designed a teaching method based on the differences between the brain hemispheres (right and left) and tested its effect on creativity and science achievement. The results were positive in favor of the teaching method based on the bilateral brain characteristics when compared with the results of the statistical method.

The results from this study also complied with Shorman's (2006), who compared a McCarthy-based and a conventional teaching method to find out their effect on primary eighth graders' acquisition of scientific concepts. The findings indicated the superiority of the McCarthy method over the conventional method. The results of this study can be explained by the fact that the Herrmann Whole Brain

Teaching Method (HWBTM) is designed to accommodate each of the four brain quadrants' characteristics in a proportionate, balanced and integrated way that responds to students' four learning styles in a single classroom and during every lesson. This teaching method adapts to individual differences among students and is in line with Ursin (1995), Qudah (2009), and Salmiza (2010).

However, many studies (She, 2005 ; Lister, 2005) have stressed that delivering instruction to students during a single lesson time in a way that responds to their learning styles results in increased achievement and enhances their ability to acquire understanding of scientific concepts. Bull, Montgomery and Kimball (2000) cited in Rawashdeh, Nawafleh, & Alomari (2010), however, advise that teachers deliver their instruction based on students' learning styles and by responding to their individual differences. This approach, in fact, complies with the Herrmann Whole Brain Teaching Method (HWBTM) suggested by this study. Specifically, the instructional content is developed to accommodate the characteristics of each of the brain's four quadrants in an integrated and balanced way. In this method, the teacher never delivers instruction that only accommodates one learning style during a single class session but gives instruction during each lesson time that is based on a composite of varied learning styles, using the same teaching method each time.

Our results, which show the superiority of the Herrmann Whole Brain Teaching Method (HWBTM) over the conventional one for teaching electric circuits, can be explained by the HWBTM's inclusion of varied activities and student interactions in classroom. Sims and Sims (1995) have argued that if the classroom lesson progresses without variety (one-way), learners will effectively use a single learning style while discarding the others and will feel bored. This argument contradicts Herrmann's model, which stresses learning that uses the whole integrated brain (Herrmann, 2000).

She (2005) argues that teaching methods that allow students to practice experimentation and problem solving, whether in cooperative learning groups or individually, outperform traditional methods in teaching scientific concepts and encouraging students to like each other and form proper relationships. The teaching method suggested by the current study HWBTM does so by making the student the hub of the teaching-learning process. HWBTM gives a student more time for thinking, planning and experimentation, which improves his or her understanding of the scientific concepts (She, 2005). Malak (2008) argues that teaching methods that encourage student encounters with experiences, concepts and basic cognition enhance their concept-building skills.

Results from this study are inconsistent with Delaney (2002) and Vaughn, Feldhusen, & Asher (1991), who showed that McCarthy-based teaching methods do not improve science achievement. Delaney (2002) explained this finding by pointing out that the teaching period was short (around ten days). The discrepancy between the results from this study and the former studies can be explained by the varied designs of the educational situations. In the present study, the learning situation was designed based on the characteristics of the brain's four quadrants, as suggested by Herrmann's

Whole Brain Model. In Delaney's (2002) and Vaughn, Feldhusen, & Asher's (1991) experiments, the learning design was based on the McCarthy model. The discrepancy can also be accounted for by the differing populations and ages of the participants.

Discussion of question two: Results related to the second question indicate no statistically significant effect related to eighth students' understanding of electricity circuits that varies by gender. This result is consistent with Baz and Bawaneh (2008), Nawafleh (2008), Rawashdeh, Nawafleh and Alomari (2010) and Obeidat (2000). This result can be accounted for by following:

1. Social, economic, and cultural conditions were similar among students and among students' parents.
2. Place and time conditions were similar for male and female students; both had an equal opportunity to learn within the same time period.
3. Somewhat equal technical and academic levels between the male and female science teachers; teachers involved in the present study had similar academic and teaching backgrounds.
4. Jordanian parents no longer differentiate between male and female students, allowing both an equal opportunity to learn. This attitude shift is due to conscious promotion programs that emphasize the need to provide girls with education at higher levels. The trend is obvious and is reflected in the male-female ratio at universities and in the demographics of the workforce employed in various sectors in Jordan.

Discussion related to question three: Result related to question three indicated no interaction effects between gender and teaching methods, meaning that the effects of the experimental methods did not vary by gender, indicating students both males and females were influenced by the teaching methods at the same level. This result is favorable to the Herrmann Whole Brain Teaching Method (HWBTM), which can achieve this result because it takes into account the brain characteristics set forth in Herrmann's model when developing the instructional content.

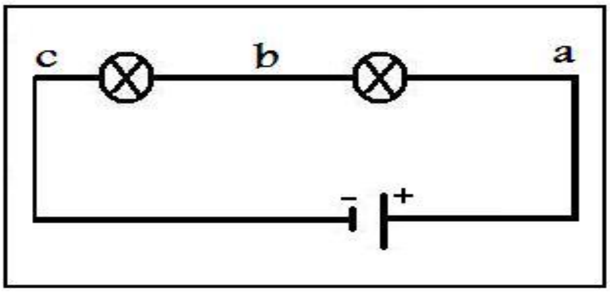
Implications

Based on the results, curriculum developers and textbook authors are advised to take into account students' preferred learning styles and the characteristics of the brain's parts, as illustrated by the Herrmann Model, in the curricula and textbooks they develop. Teachers are also recommended to focus on individual differences among students and respond to their preferred learning styles in the course of science lessons. Workshops providing training for teachers on how to employ these teaching methods are also recommended.

Appendix A

(Sample of the Conceptual Test)

Q1: The relation between current in the points a, b, and c is:

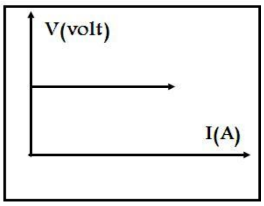


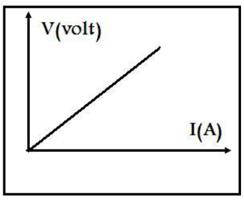
a- (a < b < c) b- (a = b = c)
c- (c < b < a) d- (c < a < b)

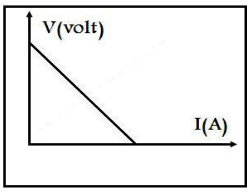
Q2: The reason for choosing the answer in the previous question is:

a- The light of lamp consumed energy not current.
b- The light of lamp consumed both energy and current.
c- The light of lamp consumed current not energy.
d- The light of lamp doesn't consume energy or current.

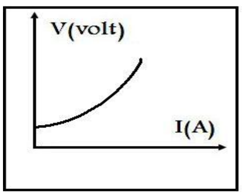
Q3: Which figure reflects the relation between the current (I) and the voltage (V) in metallic conductor (at constant temperature)?







c



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