

## Comparing the effectiveness of Vee heuristics, mind mapping and lecture methods on Secondary School Students Achievement in Biology in Delta State

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### Abstract

*This study aims to investigate and compare the effectiveness of three instructional methods, Vee heuristics, mind mapping, and lecture methods on Secondary School Students' achievement in the biology in Delta. The study was guided by the formulation of two research questions and the subsequent development of two hypotheses. The study employed a 3x2 pre-test, post-test planned variation quasi-experimental factorial design for its design. The population of the study consisted of 39,904 Biology students enrolled in public Senior Secondary Schools in Delta State. The study included a sample of 214 Biology students from SSII, who were selected using the simple random sampling technique. The data collection instrument employed in this study was the Biology Achievement Test (BAT), which underwent a thorough validation process. The reliability of the BAT was assessed using the Kuder-Richardson formula 21 (KR-21), resulting in a reliability coefficient of 0.81. The data that was obtained was subjected to analysis using statistical measures such as the mean, standard deviation, t-test, and ANOVA. The findings indicated a statistically significant variation in the mean achievement scores among students who were instructed in Biology using the Vee heuristics strategy, mind-mapping strategy, and lecture method. According to the results of Scheffe's post-hoc test, it was found that the Vee heuristics strategy and mind-mapping strategy were determined to be more effective than the lecture method when comparing the three teaching strategies. The study's findings indicate that the utilization of Vee heuristics and mind-mapping strategies in Biology instruction leads to greater academic achievement among students compared to the traditional lecture method. Therefore, it is suggested that teachers teaching biology at the secondary school level should incorporate Vee heuristics and mind-mapping strategies into their instructional practices for the purpose of enhancing the teaching and learning of Biology.*

**Keywords:** *Vee Heuristics, mind mapping, lecture method, students' achievement, Biology*

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### Introduction

Biology is the scientific study of living organisms and their various processes, including but not limited to their origins, growth, reproduction, structure, and behaviour. (Mayr, 2004). Biology finds practical applications in fields such as Medicine, Embryology, Botany, Zoology, Agriculture, Biotechnology, and Ecology. Biology has significantly contributed to human welfare across multiple domains. These contributions

are exemplified in various industries such as beer brewing, mining, milk processing, bread making, and waste disposal. Biology has extensive applications in the field of medicine. Advancements in medical technology have facilitated disease control and organ transplantation. Biology has been applied in agriculture to enhance plant and animal breeding for improved yield and disease resistance. Biological knowledge has had a significant impact on population control (Gawade&Patankar, 2016).

Biology is a complex and dynamic field of study that encompasses a wide range of topics and concepts. For many students, learning biology can be challenging and overwhelming, as they are often required learn significant amount of information and understand intricate biological processes.

Also, without a credit pass in Biology at the Senior School Certificate Examination (SSCE), candidates intending to study disciplines such as medicine, pharmacy, nursing, microbiology etc. will not qualify. This makes Biology one of the important science subject taught at the Senior Secondary school level. Despite the importance of Biology, the outcome of the review of the West African Examination Council (WAEC) Chief examiners annual reports (2015-2021) on students' academic performances in the West African Senior Secondary Certificate Examination (WASSCE) over the years is not encouraging. Students' achievement in Biology, however, continues to fall short of what is expected. The review showed that students lack understanding of Biology concepts that result in students' inability to remember information longer and to use it effectively. Teaching of Biology in the 21<sup>st</sup> century has undergone significant changes due to new discoveries, advances in technology and changes in the way students learn. Emphasis is on active learning approaches rather than just memorizing facts, students are encouraged to ask questions, design experiments and collect data. This helps students develop critical thinking skills and a deep sense of understanding of biology concepts. To facilitate students learning and achievement, educators have implemented various teaching methods including vee heuristics, mind-mapping and lecture based instructional strategies.

Vee Heuristics (Vee mapping) teaching strategy is a teaching strategy where students use V-shaped maps to represent the key elements (ideas) that are contained in the structure of knowledge. The Vee map is made up of two sides. The left-hand side also known as the theoretical 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 shows the methodology, often known to as methodological side. The right side highlights the knowledge and value claims as well as records and transformations. Also in the vee map is the focus question in the upper centre part of the Vee map and events or objects to be observed at the bottom centre of the vee map. Vee Heuristics teaching strategy helps students develop critical thinking abilities and problem solving abilities. Vee Heuristics teaching strategy is founded on the principles of Heuristics learning, which involves discovering solutions from experimentation and problem solving. According to Ajayi (2019), Vee Heuristic strategy facilitates the comprehension of the relationship between existing knowledge and knowledge gaps. Okafor (2016) asserted thatVee Heuristic fosters students' achievement in basic science than conventional method.

Empirical evidence has shown that the use of Vee Heuristics can improve students' achievement. For example a study by Njue et.al (2018) found that Vee Heuristics improved students' critical thinking skills in Biology.Suprpto (2017) found that Vee heuristics enhanced students' understanding of ecological concepts and improved their ability to apply knowledge in real-world contexts. A study carried out by Okafor (2016) found thatVee Heuristic fosters students' achievement in basic science than the conventional method.

Mind Mapping is a visual tool that helps students organize and connect ideas. It is a technique that was developed by Tony Buzan in the 1970s. Mind Mapping involves creating a diagram that connects related concepts with lines and images. By using Mind Mapping, students can see the relationships between ideas and concepts, making it easier to understand and remember them.

Mind-mapping is a powerful strategy used to visually organize and connect ideas, information and concepts. A mind- map is a diagram that begins with a central idea or topic and branches out into sub topics, keywords

and concepts. Mind-mapping is based on the principle that the brain works best when information is presented in a visual and interconnected way. Lumsdaine (2015) describes mind-mapping strategy as a student-centred method, which prioritizes active learning and deep understanding over passive listening. According to Adodo (2013), the process of creating a mind map can enhance memory recall and improve understanding of complex information. Mind mapping can also promote critical thinking skills by encouraging students to analyse, evaluate, and synthesize information. Boyson (2009) asserted that using mind-mapping for lesson planning can help teachers or trainers identify a logical plan or teaching route and increases recall of the subject matter.

According to Okereke et.al (2019), students taught computer studies using mind mapping performed better than those taught using the conventional method. Also, the result showed no significant gender difference. Ogunleye et.al (2019) found that students taught Basic Science using mind mapping strategy outperformed their counterparts taught using lecture method. The study also revealed that gender did not have any significant effect on the dependent variable.

Lecture method is the oldest form of instruction. In this method, the teacher explains the subject using gestures, simple devices, voice changes, position changes and facial expressions. (Eluodin, 2021). Students are passive while the teacher is more active, however the teacher also uses questions to keep the students attention.

This method is cost effective and suitable for usage with lots of students. Additionally to saving time, it aids in completing the curriculum. For educators, it is the most straightforward technique because no preparations are needed. It helps the students develop their listening skills.

Large classes can benefit from this strategy, but it also has significant drawbacks (Eluodin, 2021). With this method, the students become passive listeners. Students' activities have very little room to grow. Although lecture method as a form of instruction is frequently criticized, it has remained in use for so long despite several technological advancements. (Baig, 2011).

According to Okereke and Okigbo (2019), achievement is the fulfilment of desired or expected outcomes. Achievement involves both overcoming obstacles and attaining success. Academic achievement refers to the attainment of educational goals by students, teachers, or institutions, whether short-term or long-term. Assessing academic achievement is typically done through exams or continuous assessments, but there is no consensus on the optimal way to evaluate achievement. In this study, academic achievement was measured using standardized Biology achievement test before and after exposure to Vee heuristics teaching strategy, mind-mapping teaching strategy and the lecture method in an attempt to isolate the most effective teaching strategy.

There is a growing concern regarding the influence of students' gender on methods of teaching in relation to their achievement in school. Certain teaching strategies may have different impacts on the academic achievement of male and female students. Gender is a moderator variable in this study, referring to the gender categories (male and female) students in a school setting. Thus, in this study, attempt was made to compare the effects of Vee heuristics, mind-mapping and lecture methods on secondary school students' achievement in Biology and also determine whether they are dependent on gender, with the intention of isolating the most effective among them.

### **Statement of the Problem**

Despite the importance of biology, students often face challenges in achieving the desired learning outcomes. There is growing concern about which strategy of teaching in our secondary schools would be able to reverse the deteriorating trends in students' poor academic achievement in Biology (WAEC Chief Examiner's Report, 2015-2021). The poor achievements of students have been attributed to lack of active participation of the

students in the teaching and learning process. To address this issue, teaching strategies that engage students actively in the teaching and learning process should be adopted. Thus, this study aims to investigate the effects of Vee heuristics, mind-mapping and lecture method on students' achievement in Biology.

The problem of this study, therefore, was to find out which method among Vee heuristics, mind mapping strategies and lecture methods will yield the highest level of students' achievement in Biology.

### **Research Questions**

The following research questions guided the study:

1. What is the difference among the mean achievement scores of students taught Biology with Vee heuristics teaching strategy, mind-mapping teaching strategies and lecture method?
2. What is the difference between the mean achievement scores of male and female students taught Biology using Vee heuristics, mind-mapping teaching strategies and lecture method?

### **Research Hypotheses**

Three hypotheses were tested at 0.05 level of significance:

1. There is no significant difference among the mean achievement scores of students taught Biology with Vee heuristics, mind-mapping teaching strategies and lecture method.
2. There is no significant difference between the mean achievement scores of male and female students taught Biology using Vee heuristics, mind-mapping teaching strategies and lecture method.

### **Methodology**

The study utilized a quasi-experimental factorial design with a 3x2 pre-test and post-test planned variation. The study included 214 SSII Biology students from six Public Secondary Schools in Delta State's three Senatorial Districts, selected using a simple random sampling technique. The data collection instrument was a validated Biology Achievement Test (BAT). The reliability of the BAT was assessed through the utilization of Kuder-Richardson Formula 21 (KR-21). The obtained coefficient of internal consistency was 0.81.

The treatment involved training research assistants, who were Biology teachers assigned to Vee heuristics and mind-mapping groups. The treatment itself consisted of teaching selected Biology concepts to students using Vee heuristics, mind-mapping, and lecture methods. The six research assistants were provided with extracts containing the contents of the six-week lesson plans one week prior to the treatment commencement. The selected topics were derived from Essential Biology, which covers the principles outlined in six-week instructional schemes utilizing Vee heuristics, mind-mapping, and lecture-based techniques. This was done to ensure the appropriate implementation of teaching strategies in each designated group. The lesson plans outlined the activities of both teachers and students during instruction.

A day before the commencement of treatment, BAT was administered as pre-tests to the students in Vee heuristics, mind-mapping and lecture groups. The purpose of this was to establish the comparability of the groups prior to treatment and ensure that any observed changes subsequent to treatment were attributable to the administered treatment. On the actual treatment, the Vee heuristics and mind-mapping groups received treatment using Vee heuristic and mind-mapping teaching strategies. The Vee heuristics teaching strategy was applied to students in the Vee heuristics group, which included drawing Vee maps after classroom discussions. The students formed groups to create Vee maps using the identified elements from the discussion. They drew a V-shaped diagram and labelled the left side as the "thinking" side and the right side as the "doing" side. The thinking aspect was structured with an outline

that included theory, principles, constructs, and relevant concepts. The doing side contained knowledge claims, value claims, transformations and records. The focus question was placed at the top centre position and the events were written at the bottom centre. The students in the mind-mapping group were instructed using the mind-mapping teaching strategy. After being shown examples of mind-maps at the start of the lesson, the students were organized into groups to create their own mind-maps. The students identified significant content concepts in their respective groups. The concepts were arranged hierarchically, beginning with the most comprehensive and general concepts and progressing to less comprehensive and specific ones. The teacher facilitated active participation and provided guidance in concept identification and organization. The students utilized linking words to connect the various concepts.

The students in the lecture group were instructed through the use of the lecture methodology. The teachers in this group provided required information on the selected Biology concepts to students during instruction. Little or no opportunity was given to the students to ask question as the lesson progressed.

The BAT was given as a post-test to the students in all three groups after the treatment period. The collected scores were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (t-test and ANOVA).

## Findings

### Research Question 1

What is the difference among the mean achievement scores of students taught Biology with Vee heuristics teaching strategy, mind-mapping teaching strategy and lecture method?

**Table 1: Mean and Standard Deviation (SD) of Pre-test and Post-test Achievement Scores among Students Taught Biology Using Vee Heuristics Strategy, Mind-Mapping Strategy and Lecture Method**

| Group          | N  | Pre-test |      | Post-test |       | Mean Gain |
|----------------|----|----------|------|-----------|-------|-----------|
|                |    | Mean     | SD   | Mean      | SD    |           |
| Vee heuristics | 63 | 22.25    | 9.43 | 62.03     | 9.65  | 39.78     |
| Mind-mapping   | 74 | 21.45    | 9.46 | 58.05     | 10.23 | 36.60     |
| Lecture        | 77 | 21.90    | 8.26 | 49.38     | 10.52 | 27.48     |

Table 1 shows a pre-test mean achievement score of 22.25, 21.45 and 21.90, with corresponding standard deviation score of 9.43, 9.46 and 8.26, for students taught Biology using Vee heuristics strategy, mind-mapping strategy and lecture method respectively. Regarding the post-test, students in Vee heuristics group obtained a mean achievement score of 62.03, with a standard deviation of 9.65, and students in mind-mapping group obtained a mean achievement score of 58.05, with a standard deviation of 10.23. Students in the lecture group obtained a mean achievement score of 49.38, with a standard deviation of 10.52. Table 1 indicates that students taught using Vee heuristics strategy achieved the highest mean gain followed by students taught using mind-mapping strategy and lecture method respectively.

**Research Question 2**

What is the difference between the mean achievement scores of male and female students taught Biology using Vee heuristics, mind-mapping teaching strategies and lecture method?

**Table 2: Mean and Standard Deviation (SD) of Post-test Mean Achievement Scores of Male and Female Students Taught Biology Using Vee Heuristics, Mind-Mapping Strategies and Lecture Method**

| Method         | Sex    | N  | Mean  | SD    | Mean Difference |
|----------------|--------|----|-------|-------|-----------------|
| Vee heuristics | Male   | 32 | 64.59 | 9.76  | 5.20            |
|                | Female | 31 | 59.39 | 8.92  |                 |
| Mind-mapping   | Male   | 37 | 59.46 | 8.30  | 3.00            |
|                | Female | 37 | 56.65 | 11.80 |                 |
| Lecture Method | Male   | 45 | 47.82 | 10.26 | 3.74            |
|                | Female | 32 | 51.56 | 10.65 |                 |

Table 2 shows a post-test mean achievement score of 64.59, with a standard deviation of 9.76, for male students exposed to Vee heuristics strategy and female students had a post-test mean achievement score of 59.39, with a standard deviation of 8.92. The mean achievement scores of male and female students in the Vee heuristics group differ by 5.20, favouring male students.

Table 2, again, shows a post-test mean achievement score of 59.46, with a standard deviation of 8.30, for male students exposed to mind-mapping strategy and female students had a post-test mean achievement score of 56.65, with a standard deviation of 11.80. The mean achievement scores of male and female students in the mind-mapping group differ by 3.00, favouring male students.

Table 2, further, shows a post-test mean achievement score of 47.82, with a standard deviation of 10.26, for male students exposed to lecture method and female students had a post-test mean achievement score of 51.56, with a standard deviation of 10.65. The mean achievement scores of male and female students in the lecture group differ by 3.74, in favour of female students.

**Hypothesis 1**

There is no significant difference among the mean achievement scores of students taught Biology with Vee heuristics, mind-mapping teaching strategies and lecture method.

**Table 4: ANOVA Comparison of Pre-test Scores of Students Taught Biology Using Vee Heuristics Strategy, Mind-Mapping Strategy and Lecture Method**

|                | Sum of Squares | Df  | Mean Square | F    | Sig. |
|----------------|----------------|-----|-------------|------|------|
| Between Groups | 22.522         | 2   | 11.261      | .138 | .871 |
| Within Groups  | 17221.389      | 211 | 81.618      |      |      |
| Total          | 17243.911      | 213 |             |      |      |

p>0.05

Table 4 shows that there is no significant difference in the pre-test mean achievement scores among students taught Biology using Vee heuristics strategy, mind-mapping strategy and lecture method,  $F(2, 211) = 0.138$   $P(0.871) > 0.05$ . Hence,  $H_{01}$  was tested using ANOVA.

**Table 5: ANOVA Comparison of Post-test Scores of Students Taught Biology Using Vee Heuristics Strategy, Mind-Mapping Strategy and Lecture Method**

|                | Sum of Squares | Df  | Mean Square | F      | Sig. |
|----------------|----------------|-----|-------------|--------|------|
| Between Groups | 5979.940       | 2   | 2989.970    | 28.913 | .000 |
| Within Groups  | 21819.798      | 211 | 103.411     |        |      |
| Total          | 27799.738      | 213 |             |        |      |

P<0.05

Table 5 shows that there is a significant difference in the post-test mean achievement scores among students taught Biology using Vee heuristics strategy, mind-mapping strategy and lecture method,  $F(2, 211) = 28.913$ ,  $P(0.000) < 0.05$ . Therefore, the null hypothesis is rejected. Thus, there is a significant difference in the mean achievement scores among students taught Biology using Vee heuristics strategy, mind-mapping strategy and lecture method. In order to determine the direction of the difference among the three groups (Vee heuristics strategy, mind-mapping strategy and lecture method), Scheffe's post-hoc test was performed as shown in Table 6.

**Table 6: Scheffe's Post-hoc Test Comparison of Achievement Scores of Students Taught Using Vee Heuristics, Mind-Mapping Strategies and Lecture Method**

| (I) Teaching Methods | (J) Teaching Methods | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|----------------------|----------------------|-----------------------|------------|------|-------------------------|-------------|
|                      |                      |                       |            |      | Lower Bound             | Upper Bound |
| Vee heuristics       | Mind Mapping         | 3.978                 | 1.743      | .076 | -.32                    | 8.28        |
|                      | Lecture Method       | 12.655*               | 1.728      | .000 | 8.40                    | 16.91       |
| Mind Mapping         | Vee heuristics       | -3.978                | 1.743      | .076 | -8.28                   | .32         |
|                      | Lecture Method       | 8.677*                | 1.655      | .000 | 4.60                    | 12.76       |
| Lecture Method       | Vee heuristics       | -12.655*              | 1.728      | .000 | -16.91                  | -8.40       |
|                      | Mind Mapping         | -8.677*               | 1.655      | .000 | -12.76                  | -4.60       |

The Scheffe's post-hoc test shows that there is no significant difference between the mean achievement scores of students taught Biology using Vee heuristics strategy and those taught using mind-mapping strategy; there is a significant difference between the mean achievement scores of students taught Biology using Vee heuristics strategy and those taught using the lecture method, in favour of students taught using Vee heuristics strategy. The post-hoc test also indicates that there is a significant difference between the mean achievement scores of students taught Biology using mind-mapping strategy and those taught using lecture method, in favour of students taught using mind-mapping strategy. As indicated in Table 6, among the three instructional methods, Vee heuristics strategy and mind-mapping strategy proved more effective than the lecture method.

**Hypothesis 2**

There is no significant difference between the mean achievement scores of male and female students taught Biology using Vee heuristics, mind-mapping teaching strategies and lecture method.

**Table 7: T-test Comparison of Post-test Mean Achievement Scores of Male and Female Students Taught Biology Using Vee Heuristics, Mind-Mapping Strategies and Lecture Method**

| Method         | Sex    | N  | $\bar{x}$ | SD    | Df | t-cal. | Sig. (2-tailed) | Decision               |
|----------------|--------|----|-----------|-------|----|--------|-----------------|------------------------|
| Vee heuristics | Male   | 32 | 64.59     | 9.76  | 61 | 2.208  | 0.031           | Rejected<br>P<0.05     |
|                | Female | 31 | 59.39     | 8.92  |    |        |                 |                        |
| Mind-mapping   | Male   | 37 | 59.46     | 8.30  | 72 | 1.185  | 0.240           | Not Rejected<br>p>0.05 |
|                | Female | 37 | 56.65     | 11.80 |    |        |                 |                        |
| Lecture method | Male   | 45 | 47.82     | 10.26 | 75 | 1.552  | 0.125           | Not Rejected<br>p>0.05 |
|                | Female | 32 | 51.56     | 10.65 |    |        |                 |                        |

Table 7 shows that there is a significant difference in the post-test mean achievement scores between male and female students taught Biology using Vee heuristics strategy,  $t = 2.208$ ,  $P(0.031) < 0.05$ . Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean achievement scores of male and female students taught Biology using Vee heuristics strategy, in favour of male students.

Table 7, again, shows that there is no significant difference in the post-test mean achievement scores between male and female students taught Biology using mind-mapping strategy,  $t = 1.185$ ,  $P(0.240) > 0.05$ . Hence, the null hypothesis is not rejected. Therefore, there is no significant difference between the mean achievement scores of male and female students taught Biology using mind-mapping strategy.

Table 7, further, shows that there is no significant difference in the post-test mean achievement scores between male and female students taught Biology using lecture method,  $t = 1.552$ ,  $P(0.125) > 0.05$ . Hence, the null hypothesis is not rejected. Therefore, there is no significant difference between the mean achievement scores of male and female students taught Biology using lecture method.

**Discussion of Findings**

One of the findings of the study revealed that there is a significant difference in the mean achievement scores among students taught Biology using Vee heuristics strategy, mind-mapping strategy and lecture method. Scheffe’s post-hoc test revealed that among the three teaching strategies, Vee heuristics strategy and mind-mapping strategy are more effective than the lecture method. However, Vee heuristics strategy is as effective as mind-mapping teaching strategy with reference to students’ academic achievement in Biology. The observed higher achievement scores of students taught Biology using Vee heuristics and mind-mapping teaching strategies over their counterparts taught using the lecture method may be as a result of students’ active participation in the teaching and learning process. The use of Vee heuristics and mind-mapping teaching strategies may have promoted students’ active involvement during the teaching and learning process than the lecture method. This may have aided students’ comprehension of Biology concepts in Vee heuristics strategy and mind-mapping strategy groups. Students taught using Vee heuristics and mind-mapping strategies were given the opportunity to discover knowledge for themselves using Vee maps and mind maps. The use of Vee maps and mind maps aid students in generating ideas on their own on a given problem posed by the teacher by engaging in sound reasoning. This stimulates students to be actively involved in the teaching and learning process. However, the students taught using the traditional lecture method were provided the needed knowledge by the teacher. The students merely listened to the teachers’ explanation. The passive involvement of students in the lecture method group may have accounted for the observed less performance of students in the group. The observed higher performance of students taught using Vee heuristics and mind-mapping strategies over those that were taught using the lecture method agrees with the views of Mutai (2015) and Okereke and Okigbo (2019). Mutai (2015) reported that Vee



heuristics teaching strategy significantly enhanced students' conceptual understanding than the lecture method. Okereke and Okigbo (2019) on the other hand reported the significant effect of mind-mapping teaching strategy over the lecture method in Computer Science. The study showed that there is a significant difference between the mean achievement scores of male and female students taught Biology using Vee heuristics strategy, in favour of male students. One possible explanation for this observation may be due to the fact that Vee heuristics teaching strategy arouses, captures and sustains the interest of male students more than their female counterparts. This may have accounted for the higher achievement scores of male students more than their female counterparts. This finding disagrees with the view of Namasaka (2009) who reported that sex did affect achievement in Biology where female students performed better than male students taught using Vee heuristic teaching strategy.

Furthermore, the study showed that there is no significant difference between the mean achievement scores of male and female students taught Biology using mind-mapping strategy. In other words, mind-mapping teaching strategy equally enhanced the mean achievement scores of male and female students. This may be predicated on the fact that mind-mapping teaching strategy may have equally stimulated and captured the interest of male and female students. This finding agrees with that of Okereke and Okigbo (2019) who reported that gender was not a significant factor in determining students' achievement and interest in mind-mapping teaching strategy.

The study also revealed a non-significant difference between the mean achievement scores of male and female students taught Biology using the lecture method. This observation could be as a result of non-involvement of male and female students during instruction using the lecture method. The passive involvement of both sexes during instruction may have manifested the insignificant difference between the mean achievement scores. This finding further agrees with that of Okereke and Okigbo (2019) who reported that gender was not a significant factor in determining students' achievement and interest in mind-mapping teaching strategy.

## **Conclusion**

Based on the findings of this study, the following conclusions were drawn: Vee heuristics teaching strategy is as effective as mind-mapping teaching strategy in boosting students' academic achievement in Biology than lecture method. In addition, Vee heuristics and mind-mapping strategies improved students' achievement in Biology more than the lecture method. It was also concluded that Vee heuristics improves male students' academic achievement in Biology than their female counterparts. The study, again, concludes that mind-mapping teaching strategy improves the achievement of male students' as much as female students.

## **Recommendations**

Based on the findings and conclusions of this study, the following recommendations were made:

1. Biology teachers should adopt Vee heuristics teaching strategy in teaching Biology at the secondary school level, but attention should be paid to female students to ensure they equally participate as their male counterparts in the teaching and learning process.
2. Biology teachers should adopt mind-mapping teaching strategy as an alternative strategy to Vee heuristics teaching strategy especially when there is special attention on male students' development of favourable attitude towards Biology.
3. Biology teachers should be trained on how to construct and use Vee and mind-maps in teaching Biology.

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