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Effect of Herrmann Whole-Brain Model Strategy Based on Thinking Styles on Students' Achievement in Energy Concepts in Abuja, Nigeria

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ABSTRACT
This study investigated the effect of Herrmann Whole-Brain Model Strategy based on thinking styles on students' achievement in Energy concepts in Abuja, Nigeria. Two research questions and two hypotheses guided the study. The study employed quasi-experimental research design. The Population comprise of 2700 Upper Basic 2 students from 77 public schools in FCT, Abuja, Nigeria. The sample was made up of 207 (105 males and 102 females) students randomly drawn from two public schools. Two instruments namely; Students' Preferred Thinking Style Questionnaire (SPTSQ) and Energy Achievement Test (EAT) were used for data collection. Mean and standard deviation were used to answer the research questions and ANCOVA was used to test the hypotheses at 0.05 level of significance. The findings from this study revealed that, HWBMS improves and facilitate students' achievement in Energy concepts at the Upper Basic school level and it is gender friendly. Based on the findings of this study, it was recommended that; upper basic science teachers should be encouraged to utilize HWBMS as it was found very effective in enhancing students' achievement in Energy concepts in basic school.
Keywords: Achievement, Basic Science, Energy Concepts, Herrmann Whole-Brain Model Strategy, Thinking Styles

INTRODUCTION

Basic science occupies a unique position in the school curriculum at the junior levels. It is the pivot of all science related curses hence its importance cannot be over emphasized. This is consequent upon the fact that improving education quality is a priority for all nations especially developing countries improvement could lead to structural productivity and long terms economic growth (Samuel & Eriba, 2020). This implies that Basic science involves the study of elementary biology, genetics, earth/solar system, ecology, genetics, chemistry and physics as a single science subject at the upper basic school. It offers the basic training in scientific skill required for human survival, sustainable development and societal transformation. Basic science being the foundation for further studies of all sciences and science related fields, the foundation must therefore be laid solidly well at Basic level because any inadequacy at this level would consequently create serious negative educational consequences for the learners (Samuel, 2019).

Despite the importance of Basic Science in the country's quest for scientific and technological advancement, there has been seeming ineffectiveness in the teaching and learning of the subject which in turn is strongly affecting the attainment of the country's laudable objectives and goals of developing a scientific and technologically literate citizenry. Researchers have observed that students find it difficult to understand the basic concepts taught and because they are not well grounded in science at the basic level, they show little or no interest in offering core science and technology subjects at the Senior Secondary and tertiary level (Agu & Samuel 2019). Basic science is the

cumulative approach to scientific study that synthesizes the perspective of individual disciplines such as biology, physics and chemistry and aspect of the environment to be one. Energy concepts are some of the scientific topics which are central in school science and often perceived alternatively and scientifically different by the students. As core content, Energy concepts cover reasonable part of the Basic science syllabus of Basic level of education in Nigeria. Noticeably Energy both from the Basic science syllabus and classroom practiceis presented in the physical perspective. In the syllabus, emphasis of Energy is placed on definition, types and forms of Energy and mathematical formulations; little is related to student's perception about the Energy concepts. This makes it difficult for student to learn and apply Energy in their everyday lives. In technology and economy, Energy refers to a resource including its associated technology to extract it, transform it and give it an economic or industrial use. The concept of Energy is equivalent to working or putting something in motion. Energy is related to mass of the body, a relationship discovered by Einstein who said that power has direct proportionality equal to the square of the speed of light in a vacuum. Duit and Hubler (2014) explained that the current mode of teaching Energy in science is based on students' ability to memorize definitions and other concepts for classroom and examination purpose. Outside classroom the students perceive Energy differently and often do not apply the concepts correctly. Therefore, man, an object or a thing may be said to have Energy if it possesses the ability to do work. Energy comes in different forms such as heat, electrical, chemical, Nuclear and Gravitational but all of the forms can be grouped into two major types; potential and kinetic Energy.

In spite of the new trends and techniques in teaching, no single techniques or method is said to be better than other. The teacher is tasked to the responsibility to select, organize and implement the lesson in a manner tailored to the needs in the students. Based from American Psychological Association, the brain begins to mature even before birth. Although it continues to mature throughout most of life, the brain does not mature at the same rate in each individual. The bodies grow at different rates. Human reach puberty at different ages and emotional maturity at different times as well. Thus, it is important for teachers to understand that maturation of the brain influences learning readiness. In addition, Amass (2018) stated that it is important for the teachers to understand how the brain works in designing lessons and selecting which strategies to use. According to Brown (2012), the methods you use can make your classroom experience enormously rewarding, or enormously stressful, often both at the same time. However, there are ways to approach your interaction with your classes that can make the experience both more fun and less stressful for you, and your students at the same time. This approach is called Whole Brain Teaching Strategy (WBTS). Battle (2010) elaborated that whole brain teaching provides teachers with a method that integrates both effective, fun, low stress classroom management and exciting teaching methods that produce enhanced retention and comprehension of content. There are countless ways in which schools affect students' brain, for example stress, exercise, nutrition, and social conditions and also brain-based issues like attention, classroom attendance and memory. The brain is involved in everything we do at school and to ignore it would be irresponsible (Jensen, 2005).

Hence in 1999 a new method of teaching based on brain research was established by college philosophy instructor Chris Biffle, in Southern California known as the Whole Brain Teaching Strategy (WBTS). This strategy is also called Power Teaching. This strategy could be used by teachers in any subject and any grade level (Biffle, 2010). According to Biffle (2013), in order to make students engaged in learning, whole brain teaching method is surrounded by seven fun-filled techniques known as The Big Seven namely: Class-Yes, Five Classroom Rules, Teach-Okay, Mirror, Switch, Hands and Eyes and Scoreboard. With these techniques, eight areas of the brain may activate. The eight areas of the brain are: motor cortex, visual cortex, amygdala, hippocampus, pre-frontal cortex, Broca's area, Wernicke's area, and limbic system. In addition, Alaniz (2015) opined that whole brain teaching is a form of brain-based learning and involves many different teaching strategies including direct instruction and cooperative learning. WBT is beneficial for both teachers and students if implemented. With its engaging and motivating classroom environment, student-centered learning model and positive behavior reinforcement, WBT has proven to be successful within various classroom settings.

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 (Arnold, 2015; Alaniz, 2015; Bawaneh, Zain, Saleh & Abdullah, 2012; Bawaneh, Zain & Saleh, 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, (1989), 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).

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 & Maree, 2003; Bawaneh, Ahmad, Nurulazam & Salmiza, 2010a), as shown in Fig. 1

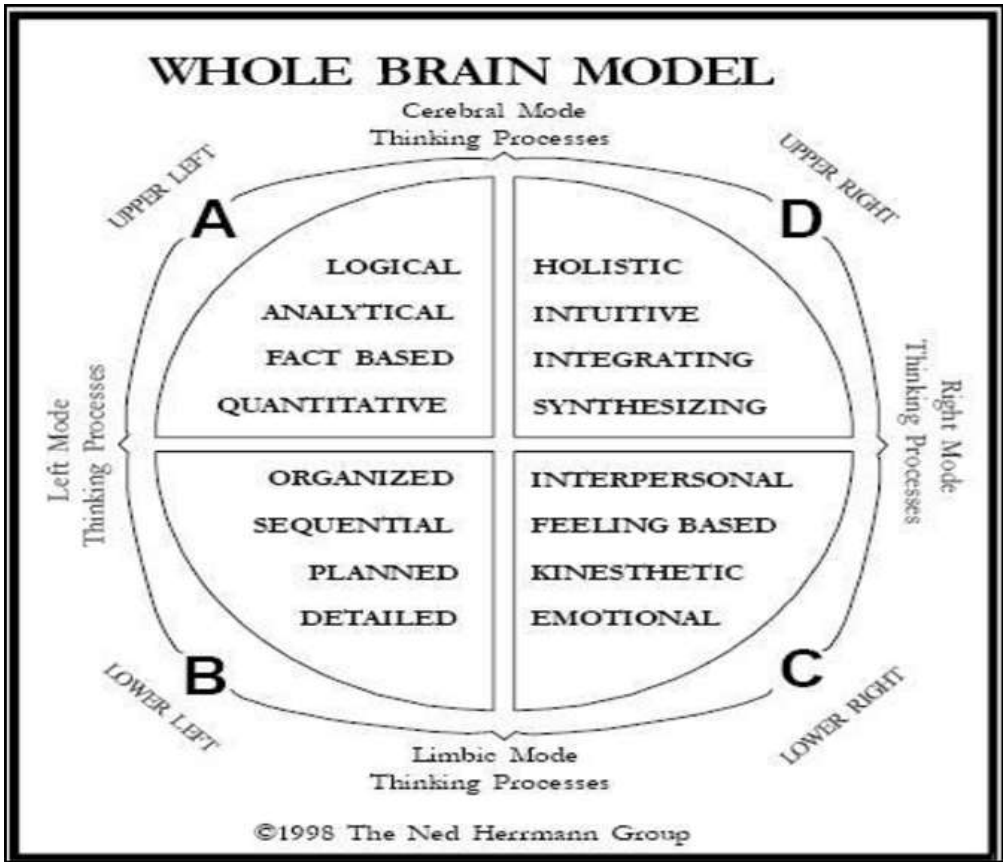

Figure 1 Brain Division by Herman's Taxonomy (Herrmann, 2000)

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 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.

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. 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.

Literature Review

Musa, Atadoga, Kabir and Sani (2017) investigated the effects of Herrmann's Whole-Brain Model on retention among secondary school physics students in the Zaria Education Zone, Kaduna State, Nigeria. There is a significant difference between the mean retention scores of students taught physics concepts using HWBM and those taught the same concepts using the lecture method in favour of the experimental group. There is no significant difference between the mean retention scores of male and female students taught physics concepts using HWBM. The study concluded that HWBM is effective in the teaching and learning of physics in senior secondary schools and it is gender-friendly.

Bawaneh, Zain, Saleh & Abdullah (2012) investigated the effect of Herrmann Whole Brain Teaching Method (HWBTM) to enhance eighth grade students' motivation towards science learning in Jordan. The results showed that HWBTM surpassed the CTM in enhancing students' motivation towards science learning. The results showed that there are no 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' motivations towards science learning were not found to be significant.

Bawaneh, Zain and Saleh (2011) investigated the effect of Herrmann Whole Brain Teaching Method over conventional teaching method on eight graders in their understanding of simple electric circuits in Jordan. 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.

Statement of the Problem

Students' achievement in Basic Science has been dwindling, studies have shown that a major cause of poor achievement is teacher's method of instruction – using lecture method does not inspire students to be actively engaged in learning science. Abstract concept like energy is even more difficult for

students to comprehend and retain what is learnt consequently high achievement cannot be contemplated. There are many alternative methods and strategies that could help students develop interest in science and achieve higher. This study as an intervention tried Herrmann Whole-Brain Model strategy based on students' thinking styles to ascertain it effect on their achievement in energy concepts in Abuja, Nigeria.

Research Questions

The following research questions guided the study;

1. What is the mean difference in the achievement of students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method?
2. What is the mean difference in the achievement of male and female students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D))?

Hypotheses

H_{O1}: There is no significant difference in the mean achievement scores of students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method.

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)).

METHODOLOGY

The study employed quasi-experimental research design. The experimental group was taught using the HWBMS, and the control group was taught using CTM. Both groups were assigned a pre-test and later a post test. The Population comprise of 2700 Upper Basic 2 students from 77 public schools in FCT, Abuja, Nigeria. The sample was made up of 207 (105 males and 102 females) students randomly drawn from two public schools.

Instrumentation

Students' Preferred Thinking Style Questionnaire (SPTSQ)

A questionnaire titled Students' Preferred Thinking Style Questionnaire (SPTSQ) was adapted from a questionnaire developed by She (2003), which was primarily based on Herrmann Brain Dominance Instrument (HBDI) that in its original version had (120) items based on the Whole Brain Theory. This enabled the researcher to categorize students according to their preferred thinking styles. Students' Preferred Thinking Style Questionnaire (SPTSQ) was made up of 30-items.

Energy Achievement Test (EAT)

The EAT consists of 30-multiple choice items adopted from Basic Education Certificate Examination (BECE, 2013-2019), based on energy and energy related topics such as forms of energy, energy transfer in an ecosystem, methods of heat transfer, energy conversion, kinetic theory of matter and work, energy and power.

Herrmann Whole Brain Model Strategy (HWBMS)

HWBMS stresses on providing equal learning opportunities for different learners, where each of the four thinking styles (A, B, C, and D) fulfilled in a single lesson, so that a student's preferable thinking style will be utilized in one quarter of the classroom time, while the remaining three quarter of total classroom time assigned will be for thinking with other thinking styles. Lessons were designed based on HWBMS, so that at the beginning a brain storming (QA) session was 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 directed the students to recognize correct answers by getting involved in activities, whether in group (QC) or individually (QB). HWBMS requires teachers to perform some experiments themselves and present practical demonstrations (QD) which are preceded by questioning and thinking situations (QA) without giving students the correct answers (QD). To attract students' attention to demonstration there was 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 was ended, a group discussion (QA, QB, QC and QD) for both student-student and student-teacher was carried out in order to reach the correct answers, which was then written on the whiteboard. Application questions were then asked in order to help the students to find the solutions. This step was 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 were then given homework assignments (QA, QB, QC, and QD).

Identification of Student's thinking Style

Student's thinking style was identified using the aggregate response score of the items on the instrument, where each student was expected to select the learning activity from which, he /she preferred to think and learn. The aggregate response scores were computed for each respondent. The percentage was then computed for each quadrant by dividing the number of items chosen within that quadrant by the aggregate number of items chosen across quadrants. Students were then 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 was considered to have two or if three quadrants had equal percentages, then the student was considered to have three thinking styles. However, students with two thinking styles or more were excluded from this study.

Conventional Method

The control group was taught energy concepts using conventional method. In this class, the researcher assumed a normal teaching environment to achieve the stated objectives. The conventional method of teaching involves the chalk, chalkboard and talk method. Students were actively involved in the teaching and learning process but they were not exposed to any special treatment.

DATA ANALYSIS/RESULT

The data collected was analyzed using the descriptive statistics of means and standard deviation to answer research questions and Analysis of Covariance (ANCOVA) to test hypotheses at 0.05 level of significance.

Research Question One: *What is the mean difference in the achievement of students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method?*

Table 1. Mean Achievement Scores of Students Taught Energy Concepts with Herrmann's Whole Brain Model Strategy Based on Their Thinking Styles and Using Conventional Method

Group	Thinking Styles	No. of Students	Mean	SD
Experimental HWBMS	Quadrant A	24	22.13	5.24
	Quadrant B	27	21.05	4.63
	Quadrant C	21	19.10	3.73
	Quadrant D	30	18.18	3.64
Control CM	Quadrant A	20	20.56	4.33
	Quadrant B	22	20.21	4.21
	Quadrant C	28	19.81	3.98
	Quadrant D	35	19.14	3.82

Table 1 shows that the mean scores for the Experimental group HWBMS reported QA (M = 4.12), QB (M = 4.22), QC (M = 4.28) and QD (M = 4.26). 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).

Research Question Two: *What is the mean difference in the achievement of male and female students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D))?*

Table 2. Mean Achievement Scores of Male and Female Students Taught Energy Concepts with Herrmann's Whole Brain Model Strategy Based on Their Thinking Styles and Using Conventional Method

Group	Thinking Styles	No. of Students	Mean	SD
Male	Quadrant A	24	12.44	2.24
	Quadrant B	30	12.32	1.93
	Quadrant C	20	11.87	1.42
	Quadrant D	31	11.48	1.26
Female	Quadrant A	20	13.10	2.81
	Quadrant B	19	12.87	2.70
	Quadrant C	29	12.33	2.11
	Quadrant D	34	11.91	1.95

Table 2 shows that the mean scores for the Experimental group HWBMS reported QA (M = 4.12), QB (M = 4.22), QC (M = 4.28) and QD (M = 4.26). 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).

Hypothesis One

H_{O1}: There is no significant difference in the mean achievement scores of students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method.

Table 3. ANCOVA Result of Mean Achievement Scores of Students Taught Energy Concepts with Herrmann's Whole Brain Model Strategy and Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1885.208	8	628.403	59.042	.000	.506
Intercept	2453.039	1	2453.039	230.476	.000	.571
Pretest	1029.115	1	1029.115	96.691	.000	.359
Methods * Thinking Styles	222.437	4	111.218	10.450	.000	.108
Error	1841.300	193	10.643			
Total	153804.000	207				
Corrected Total	3726.508	206				

Table 3 reveals that $F_{(2, 173)} = 10.450$ was obtained with associate exact probability value of 0.000 ($F_{(2,173)} = 10.45$; $P = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less

than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there was a significant difference in the mean achievement scores of students taught energy concepts with Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method in favour of the Herrmann's Whole Brain Model Strategy.

Hypothesis Two

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught Energy Concepts using Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)).

Table 4. ANCOVA Result of Mean Achievement Scores of Male and Female Students Taught Energy Concepts with Herrmann's Whole Brain Model Strategy and Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	472.848	8	236.424	36.805	.000	.568
Intercept	1125.615	1	1125.615	175.228	.000	.758
Pretest	440.178	1	440.178	68.524	.000	.550
Gender * Thinking Styles	53.751	4	53.751	8.368	.005	.130
Error	359.728	193	6.424			
Total	60929.000	207				
Corrected Total	832.576	206				

Table 4 reveals that the $F_{(1, 56)} = 8.368$ was obtained with an exact associate probability value of 0.005 ($F_{(1,56)} = 8.368$; $P = 0.005 < \alpha = 0.05$). Since the associate probability (0.005) is less than 0.05 set as level of significance, the null hypothesis was rejected. This implies that a significant difference was found to exist between the mean achievement scores of male and female students taught energy concepts using Herrmann's Whole Brain Model Strategy in favour of the female students.

DISCUSSION

The findings of the study revealed a significant difference in the mean achievement scores of students taught energy concepts with Herrmann's Whole Brain Model Strategy (based on their thinking styles (Quadrant A, B, C, D)) and with those taught using the conventional method in favour of the Herrmann's Whole Brain Model Strategy. This is in disagreement with the findings of Bawaneh, Zain, Saleh and Abdullah (2012) who found out that no significant difference was found to exist in the preferred thinking styles of students when exposed to HWBMS. But in agreement with the findings of Bawaneh, Zain and Saleh (2011) and Yusuf, Atadoga, Kabir and Sani (2017) who found out that Herrmann's Whole Brain Model Method enhances students' achievement better than the conventional method. Also, Alaniz (2015) opined that the method used in WBTS increase students' motivation, engagement, collaboration during direct instruction, and critical thinking. In addition, Arnold (2015) stated that brain-based learning like the WBTS is more effective in empowering academic achievement, motivation and retention of gained knowledge.

The study also showed that a significant difference was found to exist between the mean achievement scores of male and female students taught energy concepts using Herrmann's Whole Brain Model Strategy in favour of the female students. This is in disagreement with the findings of Bawaneh, Zain, Saleh and Abdullah (2012), Bawaneh, Zain and Saleh (2011) and Yusuf, Atadoga, Kabir and Sani (2017) who found out that gender effect on students' achievement when exposed to Herrmann's Whole Brain Model Strategy. This is also in line with Sontillano (2018) who showed that engaging students to play the role of teacher (answering questions inclusive) improves their achievement. The time allocated for individual tasks allowed both male and female students to study the individual task papers step-by-step and repeatedly, which in turn solidified the information in their brains. These might have aided on the achievement of the female students.

CONCLUSION

HWBMS improves and facilitate students' achievement in Energy concepts at the Upper Basic school level and it is gender friendly.

RECOMMENDATIONS

Based on the findings of this study, the followings recommendations are made;

1. Upper basic science teachers should be encouraged to utilize HWBMS as it was found very effective in enhancing students' achievement in Energy concepts in basic school.
2. Both coeducational and single sex schools should be encouraged to use HWBMS as it is found to be gender.

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