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# Effect of Mind Mapping and Vee-Mapping Instructional Strategies on Students' Achievement and Retention in Genetics in Sokoto State, Nigeria

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**ABSTRACT**
This study investigated the effect of mind mapping and vee-mapping instructional strategies on Biology students' achievement and retention in Genetics in Sokoto State, Nigeria. Two research questions and two hypotheses guided the study. The population of the study comprised 2,515 SS II students in public coeducational secondary schools in Sokoto North Senatorial District, Sokoto State, Nigeria. The sample of the study comprised 159 SS II students from three intact classes randomly selected from public coeducational basic schools in Sokoto North Senatorial District, Sokoto State, Nigeria. Genetics Achievement Test (GAT) was used as instrument for data collection. The reliability of GAT was determined using Kuder-Richardson formula 21 ($KR_{21}$) and this yielded a reliability coefficient of 0.83. Mean and Standard Deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the research hypotheses at 0.05 alpha level of significance. The findings of this study revealed that a significant difference existed between the Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method in favour of the vee-mapping instructional strategy followed by the mind mapping instructional strategy. Based on the findings of this study, it was recommended that; teachers should be encouraged to use mind mapping and vee mapping instructional strategies in the teaching of Genetics.
**Keywords:** Achievement, Biology, Genetics, Mind Mapping, Retention, Vee Mapping.

## INTRODUCTION

Genetics is the study of heredity and variation in living organisms. The passing on and expression of traits or characters from parents to offspring is termed heredity or inheritance. Heredity or inheritance may give rise to differences among individual organisms, this is term hereditary variations (Latta, 2010; Mader, 2011; Nworgu, 2012; Tian, 2014; Bayers, 2015; Mader & Windelspecht, 2016). The genetical knowledge acquired by man enable him to embark on series of technologies for his utilization such as the selection of different strains of plants or animal species for the purpose of cross breeding to improve the structure, function, or yield of organism for economic importance to human life. The knowledge has enabled geneticists to determine blood groups paternity there by leading to counselling of patient, finger prints detection often used in crime detection, production of test tube baby, rhesus factors in sex determination, drugs and medical preparations obtained from animal tissues and other organic sources for human utilization. It has also enabled geneticist to discovered diabetes, sickle cell anemia, human DNA, blood group of individual donors and recipients using genetics crossing and agglutination or blood transfusion in human beings (Mader, 2011; Simon, 2015 & Mader & Windelspecht, 2016).

The problems associated with low achievement in genetics are students' lack of interest and inability to retain most genetics concepts learnt, as identified by (Nworgu, 2012; Stephen, 2014) which according to them, can be traced to both teachers and students related problems. These problems include:

i. Inability of biology teachers to put across the teaching of biology concepts correctly to learners due to abstract nature of some topics, how to relate structure to function and lack of biology teachers' professional development training.
ii. Lack of professional skills and competence for teaching some biological concepts.
iii. Lack of pre-requisite knowledge for genetics.
iv. Students' attitude (forbear) towards genetics as a branch of biology.
v. Lack of laboratory equipment and apparatus.
vi. Biology teachers' persistent use of conventional teaching method.

Studies revealed that low achievement in genetics has been attributed to attitudinal problem of students, superstitions belief, cognitive and socio-economic problem of teachers, administrative policy makers and instructional strategy among others (WAEC, 2019; Stephen, 2014).

Teaching methods and strategies are among the teacher factors that affect students' academic performance. Some teaching methods and strategies have been proved more efficacious in the teaching of abstract and difficult topics in different science subjects than the conventional lecture method. Such strategies include scaffolding, concept mapping, collaborative and cooperative and guided inquiry, among others. Consequently, studies have been carried out using innovative instructional strategies such as guided inquiry and demonstration method (Irinoye, Ayodele, Adetunji & Awodele, 2015; guided inquiry and collaborative strategy (Obomanu, Nwanekezi & Ekineh, 2014); lecturing, concept mapping, cooperative learning (Ajaja, 2013); scaffolding strategy (Alake & Ogunseemi, 2013), mind mapping (Eshi, 2020) and Vee mapping (Novak & Gowin, 2005).

Mind mapping teaching strategy is referred to as a graphical technique which is used to create a mental representation in the human brain. It could be used in representing the knowledge structure in form of a map or hierarchical structural diagram for easy understanding by the learner. Thus, it could aid in improving learning and clearer thinking abilities to enhance human achievement (Andrea, 2013; Tanriseven, 2014; Malekyadeh, Bayat, 2015 and Yunus, Nordin, Saleh, Embi & Salehi, 2016). The mind mapping teaching strategy is one of the effective strategies in teaching. A mind map is considered a diagram used to represent the relationship of words, ideas, tasks and other items connected to and arranged around a central key word or idea (Deshatty & Mokashi, 2013; Jones, Ruff, Snyder, Petrich & Koonce, 2012; Tanriseven, 2014; Malekyadeh, & Bayat, 2015; Yunus, Nordin, Saleh, Embi & Salehi, 2016). It is thus, an effective tool to aid in studying and organizing information as well as writing. It helps students to associate ideas, promote creative thinking, and establish meaningful connections among ideas (Buzan, 2010).

Mind mapping teaching strategy possess the following characteristics that differentiate it from other types of innovative teaching strategy such as concept mapping.

i. Mind mapping teaching strategy focuses merely on one word or idea as the central concept for instruction.
ii. Mind mapping teaching strategy uses maps that are based on radial hierarchies and three structures that might not be the same with a central governing concept for instruction.
iii. Mind mapping teaching strategy rely on the arbitrariness of mnemonic systems used for delivering the teaching by the teacher.
iv. Mind mapping teaching strategy help in improving organization of facts in students' memory.
v. Mind mapping teaching strategy is a collection of structured words by mental context of the author with visual, mnemonics, and the use of colours, icons, and visual links for instruction which enhances the proper functioning of the mind map. However, mind mapping teaching strategy is classified into two types.

Vee-mapping (VM) is another mapping instructional strategy which aids students' investigation and put them in control through self-inquiry, discussion with colleagues and first hand experiences. Vee-mapping was invented and developed by Gowin and Novak to enable learners understand the structure of knowledge (e.g. rational networks, hierarchies, combinations) and process of knowledge construction. Gowin's basic assumption is that knowledge is not absolute but rather it is dependent upon the concepts, theories and principles on which the world is viewed. Meaningful learning implies that individuals are able to relate new knowledge to relevant concepts and propositions that they already know. Like concept mapping, Novak and Gowin (2005) agree that VM guides students through investigations; this less-structured investigative arrangement allows students to actively learn the principles of investigation. The VM comprises of two interdependent structures; the left (knowing/cognitive) and right (doing/psychomotor) sides of the Vee. Hawkins & Pea (2001) described the two interdependent aspects as comprising of knowing and doing respectively. The VM strategy will help students to understand: the nature and purpose of laboratory activities and how new knowledge is attained in an experimental situation (Novak & Gowin, 2010). The VM strategy begins by focusing students' attention on what they know before the inquiry, students then generate research questions, design and conduct experiments, and interpret the data. Through interpretation, they arrive at new knowledge that must be integrated with their prior knowledge. Although students would ask questions sequentially, a VM visually identifies the complex relationships among the various parts. All metacognitive tools aim at facilitating learning. The Vee-maps are of great benefits to teaching and learning situations, procedures and processes which in turn the researcher is trying to see how it possess the capacity to improve students' achievement and retention.

**Literature Review**

Eshi (2020) investigated the effect of mind mapping teaching strategy on senior secondary students' interest, achievement and retention in genetics. The findings of the study revealed that mind mapping showed the highest effect in enhancing students' interest, achievement and retention in genetics. Bello and Oluwatosin (2014), carried out a research work on achievement in physics using mastery learning and mind mapping approaches: implication on gender and attitude. The findings of the study revealed that mind mapping showed the highest effect in enhancing students' attitude to physics. Adodo (2013) conducted an investigation on the effect of mind mapping as a self-regulated studying method on learners' achievement in fundamental science and technology. The result of the study revealed that the multiple classification analysis of the students exposed to the mind mapping as self-regulated learning strategy had high performance and retention from adjustment of posttest means scores assessed with their counterparts in conventional groups. Kehinde and Emmanuel (2011) conducted an investigation on the effect of using mind mapping in enhancing the attitude of senior secondary learners to physics. The findings of this study revealed that learners' attitude were the same irrespective of male and female taught using mind mapping or conventional strategy.

Mutai, Changeiywo and Okere (2014) carried out a study on the effects of Gowin's Vee heuristic strategy on students' conceptual understanding and metacognition in physics among secondary schools. The findings of the study revealed that the Gowin's Vee heuristic strategy actually improves students' conceptual understanding and metacognition. Polancos (2012) carried out a study on the results of an experiment that compared the effectiveness of the use of Vee Diagrams against that of Concept Maps in learning chemistry concepts. The findings revealed that Vee Diagrams and Concept Maps. Evidently, both help students develop a rich system of concepts and their learning strategies that stimulate learners not only to use concepts that have already internalized but also to build conceptual interconnections. Ameyaw and Kyere (2019) 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. 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. Omoniyi (2017) examined the Relative Effectiveness of Problem Solving

Approach (PSA) and Vee Mapping (VMA) on students' performance in chemistry. The result showed that there was a significant difference in the effectiveness of Problem Solving Approach (PSA) and Vee Mapping (VMA) on students' performance in chemistry

Academic achievement of students in Biology has been persistently low and reports have indicated that the understanding of genetics concepts and ideas is shallow and abstract. This could be attributed to a number of factors; one of which is inappropriate instructional strategies employed for teaching genetics. The need to redress this academic problem is to find instructional strategies that could assist in enhancing students' achievement and retention of the concepts of Genetics.

**Objectives of the Study**

The purpose of this study was to investigate the effect of mind mapping and vee-mapping instructional strategies on Biology students' achievement and retention in Genetics in Sokoto State, Nigeria. Specifically, the study sought to:

1. Determine the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and conventional method.
2. Determine the mean retention scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and conventional method.

**Research Questions**

1. What are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method?
2. What are the mean retention scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method?

**Hypotheses**

**$H_{O1}$:** There is no significance difference between are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method

**$H_{O2}$:** There is no significance difference between are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method

## METHODOLOGY

Quasi-experimental, non-equivalent pretest, post-test, post-post-test control group design was employed for the study. The population of the study comprised 2,515 SS II students in public coeducational secondary schools in North Senatorial District, Sokoto State, Nigeria. The sample of the study comprised 159 SS II students from three intact classes randomly selected from public coeducational basic schools in Sokoto North Senatorial District, Sokoto State, Nigeria. The experimental groups I (n=50), II (n=53) and control group (n=56) were taught using mind mapping instructional strategy vee mapping instructional strategy and conventional method respectively. Genetics Achievement Test (GAT) was used as instrument for data collection. GAT consisted of 30 multiple choice achievement test items with 4-options A-D designed to measure students' achievement. The instrument was subjected to content and face validity by three experts in Science Education from Nasarawa State University, Keffi, Nasarawa State and Uthman Fodio University, Sokoto State. The reliability of GAT was determined using Kuder-Richardson formula 21 ($KR_{21}$) and this yielded a reliability coefficient of 0.83.

## RESULTS

Mean and Standard Deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the research hypotheses at 0.05 alpha level of significance.

### Research Question One

*What are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method?*

**Table 1. Mean Scores and Standard Deviations in GAT of Students in the Experimental and Control Groups**

| Group | | N | Pretest | Posttest |
|---|---|---|---|---|
| | Mean | | 14.62 | 22.36 |
| MM | | 50 | | |
| | Std. deviation | | 1.64 | 1.55 |
| | Mean | | 14.72 | 24.15 |
| VM | | 53 | | 53 |
| | Std. deviation | | 1.75 | 2.07 |
| | Mean | | 13.64 | 20.57 |
| CON. | | 56 | | 56 |
| | Std. deviation | | 1.83 | 3.00 |
| | Mean | | 14.31 | 22.72 |

Table 4.1 shows that the mean scores of the students taught with mind mapping was 14.62 and 22.36 in Pretest and Posttest respectively and standard deviations of 1.64 and 1.55 in the achievement test. Those taught with the vee mapping had mean scores of 14.72 and 24.15 in pretest and posttest and standard deviations of 1.75 and 2.07 respectively. It was observed that the students who were taught with Conventional approach had mean scores of 13.64 and 20.57 in pretest and posttest and standard deviations of 1.83 and 3.00 respectively.

### Hypothesis One

There is no significance difference between are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method.

Data to answer this hypothesis is presented in Table 2.

**Table 2. ANCOVA Result on Students' Achievement Scores in GAT**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Result |
|---|---|---|---|---|---|---|
| Corrected Model | 3990.662 | 2 | 1995.331 | 231.947 | 0.000 | S |
| Intercept | 389.392 | 1 | 389.392 | 45.265 | 0.000 | S |
| Pretest | 23.102 | 1 | 23.102 | 2.685 | 0.008 | S |
| Group | 2436.016 | 1 | 2436.016 | 283.175 | 0.000 | S |
| Error | 404.318 | 157 | 8.603 | | | |
| Total | 26403.000 | 160 | | | | |
| Corrected Total | 4394.980 | 159 | | | | |

S= significant at P< 0.05

Table 2 shows that F-cal is 283.175 and p=0.000 <=0.05. This therefore means that, there is a significance difference between the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method. Therefore, the null hypothesis was therefore rejected. The result implies that the mind mapping and vee mapping instructional strategies and the conventional method produced significant effect on the post-test

achievement scores of Biology students taught Genetics concepts when covariate effect (pretest) was controlled. Hence, there was a significant difference among the three groups of mind mapping and vee mapping instructional strategies and the conventional method.

Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 3.

**Table 3. Bonferroni Multiple Comparisons Results of Students' Mean Achievement Scores in GAT of students in the Experimental and Control Groups**

| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| | Mind Mapping | Vee Mapping | -2.79094* | .45640 | .000 | -3.8955 | -1.6864 |
| | | Conventional | -1.21143* | .45042 | .024 | -2.3015 | -.1214 |
| | Vee Mapping | Mind Mapping | 2.79094* | .45640 | .000 | 1.6864 | 3.8955 |
| | | Conventional | 1.57951* | .44364 | .001 | .5059 | 2.6532 |
| | Conventional | Mind Mapping | 1.21143* | .45042 | .024 | .1214 | 2.3015 |
| | | Vee Mapping | -1.57951* | .44364 | .001 | -2.6532 | -.5059 |

*. The mean difference is significant at the 0.05 level.

Table 3 shows that there was no significant difference in the mean achievement scores of students taught genetics using mind mapping, vee mapping and conventional teaching approach. There was significant difference observed between the mean achievement scores of those exposed to vee mapping, mind mapping and conventional teaching approach. Likewise, a significant difference was not observed between the mean achievement scores of those exposed to vee mapping and conventional teaching approach but a significant difference was observed between those exposed to mind mapping and conventional teaching approach.

**Research Question Two:** *What are the mean retention scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method?*

**Table 4: Mean Scores and Standard Deviations in GAT of Students in the Experimental and Control Groups**

| Groups | | N | Posttest | Retention test |
|---|---|---|---|---|
| | Mean | | 44.84 | 31.86 |
| MM | | 50 | | |
| | Std. deviation | | 3.54 | 4.54 |
| | Mean | | 49.43 | 31.92 |
| VM | | 53 | | |
| | Std. deviation | | 3.34 | 4.02 |
| | Mean | | 35.00 | 23.68 |
| CON | | 56 | | |
| | Std. deviation | | 4.04 | 3.13 |
| | Mean | | 42.91 | 29.00 |

Table 4 shows that the mean rating scores of the students exposed to the mind mapping was 44.84 and 31.86 in Post-test and Retention test respectively and standard deviations of 4.54 and 3.54 in the mean retention scores. Those exposed to the vee mapping had mean rating scores of 49.43 and 31.92 in Post-test and Retention test and standard deviations of 4.02 and 3.34 respectively. It was observed that the students who were exposed to the Conventional approach had mean retention scores of 35.00 and 23.68 in pretest and posttest and standard deviations of 3.13 and 4.04 respectively.

**Hypothesis Two**

There is no significance difference between are the mean achievement scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method.

**Table 5. ANCOVA Result on Students' Retention Scores in GAT**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 138.448[a] | 2 | 15.383 | 2.547 | .009 |
| Intercept | 6321.870 | 1 | 6321.870 | 1046.835 | .000 |
| Group | 34.161 | 1 | 34.161 | 35.657 | .019 |
| Posttest | 104.755 | 1 | 13.094 | 12.168 | .033 |
| Error | 899.816 | 157 | 6.039 | | |
| Total | 83092.000 | 160 | | | |
| Corrected Total | 1038.264 | 159 | | | |

S= significant at P< 0.05

Table 5 reveals that F-cal =35.657 and p= 0.019 <=0.05. This shows that there is a significance difference between the mean retention scores of Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method. Therefore, the null hypothesis was therefore rejected. The result implies that the mind mapping and vee mapping instructional strategies and the conventional method produced significant effect on the post-posttest retention scores of Biology students taught Genetics concepts when covariate effect (posttest) was controlled. Hence, there was a significant difference among the three groups of mind mapping and vee mapping instructional strategies and the conventional method.

Based on the established difference in the retention scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 6.

**Table 6. Bonferroni Multiple Comparisons Results of Students' Mean Retention Scores of Mind Mapping, Vee Mapping Strategies and Conventional Lecture Method**

| (I) | (J) | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| MM | VM | -.665 | .491 | .038 | -1.863 | .534 |
| | CM | 1.087 | .466 | .016 | -.050 | 2.224 |
| VM | MM | .665 | .491 | .038 | -.534 | 1.863 |
| | CM | 1.752* | .415 | .000 | .740 | 2.763 |
| CM | MM | -1.087 | .466 | .016 | -2.224 | .050 |
| | VM | -1.752* | .415 | .000 | -2.763 | -.740 |

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 6 shows that there was no significant difference in the mean achievement scores of field dependent students exposed to mind mapping with those exposed to vee mapping and those exposed to conventional method. Mind mapping and vee mapping had a P value of 0.038, since 0.038 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean scores of students exposed to mind mapping and vee mapping strategies.

## DISCUSSION

The findings of this study revealed that a significant difference existed between the Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method in favour of the vee-mapping instructional strategy followed by the mind mapping instructional strategy. This is in conformity with the findings of Ameyaw and Kyere (2019), Omoniyi (2017), Mutai, Changeiywo and Okere (2014), Polancos (2012), Esiobu and Soyibo (2008) who in their various studies found out that vee mapping instructional strategy enhances students' achievement and retention when compared with other methods. But in contrast with the findings of Eshi (202), Bello and Oluwatosin (2014), Adodo (2013), Kehinde and Emmanuel (2011) and Smith and Wood (2011) who found out that mind mapping instructional strategy enhances students' achievement and retention when compared with other methods. The increase in students' achievement and retention scores could probably be because they were in control of their information through self-inquiry, discussion with colleagues, first hand experiences and linking process by acting as meta-cognitive tool that requires them to make explicit connections between previously learnt and newly acquired information. They could have felt better about learning because they were in control of the learning situation and therefore knew what they were doing.

## CONCLUSION

The findings of this study revealed that a significant difference existed between the Biology students taught Genetics using mind mapping and vee mapping instructional strategies and those taught using the conventional method in favour of the vee-mapping instructional strategy followed by the mind mapping instructional strategy.

## RECOMMENDATIONS

Based on the findings of this study, it was recommended that;

1. Teachers should be encouraged to use vee mapping and mind mapping instructional strategies in the teaching of Genetics.

2. Seminars and workshops should be organized by stakeholders in Biology to train teachers on the use of vee mapping and mind mapping instructional strategies to help improve the achievement of students.

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