IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 6, June 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

# Mapping Biological Concepts: Concept-Vee Maps An Improver Of Students' Performance In Photosynthesis

**Y. Ameyaw & I. Kyere**
Department of Biology Education, Faculty of Science Education, University of Education, Winneba, C/R, Ghana, W/Africa

**Abstract:** This study presents the results of an experiment that compared the effectiveness of the use of integrated Concept-Vee mapping (CVM) against that of Concept mapping (CM) and Vee mapping (VM) in teaching and learning of the light stage and Calvin cycle of photosynthesis. It followed a quasi-experimental and a non-equivalent comparison group approach. The target population was SHS biology students in Ashanti Region of Ghana. The accessible population was third year SHS biology students at Anglican Senior High School, Kumasi. A sample size of 125 was selected through a purposive sampling technique. Photosynthesis achievement test (PAT) was developed, and used for both pre-test and post-test. The reliability coefficient of PAT was 0.76 using test-retest at a time interval of three weeks. The scores from the pre-test and post-test were analysed with one-way ANOVA by means of SPSS version 20. Results of the study showed that the difference between concept mapping and concept-vee mapping instructional groups was statistically significant in favour of concept-vee mapping group ($p < 0.05$). There was a statistically significant difference between vee mapping and concept-vee mapping instructional groups in favour of the concept-vee mapping group ($p < 0.05$). The difference between concept mapping and vee mapping instructional groups was not statistically significant ($p > 0.05$). Thus, the integrated use of CMs and Vee Maps/Heuristics (CVM), in teaching and learning of the light stage and Calvin cycle of photosynthesis leads to higher student achievement compared to concept mapping or vee mapping alone.

**Keywords:** Concept mapping, Vee Mapping, Concept-Vee Mapping, Photosynthesis, Light stage, Calvin cycle

## Introduction

Challenges in teaching have to do with how to communicate the perception of objects and processes in such a manner that generates understanding and excitement while avoiding

misconceptions (Robinson, 2004). There is a need for new teaching materials and approaches that present photosynthesis in all its complexity, but in a way that stimulates the interest and excitement of students and promotes deep understanding. Teachers need to try learner centered approach, in teaching photosynthesis so that learners will own the self-discovered knowledge and also have interest in developing it while teachers present it. Innovative instructional tools like concept mapping and vee mapping approaches can be adopted to stimulate learners' interests. Concept mapping and Vee mapping approaches are associated with meaningful mastery learning. They enable students to identify the major concepts and relate them to the concepts in their existing knowledge structure (Novak and Gowin, 1983; Kinchin, 2000). The learner therefore plays an active role in knowledge construction, which leads to meaningful learning. Concept mapping is a teaching approach where learners organize concepts and relationships between them in a hierarchical manner from more inclusive concepts to more specific and less inclusive concepts. While using this teaching/ learning approach, students identify major and more inclusive concepts at the top followed by the minor and more specific concepts at the bottom. The major and more inclusive concepts are referred to as super-ordinate concepts while the minor and more specific concepts are called subordinate concepts. The super-ordinate and subordinate concepts are placed in ovals and then connected using suitable linking words. According to Ameyaw (2015), a concept map is an essential teaching strategy for teaching and learning of concepts perceived as difficult by students. Novak and Gowin (1983) investigated the use of concept mapping in the learning of Biology at high school level in the United States of America. The findings showed that concept mapping had tremendous capacity to help learners to adequately cope with demands of learning the various science concepts. Orora, Wachanga and Keraro (2007) investigated the effects of using Cooperative Concept Mapping (CCM) teaching approach on secondary school students' achievement in Biology. Their findings show that students exposed to CCM approach had significantly higher achievement than those taught through regular methods.

Vee mapping is another teaching approach where students use a V-shaped map to represent key elements (ideas) that are contained in the structure of knowledge. The need for the Vee Diagram as an instructional tool to enhance conceptual learning has been stressed repeatedly by Novak (1983, 1990). The key elements usually referred to as the Vee heuristics form the point of focus in knowledge creation in the objects or events that learners observe (Gowin, 1977). The Vee map has two sides. The left hand side represents the theory and is referred to as the conceptual side. It

outlines the philosophy, theories, principles and concepts that guide learners in selecting or constructing objects or events to be observed in the learning process. The right hand side represents the methodology, often referred to as methodological side. The right side highlights the knowledge and value claims as well as data recording and transforming procedures. Placed in the middle of the Vee map is the focus question and events or objects to be observed in the learning process (APPENDIX A). The central idea in using a Vee map is that every element shown is interdependent with every other element on the Vee. The fundamental assumption is that knowledge is not absolute, but rather it is dependent upon the concepts, theories and methodologies by which the world is viewed (Roehrig, Luft, & Edwards, 2001). This assumption is supported by several views of epistemology (Toulmin, 1953). Vee maps foster interplay between conceptual and methodological elements and the resultant knowledge or value claims. The knowledge claims are integrated into an individual's cognitive meaning frameworks. Novak (1983) carried out a study on the use of Vee mapping in learning Biology at high school level. The study was done simultaneously with that of concept mapping. The findings of the study revealed that most students were relatively successful in using the Vee maps and performance improved. This can be attributed to the fact that Vee-mapping helps the students to sort out events or objects under study, key questions being addressed, major claims derived from the records or transformed records and the consistency between concepts, principles, records, events or objects and the stated claims. Therefore, concept mapping and vee mapping are tools that would aid pedagogy that derives from recent advances in educational theory (Novak, 1977; Gowin, 1970). The advances in other fields require the professional teachers to know the theory underlying the tools in order to employ them most successfully.

Concept-Vee mapping instructional strategy (CVMIS) is another strategy which constitutes a composite of these two instructional strategies (concept mapping and vee mapping). CVMIS is a hybrid of concept mapping and vee mapping. The two instructional strategies, though distinct, have many commonalities. Both techniques involve concepts and their relationships. The relationships in concepts create a graphical outlook. The use of CVMIS is likely to motivate students and thus improve on their achievement. This study investigated the relative effectiveness of using Concept mapping (CM), Vee mapping (VM) and Concept-Vee mapping (CVM) as an instructional strategies on students' achievement in light stage and Calvin cycle of photosynthesis at the Anglican Senior High School in the Ashanti Region of Ghana.

## Statement of the problem

The study is in response to the declining performance in biology by students at the WASSCE (WAEC, 2013, 2014, 2015 & 2016). Students tend to have more weaknesses in photosynthesis than other Biology topics (Lonergan, 2006). Students' responses to questions related to photosynthesis depict complete lack of understanding of the concepts (Chief Examiner's Report for Biology, 2014; Songer and Mintzes, 1994) and adjudged to be difficult by many teachers (Songer and Mintzes). The chief examiner's reports for May/June, 2013, 2014, 2015 and 2016 emphasized that in an attempt to overcome this weakness, teachers should make conscious efforts to cover the syllabus and also to make the teaching of biology practically-oriented and meaningful to enhance students' conceptual understanding and also boost students' interests. Concepts such as light stage, Calvin cycle, cyclic and non- cyclic photophosphorylation, and experiment to show the evolution of oxygen gas and so on could best be taught with the aid of simulations, animations and mappings to lend credence to the chief examiners. It is therefore, deemed necessary to investigate the relative effectiveness of using concept mapping, vee mapping and concept-vee mapping as instructional strategies to elevate students' achievement in particularly photosynthesis concepts.

## Research Hypotheses

The null and alternative hypotheses below were proposed to guide the study.

**$H_0$:** There is no statistically significant difference in achievement scores between students exposed to photosynthesis concept using concept mapping, vee mapping and concept-vee mapping instructional strategies.

**$H_A$:** There is a statistically significant difference in achievement scores between students exposed to photosynthesis concept using concept mapping, vee mapping and concept-vee mapping instructional strategies.

## Delimitation of the study

The study was delimited to only the concept of photosynthesis as specified in the Senior High School Biology Syllabus. The study was restricted to only third year elective biology students of Anglican Senior High in the Ashanti Region of Ghana.

## Limitation of the study

The study was limited to only elective biology students at the Anglican Senior High in the Ashanti Region. Consequently, the results of the study would be strictly applicable to only elective biology students at the Anglican Senior High.

## Methodology

### Sample and Sampling Technique

The accessible population comprised of Anglican Senior High School Students in the Kumasi Metropolitan of the Ashanti Region of Ghana. Purposive sampling technique was used to select three intact biology classes of S.H.S 3 students constituting a total sample size of 125. The detail of the sample is presented in the Table 1:

**Table 1: Distribution of students in the Three Instructional Groups (Sample for the Study)**

| Class/Group | Male | Female | Total |
|---|---|---|---|
| Intact Class 1 (Concept mapping group) | 28 | 14 | 42 |
| Intact Class 2 (Vee mapping group) | 28 | 11 | 39 |
| Intact Class 3 (Concept-vee mapping group) | 29 | 15 | 44 |
| **Total** | **85** | **40** | **125** |

### Research Design

This study used quasi experimental research design. Three intact third year biology classes were used and assigned experimental groups 1, 2 and 3 without a control group. There was no control group because few months before the study, the biology teacher of these intact classes who is also one of the researchers of the study had already taught the subjects (students) photosynthesis concept using the usual conventional lecture-based instructional strategy. The groups were randomly assigned to one of the three treatments. Thus experimental groups 1, 2 and 3 were randomly assigned to concept mapping, vee mapping and concept-vee mapping instructional strategies respectively. A pre-test was administered to the subjects before the groups were taught

the topic again for four weeks using their respective assigned treatment. Symbolically, this design is represented in Figure 1.

| | | | |
|---|---|---|---|
| Concept mapping group: | $T_1$ | $X_1$ | $T_2$ |
| | - - - - - - - - - - - - - - - | | |
| Vee mapping group: | $T_1$ | $X_2$ | $T_2$ |
| | - - - - - - - - - - - - - - - | | |
| Concept-Vee mapping group: | $T_1$ | $X_3$ | $T_2$ |

**Figure 1: Design of the Study**

Key:

-------- = no randomization is done

$X_1$= Treatment for Concept mapping group

$X_2$= Treatment for Vee mapping group

$X_3$= Treatment for Vee mapping group

$T_1$ = Pre- treatment test

$T_2$ = Post- treatment test

**Instrument**

The instruments used in this study for data collection were divided into two, treatment instruments and test instrument.

The treatment instruments were the CM, VM and CVM instructional strategies lesson plans on the concept of photosynthesis. The test instrument was photosynthesis achievement test (PAT). The PAT contained 30 test items made up of 15 multiple-choice items, 10 true or false questions, and 5 written questions, which were used to measure the understanding of photosynthesis as a biological concept by the students. In addition, both the treatment instrument (lesson plans) and the test were validated. The reliability of the test items was obtained by administering the test items to an intact class of a non-participating school using test-retest in a time interval of three weeks. A reliability co-efficient of 0.76 was obtained.

**Procedure for Data Collection**

As pre-test, PAT was administered to the subjects in all the three experimental groups for the purpose of establishing equivalence about the knowledge of the subject matter among the groups

at the beginning of the study. Photosynthesis was taught to the experimental groups 1, 2, and 3 by employing CM, VM and CVM instructional strategies respectively using 40 minutes lessons per week for four weeks. After the treatment the post-test was administered using the same test instrument used in the pre-test with items ordering re-arranged.

**Data Analysis Techniques**

The data collected from the pre-test and post-test scores were analysed using mean and standard deviation, and one-way analysis of variance (ANOVA) and by means of SPSS (version 20). A 0.05 level of probability was adopted as the criterion for significance.

**Results of the study**

**Performance in PAT Pre-Test between the Experimental Groups**

A comparison of the experimental and control groups using PAT pre-test scores showed that the mean scores were similar for the three groups. They ranged from 15.93 to 16.67 (Table 2). Meanwhile, the differences between the means were not statistically significant ($F_{2, 122} = 0.567$; $p = 0.569$).

**Table 2: Descriptive statistics for Pre-PAT Score**

| Instructional Groups | N | Mean | Std. Deviation | Std Error |
|---|---|---|---|---|
| Concept Mapping | 42 | 16.21 | 2.81 | 0.43 |
| Vee Mapping | 39 | 16.67 | 3.60 | 0.58 |
| Concept-Vee Mapping | 44 | 15.93 | 3.04 | 0.46 |
| **Total** | **125** | **16.26** | **3.14** | **0.28** |

**Table 4: Descriptive Statistics for Post-PAT Score**

| Instructional Groups | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| Concept Mapping | 42 | 25.38 | 1.70 | 0.26 |
| Vee Mapping | 39 | 25.26 | 2.09 | 0.33 |
| Concept-Vee Mapping | 44 | 26.80 | 1.96 | 0.29 |
| **Total** | **125** | **25.81** | **2.03** | **0.18** |

Results in Table 4 shows that concept-vee mapping instructional group had the highest post-test mean score at 26.80 followed by concept mapping group with a mean score of 25.38. Vee mapping instructional group had lower mean score at 25.26.

The Analysis of Variance of the Post-test scores indicated a statistically significant difference in the mean scores across the three instructional groups ($F_{2, 122} = 8.47$; $p = .000$).

The mean difference between concept mapping and concept-vee mapping instructional groups was statistically significant in favour of concept-vee mapping group (Md = 1.415, SD = 0.134, p-value =.002). Again, there was a statistically significant mean difference between vee mapping and concept-vee mapping instructional groups in favour of concept-vee mapping group (Md = 1.539, SD= 0.045, p-value = .001). However, the mean difference (Md = 0.12) between concept mapping and vee mapping instructional groups was not statistically significant (Md = 0.125, SD = 0.089, p-value = .954).

## DISCUSSION

The mean difference between CM and CVM instructional groups was statistically significant in favour of concept-vee mapping group. Again, there was a statistically significant mean difference between VM and CVM instructional groups in favour of concept-vee mapping group. These findings agree with those of Mutai, Changeiywo and Okere (2014). It emerged from Mutai et al (2014) that the integration of concept mapping and vee mapping instructional/learning tools yielded positive impact on students' achievement and transformation in Physics. Earlier Cañas, Novak and González (2004) had observed that the concurrent use of CM and VM in learning about a new topic contributed significantly in highlighting the close correspondence between the conceptual structure of a mathematics topic and its methods. The positive effect of CVMIS is attributed to the fact that the vee maps elaborated on the concepts shown by the concept maps and this enables the students to understand the topic better. These concurrent maps are more visual and effective because they show the relationship between the different concepts being learned. Concept maps and Vee maps are powerful graphic techniques, which work in harmony with how the mind function (Gordon & Jeannette, 2001). The task of making the maps in itself requires clear thinking and understanding and this in turn improves teaching and learning (John, 2003).

The students develop clear concepts because these learning strategies stimulate learners not only to use concepts that have already been internalized but also to build conceptual interconnections.

The mean difference between CM and VM instructional groups was not statistically significant. This is consistent with the finding of Polancos (2012). Polancos (2012) reported that there was no significant difference in students' achievement in Biology when VM and CM instructional approaches were used. Thus, both concept maps and vee maps help students conduct a qualitative analysis of a problem from different angles and also offers a unique graphical view of how to organize, connect, and synthesize concepts.

**Conclusions**

The findings of the study have educational implications for students, teachers and the Ministry of Education as it provide useful feedback on the comparative effectiveness of concept mapping, vee mapping and concept-vee mapping instructional strategies as effective instructional delivery approach and therefore provide the basis upon which biology teachers could build on to enhance the efficacy of their instructional delivery strategy in teaching. In conclusion, integrated use of concept maps (CMs) and Vee Maps/Heuristics (VMs), in teaching and learning of the light stage and Calvin cycle of photosynthesis could lead to higher student achievement compared to the use of concept mapping or vee mapping alone. This is because the vee maps elaborated on the concepts shown by the concept maps and this enabled the students to understand the topic better. Concept-Vee Mapping Instructional Strategy (CVMIS) could therefore be used to address the problem of poor performance in Biology especially, photosynthesis if adopted as one of the instructional approaches. The incorporation of these approaches in teaching would be beneficial to learners. In view of this, the following recommendations are made.

**Recommendations**

The mean difference between CM and CVM instructional groups was statistically significant in favour of concept-vee mapping group. Again, there was a statistically significant mean difference between VM and CVM instructional groups in favour of concept-vee mapping group. The adoption of Concept-Vee Mapping Instructional Strategy (CVMIS) teaching strategy is therefore necessary to address the current poor performance of students in Biology, especially photosynthesis. The results cannot be generalized, but we hope that the findings of this study

would encourage other teachers to use Concept-Vee Mapping Instructional Strategy (CVMIS) in biology classroom at the Senior High School level.

**Acknowledgements**

Appreciation to Science Teachers and Students of Anglican Senior High School, Kumasi in the Asante Region of Ghana.

**References**

Ajaja, O. P. (2011). Concept mapping as a study skill: Effects on students Achievement in Biology. *International Journal on Science Education, 3*(1), 49-57.

Ameyaw, Y. (2015). Improving Teaching and Learning of Glycolysis and Kerbs' Cycle Using Concept Mapping Technique. *International Journal of Sciences, 4*(6). DOI: 10.18483/ijSci.706

Cañas, A. J., Novak, J. D., & González, F. M. (2004) Eds. Learning New Mathematics Topics. Concept Maps: Theory, Methodology, Technology. *Proc. of the First Int. Conference on Concept Mapping.* Pamplona, Spain. https://www.researchgate.net/publication/228568850

Gordon, D. & Jeaennette, V. (2001). *The Learning Revolution.* Stafford: Network Educational Press Ltd.

Gowin, D. B. (1970). The Structure of Knowledge. *Educational theory*, 20, 319 – 328.

Gowin, D. B (1977). *The domain of education* (unpublished manuscript) Ithaca, New York: Cornell University.

John, R.B. (2003). *How to Use You Brain.* Mumbai: Jaico Publishing House.

Kinchin, I. M. (2000). Concept mapping in Biology. *Journal of Biological Education, 34*(2), 61-69

Lonergan T., Brenner C., & Bavister B. (2006). Differentiation-related changes in mitochondrial properties as indicators of stem cell competence. *J. Cell Physiol*, 208, 149–153.

Mutai, K. D., Changeiywo, M. J., & Okere,I. M. (2014). Effects of Gowin's Vee Heuristic Strategy on Secondary School Students' Conceptual Understanding and Metacognition in the Topic of Moments in Physics, in Uasin Gishu County, Kenya. *Journal of Education and Practice 5*(29), 193-205.

Novak, J.D. (1977). *A theory of education*. Ithaca, NY: Cornell University Press.

Novak, J. D. (1990). Concept maps and Vee diagrams: Two metacognitive tools to facilitate meaningful learning. *Instructional Science, 19*, 29-52.

Novak, J. D., & Gowin, D. B. (1983). The Use of Concept Mapping and Knowledge Vee

Mapping with Junior High School Science Students. *Science Education*, *67*, 625-645.

Novak, J. D., & Gowin, D. B. (1990). Concept maps and Vee diagrams: Two metacognitive tools to facilitate meanful learning. *Instructional Science,* 19 (1), 29-52.

Orora, W., Wachanga, S. W. & Keraro, F. N. (2007). Effects of Cooperative Concept Mapping Teaching Approach on Secondary School Students' Achievement in Biology in Gucha District, Kenya. Zimbabwe Journal of Education Research. 1-18

Polancos T. D. (2012). Effects of Vee Diagram and Concept Mapping on the Achievement of Students in Chemistry. *Liceo Journal of Higher Education Research, 7*(1). DOI:org/10.7828/ljher.v7i1.17

Robinsin, A.W. (2004). Meta-Analysis of achievement effects in micro-concept maps applications in elementary schools, *Educational Administration Quarterly 27* (2) (1991), 161-184.

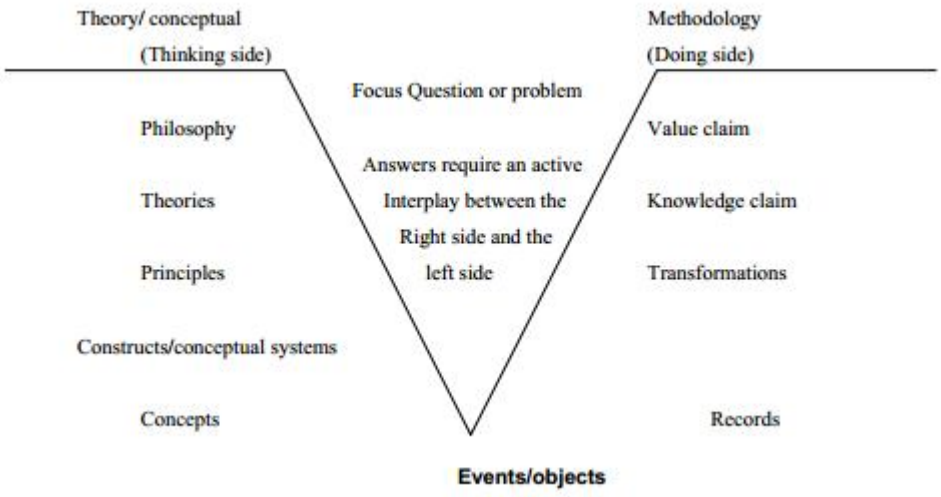
Roehrig, G., Luft, V.A. & Edwards, M. (2001).Versatile Vee maps. *The Science Teacher, 68*(1), 28-31.

Songer, C.J., & Mintzes, J.J. (1994). Understanding cellular respiration: An analysis of conceptual changes in college Biology. *Journal of Research in Science Teaching, 31*(6), 621-637.

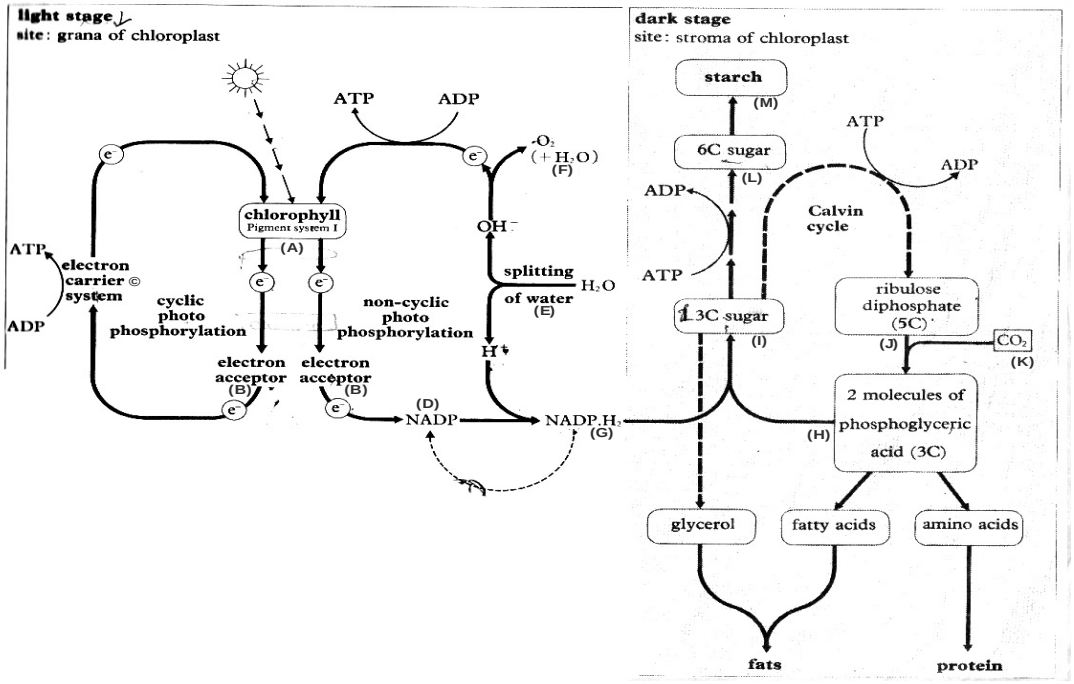
Toulmin, S. (1953). *The Philosophy of Science, an Introduction*. New York: Hutchinson's University Library.

West African Examination Council (2013-2016). *Chief Examiners' Report*. WAEC Press Ltd.

## APPENDIX A: FRAMEWORK OF GOWINS'S VEE MAPPING



## APPENDIX B: EXPERT CONCEPT MAP ON LIGHT AND DARK STAGES




## APPENDIX C: Table 3: One-way ANOVA analysis for Pre-PAT Score

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 11.27 | 2 | 5.64 | .567 | .569 |
| Within Groups | 1212.53 | 122 | 9.94 | | |
| **Total** | **1223.81** | **124** | | | |

**APPENDIX D: Table 5: One-way ANOVA analysis for Post-PAT Score**

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 62.30 | 2 | 31.15 | 8.47 | .000 |
| Within Groups | 448.50 | 122 | 3.68 | | |
| **Total** | **510.80** | **124** | | | |

**APPENDIX E: Table 6: Post Hoc Tests Analysis (Tukey HSD) for Post-PAT Score**

Dependent Variable: Post-PAT Score

| Instructional Strategies (I) | Instructional Strategies (J) | Mean Difference (Md) (I-J) | Std. Error | Sig |
|---|---|---|---|---|
| Concept Mapping | Vee Mapping | .125 | .426 | .954 |
| | Concept-Vee Mapping | -1.415* | .414 | .002 |
| Vee Mapping | Concept Mapping | -.125 | .426 | .954 |
| | Concept-Vee Mapping | -1.539* | .422 | .001 |
| Concept-Vee Mapping | Concept Mapping | 1.415* | .414 | .002 |
| | Vee Mapping | 1.539* | .422 | .001 |

* The mean difference is significant at $p<0.05$