Journal of Education and Learning (EduLearn)
Vol. 20, No. 1, February 2026, pp. 391~400
ISSN: 2089-9823 DOI: 10.11591/edulearn.v20i1.22963

Activity oriented teaching: efficacy of Vee diagrams and mind-maps on biology scholars' attitudes and academic achievement

Edarho Oghenevwede Oyovwi[1], Rita Ewere Chukwuka[2]
[1]Department of Science Education, Faculty of Education, Delta State University, Abraka, Nigeria
[2]Department of Science Education, Faculty of Education, University of Delta, Agbor, Nigeria

Article Info

Article history:

Received Aug 4, 2024
Revised Feb 26, 2025
Accepted Mar 19, 2025

Keywords:

Academic achievement
Attitude
Biology students
Mind-map
Teaching biology
Vee diagram

ABSTRACT

The study investigated the efficacy of Vee diagrams and mind-maps on biology scholars' attitudes and academic achievement. The study adopted a pretest, posttest planned variation quasi-experimental design. The 276 senior secondary II (SSII) biology scholars made up the study's sample. The instruments utilized for data collection include biology achievement test (BAT) and biology attitude scale (BAS). Analysis of covariance (ANCOVA) was applied to examine the pretest and posttest ratings at the 0.05 level of significance. The study demonstrated that scholars tutored biology concept with Vee diagrams improve in their achievement compared to scholars tutored using mind-maps, Vee diagrams improve scholars attitude in comparison to those tutored biology using mind-maps, male/female did not in fluence scholars tutored biology using Vee diagrams, male/female scholars tutored in biology using Vee diagram did not differ in their attitude ratings, no effect of male/female on biology scholars instructed using mind-maps, no significant discernible disparity in the attitude ratings of male/female scholars tutored biology using mind-maps.

Corresponding Author:

Edarho Oghenevwede Oyovwi
Department of Science Education, Faculty of Education, Delta State University
Abraka, Nigeria
Email: oyovwieo@delsu.edu.ng

1. INTRODUCTION

In science, biology studies living things- their composition, roles, growth, development, evolution, and correlations with their surroundings. Numerous sub-disciplines fall under this large umbrella field, such as botany (study of plants), zoology (study of animals), microbiology (study of microorganisms), genetics (study of genes and heredity), ecology (study of organisms and their interactions with the environment), and many others. Scholars who study biology are more apt to have a deep understanding of nature. Their basic understanding of living things is imparted to them, their structures, and their functions [1]. This scientific literacy is crucial in today's modern society, where scientific advancements and issues related to health, genetics, and the environment are prevalent. Professions, including medicine, veterinary science, pharmacy, biochemistry, genetics, microbiology, and environmental science, are based on biology. Secondary school biology instruction helps scholars take an early interest in these subjects and critically judge their postsecondary education and future careers [2]. Through biology, scholars can learn about human health, including issues like disease, nutrition, and the workings of the body's systems. To help scholars comprehend intricate biological concepts, the application of visual tools in curriculum implementation, and learning has been recommended [3].

Any graphic or visual representation shape that facilitates information understanding or communication is called a visual tool. These tools include maps, charts, diagrams, graphs, and other visual elements. The primary

goal of visual aids is to convey abstract or complicated information in a way that is easier to view and comprehend [4]. They can be applied to improve understanding, analysis, and communication of data or concepts in various fields, including education, business, research, and communication [5]. The application of visual aids in the classroom encourages participation and active engagement [6]. Utilizing visual tools in the classroom fosters involvement and lively interaction. Whether working independently or in teams, scholars can actively engage in crafting visual depictions. This hands-on approach improves retention and understanding as scholars can digest and integrate information more effectively [7].

On the other hand, a mind-map serves as a graphical representation of information and helps arrange and systematize thoughts, concepts, and ideas [8]. It is an effective tool for brainstorming, note-taking, problem-solving, and learning endeavors. Within a mind-map, concepts are linked across branches that radiate from a central term or principle, creating a hierarchical structure parallel to the human brain's innate cognitive processes. It focuses on a core idea surrounded by bright related ideas [9]. Mind-maps are versatile and can be applied in different areas. They are often applied in collaborative, non-linear brainstorming sessions to generate and systematize ideas [10]. Additionally, mind-maps are great for applying note-taking tasks. They capture information in a structured and visually compelling way.

Academic performance alludes to a student's performance in a formal educational environment and is usually evaluated through various assessments such as exams, assignments, projects, and grades [11]. It entails learning something new and skills and abilities tutored in a specific academic area or curriculum. They are often applied to measure a student's overall academic performance and potential for success in further educational endeavors or career goals. Jirgba and Bur [12] viewed academic achievement as the knowledge attained and skills developed in school subjects, the level of which is determined by test scores. Conversely, attitude concerns scholars' mindset, beliefs, and behavior on knowledge acquisition and skill development [8]. An affirmative attitude toward learning typically comes with curiosity, eagerness, persistence, flexibility, and a growth mindset. Scholars with an affirmative attitude are generally receptive to new concepts, actively participate in class activities, accept challenges, and view mistakes as opportunities for personal growth. Conversely, a negative attitude towards learning can manifest in a lack of commitment, disparity, lack of drive, and a fixed mindset in which scholars perceive their abilities as static and unable to be improved. Obro [11] explained that teachers are fundamental determinants of achievement and attitude towards school subjects.

The utilization of Vee diagrams and mind-maps presents significant potential for enhancing students' performance and attitudes towards biology. These tools offer lucid visual depictions of interconnections and simplify the comprehension of how various biological concepts are interconnected and bolster each other Awodun [13]. Consequently, students cultivate a holistic understanding of biology that transcends fragmented information. Engaging with Vee diagrams and mind-maps necessitates students to engage in critical thinking to delineate and illustrate connections among concepts. This fosters the cultivation of advanced cognitive abilities such as analysis, evaluation, and synthesis of information [14]. Vee diagrams and mind-maps offer a structured and systematic approach to organizing this information, facilitating improved retention, and accessibility. Students can generate and cultivate inventive concepts with the aid of Vee diagrams and mind-maps, which offer a versatile framework. Scholars can unearth fresh ideas and innovative methodologies for addressing challenges by delving into the connections among diverse concepts.

Vee and mind-maps emerge as potent instruments that facilitate students' success in biology by enabling them to visualize the relationships among ideas, organize information, cultivate critical thinking abilities, hone their problem-solving skills, and foster creativity. Vee diagrams, also known as Vee maps or Vee heuristics maps, are problem-solving tools commonly used in education. They systematically identify, analyze, and solve problems by breaking them into smaller components [15]. The Vee maps consist of 2 main branches, the left side representing the problem analysis phase and the right side representing the solution implementation phase [16]. According to Ameyaw and Kyere [4], breaking down the problem into smaller components and following a logical sequence, the Vee map facilitates a more thorough understanding of the problem and the development of practical solutions.

A mind-map consists of nodes representing key points or ideas and branches connecting these nodes and showing the relationship between them [17]. The central idea is placed in the center of the map, and related ideas are added as branches radiating from the central idea. Mind-maps are versatile and can be used for various purposes. They are commonly used for brainstorming sessions, where ideas are generated and organized in a collaborative and non-linear manner [18]. For Onah *et al.* [19] mind-maps are also effective in note-taking as they capture information structurally and visually engagingly. These maps help scholars make connections involving ideas, which improve understanding and retention. On the other hand, the Vee diagram simplifies thought processes by breaking down complex issues into smaller, more manageable parts. It serves as a framework for problem-solving.

Oyovwi and Emmanuel [20], investigated scholars retention of biology curriculum concepts through problem solving instructional strategy. The study ascertained that scholars will have better achievements when

tutored using Vee diagrams and mind-maps. Kusumawati *et al.* [6] studied the scholars worksheets based on inquiry with Vee diagrams to improve scholars writing skills reported improved overall performance which enhanced knowledge recall and retention. Joshua and Amina [16] examined effect of Vee diagrams and mind-maps strategies on students' performance. The study reported enhanced performance for students tutored using Vee diagram and mind-mapping. While earlier studies have explored the effect of Vee diagrams and mind-maps on scholars' achievement, they have not explicitly addressed its influence on scholars' attitude. This indicates the necessity for a comparable investigation to validate or disprove this assertion. This is the void that this study examined and addressed.

a. Research questions

- How do the average performance levels of scholars tutored with mind-maps and those tutored with Vee diagrams compare in biology?
- How do the average disposition ratings of scholars using Vee diagrams and those using mind-maps differ when teaching biology?
- How do male/female scholars tutored biology using Vee diagrams differ in average achievement ratings?
- How do male/female scholars tutored in biology using Vee diagrams differ in their average attitude ratings?
- How do male/female scholars tutored in biology using mind-maps differ regarding average achievement ratings?
- Which genders' average attitude ratings differ when using mind-maps to teach biology?

b. Research hypotheses

- H1: no discernible disparity exists between the average achievement ratings of scholars who tutored biology using Vee diagrams and those who were tutored using mind-maps.
- H2: no discernible disparity exists between the average attitude ratings of scholars who tutored biology using Vee diagrams and those who used mind-maps.
- H3: male/female scholars' average achievement ratings do not differ considerably when using Vee diagrams to teach biology.
- H4: when using Vee diagrams to teach biology, male/female scholars' average attitude ratings do not differ considerably.
- H5: no discernible disparity exists in the average achievement ratings of male/female scholars who receive Wits map instruction in biology.
- H6: no discernible disparity exists in the average attitude ratings of male/female biology scholars tutored using mind-maps.

2. METHOD

The study applied a quasi-experimental design with planned variation before and after the test, consisting of 2 groups (Vee and mind-maps) and 2 gender levels (male/female). The independent variables included 2 visual aids (Vee and mind-maps), with gender as a moderator variable and the dependent variables being achievement and attitude toward biology. The study population included 12,956 senior secondary II (SSII) biology scholars in Delta North Senatorial District public schools. The sample consisted 276 SSII biology scholars selected from intact classes in four public schools in the 3 senatorial districts in Delta State. Schools were selected through simple random sampling to ensure all schools had equal choice. Data collection instruments included the biology achievement test (BAT) and the biology attitude scale (BAS). The BAT consisted of 50 objective questions derived from previous West African Examinations Council (WAEC) respiration questionnaires, each with A-D options. The BAS comprised 20 items assessing scholars' opinions about their attitudes toward biology, framed on a 4-point scale ranging from strongly agree (SA-4) to disagree strongly (SD-1). The Kuder-Richardson 21 (KR-21) method was utilized to assess the reliability of the BAT. An internal consistency coefficient of 0.79 was obtained. Parallelly, BAS, using Cronbach's alpha, yielded a reliability coefficient of 0.77.

3. RESULTS AND DISCUSSION

3.1. Results

The following research question was used to guide the study and was answered.

- RQ 1: how do the average performance levels of scholars instructed with mind-maps and those instructed with Vee diagrams compare in biology?

Table 1 shows the pretest average achievement ratings of 23.79 and 23.29 for scholars who were tutored biology using Vee and mind-maps, respectively. Scholars instructed using Vee diagram had a higher average score on the posttest-56.18 than scholars instructed using mind-maps, with an average score of 48.63. Scholars instructed using Vee diagram showed the biggest average achievement gain (32.39), while scholars

instructed with mind-maps (25.34). There is a discrepancy involving the 2 groups' average gains. The result shows that the scholars instructed using outperformed their counterparts instructed using the mind-mapping teaching approach. Thus, those who were instructed using the Vee diagram approach had enhanced performance in comparison to scholars instructed with the mind-map approach.

Table 1. Average of pretest and posttest achievement ratings of scholars tutored biology using Vee and mind-maps

Group	N	X	Standard deviation	X	Standard deviation	Average gain
Vee	132	23.79	9.30	56.18	11.96	32.39
Mind-maps	143	23.29	7.91	48.63	13.12	25.34

- HO_1: no significant discernible disparity exists between the average achievement ratings of scholars instructed biology using Vee diagrams and those instructed using mind-maps.

The posttest average achievement ratings of scholars instructed in biology with Vee diagram and mind-maps show a considerable disparity, as shown in Table 2: $F(2, 272)=30.905$, $P(0.000)<0.05$. As such, the null hypothesis is rejected. Thus, there is a discernible disparity involving the average achievement ratings of scholars who learned biology using mind-maps and Vee diagrams, with Vee diagrams outperforming scholars instructed using mind-maps.

Table 2. Analysis of covariance (ANCOVA) comparison of posttest achievement ratings of scholars instructed biology using vee and mind-maps

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	16119.232	2	8059.616	70.783	0.000
Intercept	37507.009	1	37507.009	329.402	0.000
Pretest	12204.043	1	12204.043	107.181	0.000
Visual tools	3518.926	1	3518.926	30.905	0.000
Error	30970.950	272	113.864		
Total	797988.000	275			
Corrected total	47090.182	274			

- RQ 2: how do the average disposition ratings of scholars instructed using Vee diagrams and those instructed using mind-maps differ when teaching biology?

The pretest average attitude ratings for scholars instructed biology using Vee diagram and mind-maps are shown in Table 3 at 33.79 and 32.85. Regarding average attitude ratings on the posttest, scholars instructed using Vee diagram received a higher average score-65.68, than scholars instructed Wits maps, who received an average score of 62.66. Scholars instructed biology using Vee diagram showed the highest average attitude gain (31.89), followed by scholars instructed the subject using mind-maps (29.81). The average gains of the 2 groups show a disparity of 2.08 points.

Table 3. Average of pretest and posttest attitude ratings of scholars instructed biology using Vee and mind-maps

Group	N	Pretest		Posttest		Average gain
		Average	Standard deviation	Average	Standard deviation	
Vee	132	33.79	8.00	65.68	9.72	31.89
Mind-maps	143	32.85	7.65	62.66	10.07	29.81

- HO_2: no significant discernible disparity exists between the average attitude ratings of scholars instructed biology using Vee diagrams and those tutored using mind-maps.

Table 4 shows that the posttest average attitude ratings of scholars instructed biology using Vee diagrams and mind-maps showed a considerable disparity ($F(2, 272)=6.094$, $P(0.000)<0.05$). As a result, the null hypothesis is disproved. The average attitude ratings of scholars tutored biology using Vee diagrams and mind-maps show a considerable disparity, favoring Vee maps. Thus, a significant variance exists in the attitude ratings of scholars tutored biology using Vee diagrams and mind-maps. The attitude of scholars instructed with Vee diagram was boost compared to the scholars instructed using the mind-map instructional approach. In other words, Vee diagrams efficiently boost scholars' attitude towards biology concept than scholars instructed with the mind-map method.

Table 4. ANCOVA comparison of posttest attitude ratings of scholars tutored biology using Vee diagram and mind-maps

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	714.721	2	357.361	3.642	0.027
Intercept	54372.878	1	54372.878	554.077	0.000
Pretest	86.840	1	86.840	0.885	0.348
Visual tools	598.049	1	598.049	6.094	0.014
Error	26692.006	272	98.132		
Total	1157650.000	275			
Corrected total	27406.727	274			

- RQ 3: how do male/female scholars tutored biology using Vee diagrams differ in average achievement ratings?

Table 5 shows that male scholars' pretest average achievement score was 22.49, while female scholars' pretest average achievement score was 25.45, demonstrating that the 2 gender groups did not start at the same level of achievement. Regarding average achievement ratings on the posttest, male scholars scored better than female scholars, with males scoring 56.70 higher on average and female scholars scoring 56.03 lower. The result indicates that when it came to average achievement gain, male scholars instructed biology using Vee diagrams showed the highest gain (34.21) compared to the average gain of female scholars (30.58). There is a 3.63 disparity involving the average achievement gains of the 2 genders. Therefore, male scholars outperformed their female scholars using the Vee diagrams approach at the posttest.

Table 5. Average of pretest and posttest achievement ratings of male/female scholars tutored biology using Vee diagrams

Sex	N	Pretest		Posttest		Average gain
		Average	Std	Average	Std	
Male	74	22.49	8.69	56.70	11.86	34.21
Female	58	25.45	9.85	56.03	12.23	30.58

Note: Std is standard deviation.

- HO_3: male/female scholars' average achievement ratings do not differ considerably when using Vee diagrams to teach biology.

Table 6 shows that the posttest average achievement ratings of male/female scholars who received biology instruction using Vee diagrams do not considerably differ from one another; $F(1, 129)=2.989$, $P(0.086)>0.05$. As such, the null hypothesis is maintained. As a result, no discernible disparity exists in the average achievement ratings of male/female biology scholars who applied Vee diagrams. The inference is that scholars' students tutored with Vee diagrams did not differ in their achievement rating with regard to scholars' gender. Significant variance did not exist in the biology achievement rating of scholars exposed to Vee diagram with regard to male/female. Thus, male/female did not influence scholars' achievement rating.

Table 6. ANCOVA comparison of posttest achievement ratings of male/female scholars tutored biology using Vee diagrams

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	6710.562	2	3355.281	35.761	0.000
Intercept	23816.703	1	23816.703	253.843	0.000
Pretest	6696.043	1	6696.043	71.368	0.000
Sex	280.412	1	280.412	2.989	0.086
Error	12103.347	129	93.824		
Total	438836.000	132			
Corrected total	18813.909	131			

- RQ 4: how do male/female scholars who tutored biology using Vee diagrams differ in their average attitude ratings?

Table 7 shows male scholars' pretest average attitude score was 36.32, and female scholars' pretest average attitude score was 30.55. These results show that the 2 gender groups did not begin at the same level of attitude. At posttest average attitude ratings, female scholars scored 64.28, while male scholars scored higher at 66.78. It demonstrates that, compared to male scholars' average attitude gain (30.46), female scholars who received biology instruction using Vee diagrams showed the highest average attitude gain (33.73). There is a

3.27 disparity involving the average attitude gains of the 2 genders. The implication is that in comparison of male/female attitude, female scholars instructed biology using Vee diagrams outperformed male scholars. Thus, female scholars had improved attitude better their male counterparts.

Table 7. Average of pretest and posttest attitude ratings of male/female scholars tutored biology using Vee diagrams

Sex	N	Pretest		Posttest		Average gain
		Average	Std	Average	Std	
Male	74	36.32	8.521	66.78	9.90	30.46
Female	58	30.55	5.927	64.28	9.39	33.73

Note: Std is standard deviation.

- HO_4: male/female scholars' average attitude ratings will not significantly differ when using Vee diagrams to teach biology.

Table 8 shows that, for male/female scholars tutored biology using Vee diagrams, there exists no statistically considerable disparity in the posttest average attitude ratings ($F(1, 129)=2.897$, $P(0.091)>0.05$). As such, the null hypothesis is maintained. Therefore, no discernible disparity exists involving male/female scholars tutored in biology using Vee diagram in terms of their average attitude ratings. The implication of this result is that Vee diagrams can be effective for both male/female. Thus, the Vee diagram approach can used to tutor male/female scholars without recourse to scholars' gender. No considerable gender disparity emerged when male/female scholars used the Vee diagram approach.

Table 8. ANCOVA comparison of posttest attitude ratings of male/female scholars tutored biology using Vee diagrams

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	280.644	2	140.322	1.496	0.228
Intercept	29560.295	1	29560.295	315.251	0.000
Pretest	76.134	1	76.134	0.812	0.369
Sex	271.632	1	271.632	2.897	0.091
Error	12095.992	129	93.767		
Total	581838.000	132			
Corrected total	12376.636	131			

- RQ 5: how do male/female scholars tutored biology using mind-maps differ in average achievement ratings?

A pretest average achievement score of 23.18 for male scholars and 23.42 for female scholars in Table 9 indicates that the 2 gender groups initially demonstrated parallel levels of achievement. In posttest, male scholars obtained an average of 48.44, and female scholars obtained an average of 48.86. Male biology scholars tutored using mind-maps demonstrated an average achievement gain of 25.26, whereas female scholars showed an average achievement gain of 25.44. There is a 0.18 disparity involving the average achievement gains of the 2 genders. In other words, female scholars outperformed the male scholars with a variance of 0.18 average gain when instructed biology concepts with mind-maps. The implication is that female scholars outperformed male scholars in the same group after they have undergone instruction in biology concept using the mind-map strategy.

Table 9. Average of pretest and posttest achievement of male/female scholars tutored biology with mind-maps

Sex	N	Pretest		Posttest		Average gain
		Average	Std	Average	Std	
Male	78	23.18	8.32	48.44	13.77	25.26
Female	65	23.42	7.46	48.86	12.40	25.44

Note: Std is standard deviation.

- HO_5: no significant discernible disparity exists in the average achievement ratings of male/female scholars who receive mind-maps instruction in biology.

Table 10 shows that there exists no significant disparity involving male/female scholars instructed biology using mind-maps in their posttest average achievement ratings: $F(1, 140)=0.015$, $P(0.902)>0.05$.

As such, the null hypothesis is maintained. Therefore, no discernible disparity in the average achievement ratings of male/female biology scholars instructed using mind-maps. On this basis, hypothesis 5 was accepted. The implication is that that mind-maps improve male/female scholars respectively. Thus, the result indicates that mind-maps can be utilized in instruction of both sexes (male/female). It is useful and effective instructional approach for male scholars as well as female scholars.

Table 10. ANCOVA comparison of posttest achievement ratings of male/female scholars tutored biology using mind-maps

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	5388.175	2	2694.087	19.794	0.000
Intercept	13677.035	1	13677.035	100.486	0.000
Pretest	5381.752	1	5381.752	39.540	0.000
Sex	2.077	1	2.077	0.015	0.902
Error	19055.182	140	136.108		
Total	362612.000	143			
Corrected total	24443.357	142			

- RQ 6: which genders' average attitude ratings differ when using mind-maps to teach biology?

The pretest average attitude ratings for the 2 gender groups were 32.90 for male and 32.80 for female scholars. Table 11 shows that the 2 gender groups initially displayed parallel attitude levels. Regarding the posttest average attitude ratings, male scholars scored 64.32, higher than female scholars, who scored 61.29. Male scholars who received biology instruction through mind-maps showed the highest average attitude gain (31.42), while female scholars showed an average increase of 28.49. There is a 2.98 disparity involving the average attitude gains of the 2 genders.

Table 11. Average and standard deviation of pretest and posttest attitude ratings of male/female scholars tutored biology using Vee diagram

Sex	N	Pretest		Posttest		Average gain
		Average	Std	Average	Std	
Male	78	32.90	8.05	64.32	9.98	31.42
Female	65	32.80	7.19	61.29	10.64	28.49

Note: Std is standard deviation.

- HO_6: no significant discernible disparity exists involving the average attitude ratings of male/female biology scholars tutored using mind-maps.

Table 12 indicates no statistically considerable disparity involving the average attitude ratings of the posttest for male/female scholars instructed biology using mind-maps ($F(1, 140)=3.061$, $P(0.082)>0.05$). Thus, the null hypothesis is supported. Therefore, there was no significant discernible disparity involving male/female scholars who tutored biology using mind-maps in their average attitude ratings. The result indicates that mind-maps is an effective teaching approach for both male/female scholars. Thus, mind-maps approach can utilize to tutor male/female scholars without recourse to scholars' gender. No considerable gender disparity emerged when male/female scholars used the mind-maps approach.

Table 12. ANCOVA comparison of posttest attitude ratings of male/female scholars tutored biology using mind-maps

Source	Type III sum of squares	Df	Average square	F	Sig.
Corrected model	512.198	2	256.099	2.435	0.091
Intercept	24449.747	1	24449.747	232.454	0.000
Pretest	187.079	1	187.079	1.779	0.184
Sex	321.973	1	321.973	3.061	0.082
Error	14725.355	140	105.181		
Total	581797.000	143			
Corrected total	15237.552	142			

3.2. Discussion

Our study found that scholars tutored biology curriculum concepts using both Vee and mind-maps had considerably different average achievement ratings, with mind-maps preferred. We discovered that when teaching biology, scholars who applied Vee diagrams outperformed those who applied mind-maps.

Vee diagrams, which graphically illustrate the connections involving concepts, ideas, and procedures, are structured and may explain this observation [21]. Our study aligns with that of Oyovwi and Emmanuel [20], Kusumawati *et al.* [6], and Joshua and Amina [16], who reported improved overall performance due to the implementation of structured information organization, which enhanced knowledge recall and retention. Our result collaborates with that of Maureen [3]. Maureen *et al.* [22] which dealt with scholars who learned genetics using Vee diagram, performed noticeably better than those instructed the subject using mind-maps. Our findings concur with Ogunleye and Ojekwu [23] study, which found discernible variation in the average achievement ratings of biology scholars tutored using Wits mapping techniques and Vee heuristics.

Our study ascertained that, when teaching biology with mind-maps as opposed to Vee diagrams, there was a considerable disparity in the average attitude ratings of the scholars. This suggests that scholars instructed with Vee diagrams had better attitude ratings than those instructed with mind-maps. Our study confirmed with Abamba *et al.* [24]. A plausible rationale for this disparity could be ascribed to the more lucid visual arrangement offered by Vee maps when illustrating biological concepts in contrast to mind-maps. Vee diagrams' logical and unambiguous information flow may have lessened cognitive load and confusion, raising average attitude ratings. Namasaka *et al.* [25] study, which reported that scholars instructed biology with Vee diagrams scored high, confirms this conclusion.

The result of our study reaffirmed that, when it comes to male/female scholars learning biology with Vee diagrams, there exists no significant disparity in average achievement ratings. One possible explanation for this finding is Vee diagrams' ability to captivate, hold, and engage the attention of male/female scholars. The lack of a discernible achievement gap involving male/female scholars could be partly attributed to this equitable engagement. Our study result contradicts the study of Namasaka *et al.* [25] and Dawal [26], who suggested that gender affects biology achievement and that when Vee diagrams are applied in the classroom, female scholars perform better than male scholars.

Additionally, the findings of our study confirmed that male/female biology scholars' average attitude ratings do not considerably differ. This shows that both male/female scholars benefit equally from Vee diagrams' promotion of positive attitudes. This observation is consistent with the research conducted by Njue *et al.* [27] who found that scholars' attitudinal changes are positively impacted by the Vee heuristics teaching strategy in all cases. Simply implies that mind-maps essentially raised both male/female scholars' average achievement ratings. This discovery of our research aligns with the findings presented by Okereke and Okigbo [28], who dealt with that gender had no discernible impact on scholars' academic performance or level of interest in the mind-mapping approach. Again, when it came to scholars' attitudes, our study showed no significant disparity involving male/female scholars instructed biology with mind-maps. This suggests that male scholars do not experience a more considerable positive shift in attitude when using mind-maps than female scholars. This possibility arises because the use of mind-maps equally stimulates the curiosity of both male/female scholars. Nacilla and Dolotallas [29], Akparobore *et al.* [30], and Omeiza [31] results, which parallelly found no considerable disparity in the average attitude ratings of male/female scholars tutored biology using the mind-mapping teaching strategy, are consistent with this finding.

4. CONCLUSION

Our findings concluded that scholars tutored biology concept with Vee diagrams improve in their achievement compared to scholars tutored using mind-maps, Vee diagrams improve scholars attitude in comparison to those tutored biology using mind-maps, male/female did not in fluence scholars tutored biology using Vee diagrams, male/female scholars tutored in biology using Vee diagram did not differ in their attitude ratings, no effect of male/female on biology scholars instructed using mind-maps, no significant discernible disparity in the attitude ratings of male/female scholars tutored biology using mind-maps. Our findings provided conclusive evidence that Vee diagrams improve scholars' achievement and attitude in comparison to mind-maps. Our study confirmed that scholars' sex (male/female) has no effect on scholars' achievement and attitude when instructed with tutored using Vee diagram and mind-maps. Also, our findings established that parallel to the effects seen in female scholars, Vee diagrams and mind-maps have an equal positive impact on male biology scholars' performance and attitude. We recommended that biology teachers should promote Vee diagrams to help scholars understand and systematize biological concepts. With this tool's help, scholars can visually represent and link concepts; biology teachers should provide scholars with resources and examples of expertly created Vee diagrams; and that biology teachers should consider incorporating Vee diagrams into evaluations like tests or quizzes.

FUNDING INFORMATION

There is no funding for this study.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Edarho Oghenevwede Oyovwi	✓	✓	✓	✓		✓	✓		✓	✓		✓		
Rita Ewere Chukwuka	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

Ethical guidelines were observed throughout the data collection process. The research concerning human utilization has adhered to all pertinent national rules and institutional policies in alignment with the principles of the Helsinki Declaration and has received approval from the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [EOO], upon reasonable request.

REFERENCES

[1] M. Erkol and Ş. Gül, "Effect of Vee diagram on the achievements and attitudes of students in science laboratory course-II," *New Trends and Issues Proceedings on Humanities and Social Sciences*, vol. 3, no. 1, pp. 500–505, Jun. 2017, doi: 10.18844/gjhss.v3i1.1812.

[2] I. S. Nwuba, S. O. Egwu, O. F. Awosika, and A. M. Osuafor, "Secondary school students' critical thinking ability as correlate of their academic achievement in biology in Awka Education Zone, Nigeria," *Human Nature Journal of Social Sciences*, vol. 3, no. 4, pp. 201–210, 2022.

[3] U. I. Maureen, "Impact of mind-mapping instructional strategy on secondary school students' achievement and retention in biology in Delta State," *International Journal of Research and Scientific Innovation*, vol. 10, no. 9, pp. 217–224, 2023, doi: 10.51244/IJRSI.2023.10921.

[4] Y. Ameyaw and I. Kyere, "Mapping biological concepts: concept-Vee maps an improver of students' performance in photosynthesis," *IJISET - International Journal of Innovative Science, Engineering & Technology*, vol. 6, no. 6, pp. 169–181, 2019.

[5] E. O. Oyovwi, "Effects of concept-mapping and inquiry strategies in teaching difficult curriculum concepts in biology on students' academic achievement and retention," *International Journal of Biosciences*, vol. 18, no. 6, pp. 258–267, 2021, doi: 10.12692/ijb/18.6.258-267.

[6] T. R. D. Kusumawati, Supeno, and A. D. Lesmono, "Student worksheet based on inquiry with Vee map to improve writing skills in physics learning," *Journal of Physics: Conference Series*, vol. 1465, no. 1, p. 012034, 2020, doi: 10.1088/1742-6596/1465/1/012034.

[7] E. O. Ekpo and O. M. Ehi, "Effects of field trip method on student's academic achievement and retention in basic science and technology," *IJRDO-Journal of Applied Science*, vol. 8, no. 9, pp. 20–27, 2022, doi: 10.53555/as.v8i9.5252.

[8] A. A. Folakemi and B. Ganiyu, "Effects of mind maps on senior school students' achievement in genetics in Ibadan, Nigeria," *Nigerian Online Journal of Educational Sciences and Technology*, vol. 6, no. 1, pp. 109–123, 2024.

[9] M. A. Katcha, A. B. Orji, U. E. Francisca, Z. Abubakar, and M. Babagana, "Effects of mind-mapping instructional approach on senior secondary school biology students' achievement in evolution in Minna, Niger State, Nigeria," *Journal of Science, Technology, Mathematics and Education*, vol. 14, no. 2, pp. 56–65, 2018.

[10] C. M. Anenye and A. M. Osuafor, "Effect of mind mapping teaching strategy on secondary school students' academic achievement in biology in Awka South Local Government Area," *South Eastern journal of Research and Sustainable Development*, vol. 11, no. 1, pp. 55–73, 2023.

[11] S. Obro, "Efficacy of innovative instructional strategies: effect of learning games strategy on students' learning outcome in social studies classroom," *International Journal of Learning and Change*, vol. 15, no. 1, pp. 96–115, 2023, doi: 10.1504/IJLC.2021.10036645.

[12] C. M. Jirgba and J. I. Bur, "Effect of self-regulated learning strategy on students' achievement in basic science in Makurdi Local Government, Benue State, Nigeria," *African Journal of Teacher Education*, vol. 8, pp. 361–379, 2019, doi: 10.21083/ajote.v8i0.5073.

[13] A. O. Awodun, "Effects of concept mapping teaching strategy on students' academic performance and retention in senior secondary school physics in Ekiti State, Nigeria," *International Journal for Research in Educational Studies*, vol. 3, no. 6, pp. 10–18, 2017.
[14] R. Sinha, "Vee mapping: a review," *Journal of Research in Humanities and Social Science*, vol. 9, no. 3, pp. 40–43, 2021.
[15] G. D. James and A. T. Yunana, "The impact of Vee mapping strategy on chemistry students' performance in quantitative analysis in Kaduna State, Nigeria," *Sapientia Foundation Journal of Education, Sciences and Gender Studies (SFJESGS)*, vol. 2, no. 4, pp. 107–112, 2020.
[16] O. Joshua and C. Amina, "Effects of computer-aided concept-diagram and Vee-mapping strategies on organic chemistry learning outcome among senior secondary school students in Niger State, Nigeria," *IOSR Journal of Research and Method in Education (IOSR-JRME)*, vol. 11, no. 4, pp. 15–21, 2021, doi: 10.9790/7388-1104051521.
[17] A. O. Akanbi, Y. W. Olayinka, E. O. Omosewo, and R. E. Mohammed, "Effect of mind mapping instructional strategy on students' retention in physics in senior secondary schools," *Anatolian Journal of Education*, vol. 6, no. 1, pp. 145–156, 2021, doi: 10.29333/aje.2021.6112a.
[18] I. G. A. Okonkwo and N. N. C. Samuel, "Comparative effects of concept mapping and simulation-game teaching strategies on students' interest in environmental concepts in chemistry," *UNIZIK Journal of STM Education*, vol. 4, no. 1, pp. 76–87, Aug. 2021.
[19] K. T. Onah, R. C. Anamezie, and F. O. Nnadi, "Effect of mind-mapping teaching approach on students' academic achievement in physics concepts of motion and kinematics," *Greener Journal of Educational Research*, vol. 12, no. 1, pp. 31–40, 2022,
[20] E. O. Oyovwi and U. O. Emmanuel, "Enhancing students retention level of basic science curriculum concepts through problem solving instructional strategy," *Journal of Innovations*, no. 70, 144–150, 2022.
[21] W. A. Hazaymeh and M. K. Alomery, "The effectiveness of visual mind mapping strategy for improving English language learners' critical thinking skills and reading ability," *European Journal of Educational Research*, vol. 11, no. 1, pp. 141–150, Jan. 2021, doi: 10.12973/eu-jer.11.1.141.
[22] U. I. Maureen, O. P. Ajaja, and T. E. Agboghoroma, "Comparing the effectiveness of Vee heuristics, mind mapping and lecture methods on secondary school students achievement in biology in Delta State," *Journal of Innovations*, vol. 73, pp. 1334–1343, 2023.
[23] B. O. Ogunleye and I. N. Ojekwu, "Effects of mind mapping strategy and gender on students' basic science achievement in Eleme Local Government Area of Rivers State," *Journal of Education*, vol. 12, pp. 193–204, 2020.
[24] E. I. Abamba, A. H. Efe, and L. E. Esiekpe, "Comparative effects of mind and concept mappings on students' academic achievement and retention of the concepts of radioactivity and electrolysis in senior secondary school science in Delta State, Nigeria," *Rivers State University Journal of Education*, vol. 24, no. 1, pp. 1–12, 2021.
[25] F. W. Namasaka, H. Mondoh, and F. N. Keraro, "Effects of concept and Vee mapping strategy on students' motivation and achievement in biology in secondary schools in Uasin–Gishu District, Kenya," *International Journal of Current Research in Life Sciences*, vol. 1, no. 7, pp. 23–28, 2013.
[26] B. S. Dawal, "Investigating gender differences in the attitude and achievement of secondary school students towards STEM education in Plateau State," *Kashere Journal of Education (KJE)*, vol. 2, no. 1, pp. 192–200, 2021.
[27] A. K. Njue, L. M. Kamau, and J. Mwania, "Effects of Vee heuristic teaching approach on secondary school students' attitudes towards biology in Kenya," *IOSR Journal of Research & Method in Education (IOSR-JRME)*, vol. 8, no. 1, pp. 18–23, 2018.
[28] C. M. Okereke and E. C. Okigbo, "Effectiveness of Wits-mapping teaching strategy in enhancing senior secondary school scholars' achievement and interest in computer studies," *UNIZIK Journal of STM Education*, vol. 3, no. 1, pp. 1–22, 2019.
[29] P. J. D. Nacilla and A. C. Dolotallas, "Mind mapping as a learning strategy on the students' performance in biology," *Journal of Education & Social Policy*, vol. 6, no. 4, pp. 133–136, 2019.
[30] B. E. Akparobore, E. O. Oyovwi, and E. Kpangban, "Comparative study of adaptive teaching and lecture methods on secondary school students' achievement in chemistry in Delat State," *International Journal of Innovative Education Research*, vol. 12, no. 1, pp. 46–52, 2024.
[31] I. I. Omeiza, "Effect of concept mapping strategy on the attitude of senior secondary school students of varied ability levels in algebra in Kogi State, Nigeria," *ATBU Journal of Science, Technology and Education*, vol. 7, no. 1, pp. 77–87, 2019.

BIOGRAPHIES OF AUTHORS

Edarho Oghenevwede Oyovwi obtained his PhD in curriculum studies (science education) at Delta State University Abraka in 2013. Obtain his M.Ed. curriculum studies (science education), Delta State University Abraka, 2007, post graduate diploma in education, Delta State University Abraka, 2002. National Diploma/Higher National Diploma in (ND/HND) in Food Technology, Federal Polytechnic Idah, Kogi State, 1987. He has held other positions in the university, which include coordinator of the Teachers' Registration Council of Nigeria, Faculty of Education, teaching and supervision at the undergraduate and postgraduate levels, and members of various committees in Delsu. He can be contacted at email: oyovwieo@delsu.edu.ng.

Rita Ewere Chukwuka is an alumnus of the Delta State University, Abraka, Nigeria. She obtained her PhD master's degree, and bachelor's degree in science education (biology) from Delta State University, Abraka, and Nigeria Certificate in Education (NCE) in biology/chemistry from the College of Education, Agbor, in 2003. She can be contacted at email: rita.chukwuka@unidel.edu.ng.