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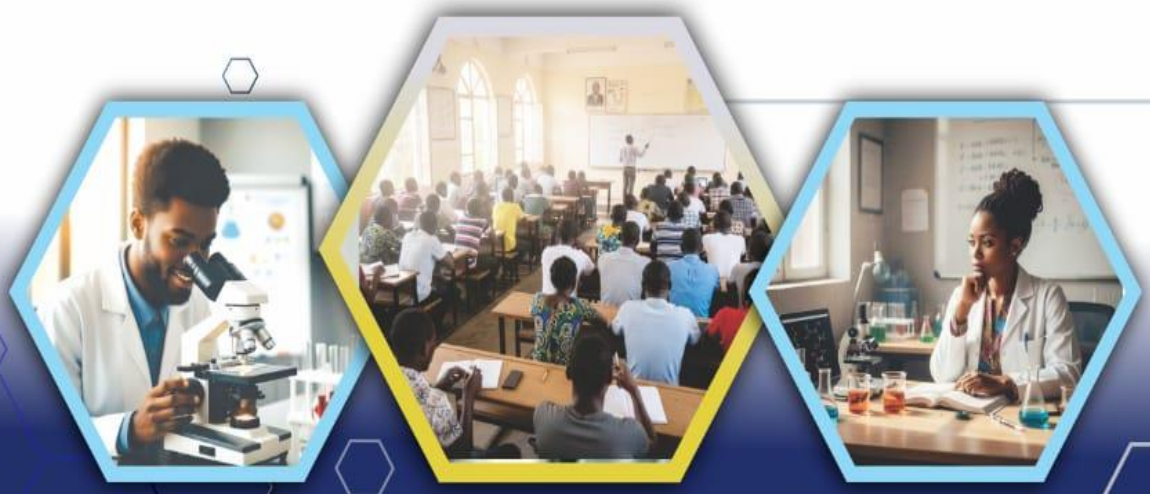

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EFFECTS OF CONCEPT MAPPINGS INSTRUCTIONAL STRATEGY ON ACHIEVEMENT AND RETENTION OF STUDENTS IN CIRCULATORY SYSTEM IN KUJE AREA COUNCIL, ABUJA, NIGERIA

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Abstract

This study investigated the effects of the Concept Mapping Instructional Strategy (CMIS) on students' achievement and retention in the circulatory system in Kuje Area Council, FCT Abuja. Four research objectives, four research questions, and four null hypotheses were formulated and tested using mean, standard deviation, and Analysis of Covariance (ANCOVA) at a 0.05 level of significance. A quasi-experimental design was employed for the study. The sample comprised 96 Senior Secondary Two (SS II) students from randomly selected co-educational public secondary schools. The students were randomly assigned into experimental (50 students) and control (46 students) groups. Two intact classes were used for the experimental and control groups. Two instruments were used for data collection: the Circulatory System Achievement Test (CSAT) and the Circulatory System Retention Test (CSRT), each consisting of 30 multiple-choice questions adapted from past WAEC examinations and aligned with Bloom's taxonomy. Content and face validity of the CSAT and CSRT were established by expert lecturers in the department. The reliability of the instruments was determined using the Kuder-Richardson Formula 21 (K-R21), yielding reliability coefficients of 0.87 for CSAT and 0.84 for CSRT. The findings revealed that students taught using the Concept Mapping Instructional Strategy (CMIS) achieved significantly higher scores in both achievement and retention compared to those taught using the conventional method. This indicates that CMIS promotes deeper understanding and long-term retention of the circulatory system concepts. The study concludes that concept mapping is an effective instructional strategy that enhances learning outcomes in biology. Based on these findings, the study recommends the integration of CMIS into the biology curriculum and teacher training programs. Further studies are suggested to explore its application across other science topics and educational contexts. Overall, this study contributes to the growing body of knowledge supporting the use of visual and interactive instructional strategies in biology education.

Keywords*:* Concept mapping, academic achievement, retention, student-centered learning, circulatory system and cognitive development.

Introduction

The 21st century is marked by rapid advancements in science and technology, and for Nigeria to achieve accelerated development; it requires high-quality science and technology education, particularly at the junior and senior secondary school levels, which form the foundation for advanced scientific learning (Omorogbe & Ewansiha, 2017). Science and technology education is critical in developing countries like Nigeria, as it ensures a steady supply of students equipped to pursue advanced careers in these fields (Samuel, 2017). A scientifically and technologically literate population is essential for Nigeria to realize its aspiration of becoming one of the world's top 20 economically developed countries by 2035 (Achimugu, 2016).

Biology, as a core science subject, plays a central role in scientific and technological development. It explores the study of living organisms and underpins advances in medicine, agriculture, biotechnology, and industry (Igwe, 2016). Senior secondary school biology provides foundational knowledge that prepares students for higher education and professional careers in biologically oriented fields, contributing to national development and societal well-being (Odubunmi, 2016; Nikita, 2018). Despite governmental and organizational initiatives, such as those by the Science Teachers Association of Nigeria (STAN), student performance in SSCE Biology examinations has continued to decline (Esu, 2018). Poor achievement in biology limits access to advanced studies and creates a potential shortage of professionals in critical areas like medicine, veterinary science, nursing, genetics, and agriculture, thereby threatening Nigeria's socio-economic progress (Anaekwe, Okpala & Olisakwe, 2016).

A critical area of difficulty in biology is the circulatory system, a fundamental topic essential for understanding human physiology and the interdependence of body systems. Its complexity arises from the interaction of numerous components, including the heart, blood vessels, and blood, along with dynamic processes such as oxygen and nutrient transport, waste removal, and hormonal regulation (Novak, 2017; Silverthorn, 2020; Sherwood, 2015). The abstract terminologies and interconnected processes often make the topic challenging for students to comprehend and retain, leading to fragmented understanding and low academic performance. Addressing these challenges is crucial for fostering robust biological understanding, improving academic outcomes, and ensuring a pipeline of skilled professionals capable of driving national scientific and technological advancement.

Table 1.1: West African Senior Secondary Certificate Examination (WASSCE) Result in Biology FCT, Abuja from 2018-2024

Year	Number of candidates registered	Total pass at credit level A1-C6	%passes at grade A1-C6	Total pass D7	failure F9 %
2018	3507	1571	44.80%	1936	55.20% = 100%
2019	3110	1201	46.66%	1909	53.34% = 100%
2020	3418	1421	41.57%	1997	58.43%=100%
2021	3482	1590	45.66%	1892	54.34%=100%
2022	3817	1520	39.82%	2297	60.18%=100%
2023	3901	1911	48.99%	1990	51.01%=100%
2024	3982	1910	48.99%	2072	52..01%=100%

Source: Educational Resource Center (ERC) FCT, Abuja (2024).

Table 1.1 illustrates the analysis of WASSCE Biology results in FCT, Abuja (2018–2024) with persistent challenges in students' achievement. While the number of candidates steadily increased, credit-level passes (A1–C6) fluctuated below 50%, with 2023 showing a slight recovery at 48.99%. pass rates (D7–) grade obtained remained consistently high, peaking at 60.18% in 2022, reflecting difficulties in mastering Biology concepts and shortcomings in teaching methodologies. These trends emphasize the need for innovative instructional strategies, such as concept mapping, to enhance understanding and retention of complex topics like the circulatory system. This study seeks to address these challenges and contribute to improved Biology education outcomes in FCT, Abuja.

Conventional teaching methods often focus on rote memorization rather than conceptual understanding. These methods are predominantly teacher-centered, limiting students' active participation and failing to address diverse learning needs, which hinders deep understanding and reduces long-term retention (Ausubel, 1968; Silverthorn, 2020; Okebukola, 2020; Dhindsa & Emran, 2020). Students may memorize facts about the circulatory system without comprehending its functions and interconnections, undermining their ability to apply knowledge in real-world contexts or advanced studies. In contrast, modern educational paradigms emphasize student-centered strategies that promote active engagement, critical thinking, and meaningful learning. Concept mapping is one such strategy that has shown promise in transforming teaching and learning, particularly in the sciences.

Concept mapping, introduced by Novak and Gowin (1984), is a visual tool that organizes knowledge hierarchically. Concepts are represented as nodes, while connecting lines

and phrases illustrate relationships. Rooted in Ausubel's theory of meaningful learning, concept mapping links new knowledge to existing cognitive structures, fostering deeper understanding and improved retention (Ausubel, 1968; Novak, 1990). By actively engaging students in constructing their understanding, concept mapping reduces misconceptions and promotes long-term retention (Chiou, 2018; Dhindsa & Anderson, 2019).

Persistent underachievement and poor retention in biology, especially in complex topics like the circulatory system, remain a major concern in Nigeria and globally. Biology is a core science subject with applications in medicine, agriculture, environmental science, and biotechnology. Challenges such as abstract content, ineffective teaching methods, and low learner engagement contribute to students' difficulties in understanding and retaining biological concepts (Okebukola, 2017; Dhindsa & Emran, 2020).

Concept mapping addresses these challenges by promoting active learning, conceptual clarity, and meaningful organization of knowledge. When applied to the circulatory system, it helps students visualize the relationships among components, such as the heart, arteries, veins, capillaries, and the distinction between systemic and pulmonary circulation, as well as the integration with the respiratory system. Research indicates that concept mapping enhances academic achievement and equips students with transferable skills, such as critical thinking and problem-solving (Vanides et al., 2018; Chiou, 2018; Dhindsa & Anderson, 2019).

Despite its proven benefits, concept mapping is underutilized in teaching the circulatory system in Nigeria. Limited research has focused on its application in this topic, highlighting the need for targeted studies to evaluate its effectiveness in improving students' achievement and retention. This study seeks to fill this gap by examining the impact of concept mapping on secondary school students' learning outcomes in the circulatory system in Kuje area Council, Abuja, providing evidence-based recommendations for integrating this strategy into the curriculum.

By exploring its application to teaching the circulatory system, this study aims to provide insights into improving biology education and fostering meaningful learning among students. Academic achievement in biology reflects students' understanding of concepts, their ability to apply knowledge, and their performance in assessments. It indicates the effectiveness of teaching strategies as well as students' engagement, motivation, and capacity to process complex scientific ideas. Biology, as a core science subject, prepares students for careers in health sciences,

environmental studies, and biotechnology. However, evidence from studies globally and in Nigeria indicates declining trends in students' academic achievement in biology. Contributing factors include abstract content, limited hands-on activities, and reliance on traditional lecture-based methods that fail to address diverse learning needs (Okebukola, 2017; Adeniran, Ochu & Atoo, 2018).

Retention, defined as students' ability to recall, integrate, and apply learned biological concepts over time, is a key indicator of meaningful learning. Unlike rote memorization, which often results in short-term recall, retention enables students to build lasting understanding essential for mastering advanced topics. Despite its importance, retention in biology is often low, particularly in complex topics like the circulatory system, where students struggle with abstract terms and interconnected processes (Novak, 2010).

Concept mapping has emerged as an effective instructional strategy to enhance both achievement and retention in biology. By visually organizing concepts and illustrating relationships, concept maps enable students to link new knowledge with prior understanding, fostering deeper comprehension. Research by Adeniran, Ochu, and Atoo (2018) showed that concept mapping improves retention in science subjects by promoting active engagement, reducing misconceptions, and enhancing critical thinking. The method is particularly effective for abstract topics, helping students visualize processes such as oxygen transport, blood circulation, and the interactions among components of the circulatory system.

To address persistent challenges in biology achievement and retention, it is essential to adopt innovative, student-centered strategies like concept mapping. This approach promotes meaningful learning, strengthens understanding of abstract concepts, and supports long-term knowledge consolidation. Teachers should be trained to implement concept mapping effectively, creating supportive learning environments that actively engage students and facilitate knowledge retention. By integrating concept mapping into biology instruction, educators can improve academic outcomes, deepen conceptual understanding, and prepare students for advanced studies and careers in science-related fields.

Statement of the Problem

Science education plays a crucial role in national development by equipping learners with the knowledge and skills needed to address real-life challenges. Biology, as a core science subject, promotes understanding of life processes and scientific literacy. However, students' academic achievement in biology has remained persistently low in many secondary schools in Nigeria,

including Kuje Area Council, Abuja. This poor performance has been largely attributed to the use of conventional lecture-based teaching methods that encourage rote learning rather than meaningful understanding and long-term retention. Such methods are often ineffective for teaching complex topics like the circulatory system, which involves interconnected structures and processes that students find difficult to comprehend and retain. Reports from examination bodies, including WAEC, consistently highlight students' weak understanding of biological concepts and poor performance in biology examinations.

Concept mapping has been identified as a learner-centered strategy that helps students organize ideas, visualize relationships, and enhance understanding and retention. Despite its proven effectiveness, its use in teaching biology topics such as the circulatory system remains limited in the Nigerian secondary school context, particularly in Kuje Area Council. Therefore, there is a need to investigate the effectiveness of concept mapping in improving students' academic achievement and retention in the circulatory system.

Objectives of the Study

The purpose of this study is to investigate the effect of concept mapping instructional strategy on achievement and retention of students in circulatory system in Kuje, Abuja, Nigeria. Specifically, the study;

1. Ascertain the effect of Concept Mapping Instructional Strategy on students' Achievement in Circulatory System.
2. Determine the effect of Concept Mapping Instructional Strategy on students' Retention in Circulatory System.

Research Questions

The following research questions guided the study:

1. What are the mean Achievement scores of students taught Circulatory System using Concept Mapping Instructional Strategy and those taught using the Conventional Method?

2. What are the mean Retention scores of students taught Circulatory System using Concept Mapping Strategy and those taught using the Conventional Method?

Statement of the Hypotheses

The following null hypotheses formulated were tested at 0.05 confidence level.

H_{O1}: There is no significance difference in the mean Achievement scores of students taught Circulatory System using Concept Mapping Instructional

Strategy and those thought using the Conventional Method.

H_{O2}: There is no significance difference in the mean Retention scores of students taught Circulatory System using Concept Mapping Instructional Strategy and those thought using the Conventional Method?

Research Methodology

This study adopted a quasi-experimental pre-test, post-test, and post-retention test control group design to determine the effects of concept mapping and conventional teaching methods on students' achievement and retention in circulatory system concepts. The design enabled comparison of instructional strategies while controlling for pre-existing differences through the use of pre-test scores as baseline measures. The population comprised 2,079 Senior Secondary School II (SS II) Biology students from public secondary schools in Kuje Area Council, Abuja. A sample of 96 students was drawn from two public co-educational secondary schools using intact classes to preserve the natural classroom setting. The selected classes were randomly assigned to either the experimental or control group through simple random sampling. The experimental group (n = 50) was taught using the Concept Mapping Instructional Strategy, while the control group (n = 46) received instruction through the conventional lecture method. Data were collected using two researcher-developed instruments: the Circulatory System Achievement Test (CSAT) and the Circulatory System Retention Test (CSRT), each consisting of 30 multiple-choice items designed to assess students' understanding and retention of circulatory system concepts. The instruments were validated for face, and content validity by three experts in Science Education who reviewed the clarity, relevance, and adequacy of the items, and their suggestions informed necessary revisions. Reliability was established through a test conducted with 40 students outside the study sample, and the Kuder–Richardson Formula 21 yielded reliability coefficients of 0.87 for the CSAT and 0.84 for the CSRT, indicating high internal consistency. Both groups were pre-tested prior to instruction, after which the experimental group received concept mapping instruction and the control group was taught using the conventional method. A post-test was administered at the end of the treatment to measure achievement, followed by a delayed test to assess retention. The collected data were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) at the 0.05 level of significance was employed to test the hypotheses, with pre-test scores used as covariates to control for initial differences and post-test and retention scores treated as dependent variables.

Results

Data collected from the study were answered using mean and standard deviation and to test the hypotheses using Analysis of Covariance.

Research Question 1

What are the mean Achievement scores of students taught Circulatory System using Concept Mapping Instructional Strategy and those taught using the Conventional Method?

The data analysis for answering this question is presented in Table 1

Table 1: **Means and Standard Deviations of Students Taught Circulatory System Using Concept Mapping Instructional Strategy and Conventional Method**

Teaching Approach	Type of Test	No of Students	Mean Score	Standard Deviation	Mean Gain
Concept Mapping	Pre-test	50	9.39	3.200	17.63
	Post-test	50	27.02	4.833	
Conventional	Pre-test	46	7.92	2.64	9.73
	Post-test	46	17.65	4.551	

Table 4.1 shows Concept Mapping group had a mean score of 9.39, while those in the Conventional group had a slightly lower mean of 7.92. This suggests that both groups started with a relatively similar level of prior knowledge about the circulatory system, with only a marginal difference between them. After the instructional interventions, the post-test scores reveal a notable difference between the two groups. Students in the Concept Mapping group achieved a significantly higher mean score of 27.02, whereas their counterparts in the Conventional group scored a mean of 17.65. This disparity in achievement indicates that students who were taught using the concept mapping strategy gained a deeper and more comprehensive understanding of the topic compared to those who were taught using traditional methods.

Hypothesis One

H_{O1}: There is no significance difference in the mean Achievement scores of students taught Circulatory System using Concept Mapping Instructional Strategy and the Conventional Method.

Table 2: **Result of One-way ANCOVA on Students' Achievement when Taught Circulatory System Using Concept Mapping Instructional Strategy and Conventional Teaching Strategies**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4805.985[a]	2	2402.993	149.494	.000
Intercept	4006.290	1	4006.290	249.237	.000
Pre-test	1034.399	1	1034.399	64.351	.000
Group	**2674.981**	**1**	**2674.981**	**166.414**	**.000**
Error	2716.544	91	16.074		
Total	94193.000	96			
Corrected Total	7522.529	95			

Table 4.2 shows that the source labeled "Group" — representing the instructional strategies (concept mapping vs. conventional method) — had a Type III Sum of Squares value of 2674.981, with 1 degree of freedom, and a Mean Square value of the same figure. The F-ratio for the group effect is 166.414, and the associated p-value (Sig.) is .000. This p-value is less than the commonly accepted alpha level of 0.05, indicating that the observed difference in mean achievement scores between the two groups is statistically significant. The "Pre-test" source also has a statistically significant result (F = 64.351, p = .000), which implies that the pre-existing differences in students' knowledge had a significant effect on the post-test outcomes. However, the ANCOVA model corrects for these differences, allowing for a more accurate comparison of the effect of the instructional strategies. The Corrected Model as a whole is statistically significant, with an F-value of 149.494 and p = .000. This suggests that the combined influence of the pre-test and the instructional strategy significantly explained the variation in students' post-test achievement scores. Given these results, the null hypothesis (HO1), which states that there is no significant difference in the mean achievement scores of students taught using concept mapping and those taught using the

conventional method, is rejected. The findings support the conclusion that the Concept Mapping Instructional Strategy significantly improves students' achievement in the circulatory system compared to the Conventional Method.

Research Question Two

What are the mean Retention scores of students taught Circulatory System using Concept Mapping Instructional Strategy and the Conventional Method?

Table 3: **Mean and Standard Deviation of Students Taught Circulatory System Using Concept Mapping Instructional Strategy and Conventional Method**

Teaching Approach	Type of Test	No of Students	Mean Score	Standard Deviation	Mean Gain
Concept Mapping	Post-test	50	27.02	4.833	4.83
	Post-post-test	50	25.49	5.067	
Conventional Method	Post-test	46	17.65	4.551	1.53
	Post-post-test	46	12.96	4.508	

Table 3 reveals that students taught with the Concept Mapping Strategy (post-test) were 27.02, while the mean on the post-post-test was 25.49. This represents a slight decrease of 1.53 points, suggesting that students retained most of what they learned. The standard deviations for the post-test and post-post-test were 4.833 and 5.067, respectively, indicating relatively consistent performance among students over time. In contrast, students taught using the Conventional Method had a post-test mean score of 17.65, which dropped significantly to 12.96 on the post-post-test, yielding a mean decline of 4.69 points. The standard deviations were 4.551 and 4.508, respectively, also suggesting consistent variability in scores, but with a more pronounced drop in retention.

Hypothesis Two

H_{O2}: There is no significance difference in the mean Retention scores of students taught Circulatory System using Concept Mapping Instructional Strategy and the Conventional Method.

Table 4: Result of One-way ANCOVA on Students' Retention when Taught Circulatory System Using Concept Mapping Instructional Strategy and Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8130.830[a]	2	4065.415	271.418	.000
Intercept	228.283	1	228.283	15.241	.000
Post-test	1389.525	1	1389.525	92.768	.000
Group	**997.493**	**1**	**997.493**	**66.595**	**.000**
Error	2531.356	91	14.978		
Total	75210.000	96			
Corrected Total	10662.186	95			

Table 4 shows the ANCOVA results of Type III Sum of Squares for Group as 997.493, with 1 degree of freedom (df) and a Mean Square of 997.493. The F-value associated with the Group variable is 66.595, and the p-value (Sig.) is .000, which is less than the 0.05 level of significance. This result indicates that there is a statistically significant difference in the retention scores between the students taught with Concept Mapping and those taught using the Conventional Method. Since the null hypothesis (HO3) assumes that there is no significant difference, and the p-value is below the 0.05 threshold, we reject the null hypothesis. The findings from Table 4.6 show that the instructional method has a significant effect on students' retention of the circulatory system content. The Concept Mapping Instructional Strategy is shown to significantly enhance long-term retention compared to the conventional teaching approach.

Discussion of Findings

The findings of this study provide evidence of the effectiveness of the Concept Mapping Instructional Strategy (CMIS) in enhancing both students' academic achievement and retention in the circulatory system when compared with the Conventional Teaching Method. The results revealed that students taught using CMIS achieved significantly higher mean scores and greater mean gains in the post-test than those exposed to the traditional lecture approach. This improvement in achievement suggests that concept mapping promotes deeper understanding by enabling learners to visually organize information, establish meaningful relationships among concepts, and integrate new knowledge with prior cognitive structures. Such active engagement facilitates meaningful learning rather than

rote memorization, which often characterizes conventional instruction. These findings are theoretically grounded in Ausubel's Assimilation Theory of Learning (1963), which posits that meaningful learning occurs when new information is systematically linked to existing knowledge. Concept mapping supports this process by presenting ideas hierarchically and relationally, thereby strengthening students' conceptual frameworks and enhancing comprehension of complex biological processes such as the circulatory system. As a result, students are better able to explain, apply, and transfer learned concepts, leading to improved academic performance.

Beyond immediate achievement, the study further demonstrated that CMIS significantly enhanced students' retention of knowledge. Students in the experimental group maintained higher mean scores in the delayed post-test, while those taught using the conventional method showed a more noticeable decline in performance over time. This pattern indicates that concept mapping not only supports short-term understanding but also promotes long-term consolidation of knowledge. The relatively small decrease in scores among students exposed to CMIS suggests that the strategy helps learners construct more durable and coherent mental representations of scientific information, thereby reducing forgetting. The present findings align with previous empirical studies. Adeniran (2018) reported that concept mapping significantly improved both achievement and retention in science subjects by facilitating meaningful connections among ideas. Similarly, Ahmed et al. (2021) found that students taught with concept maps demonstrated better recall and application of learned material weeks after instruction than those taught through lecture-based methods. Oduhunmi (2019) and Ugwoke (2022) also emphasized that visual and interactive strategies such as concept mapping enhance cognitive processing, reduce rote learning, and strengthen long-term memory of scientific concepts.

Conclusion

Based on the findings of this study, it is concluded that the Concept Mapping Instructional Strategy (CMIS) significantly improves students' academic achievement and retention in the circulatory system when compared with the Conventional Teaching Method. Students exposed to concept mapping demonstrated higher mean achievement scores and greater learning gains, indicating a better understanding of the concepts taught. The strategy facilitated meaningful learning by enabling students to organize ideas, identify relationships among concepts, and integrate new information with existing knowledge, thereby enhancing overall academic performance. In addition to

improving immediate achievement, concept mapping was found to promote long-term retention of knowledge. Students taught using CMIS maintained higher scores in the delayed assessment, suggesting that the structured and visual representation of concepts supported stronger memory consolidation and reduced forgetting over time. This confirms that concept mapping not only enhances short-term comprehension but also fosters durable learning.

The study establishes that the Concept Mapping Instructional Strategy is more effective than the conventional method in enhancing both achievement and retention. Its use in biology instruction is therefore recommended as a practical approach for improving students' understanding and sustaining knowledge of complex topics such as the circulatory system.

Recommendations

The following recommendations are made based on the findings of the study.

1. Biology teachers should adopt the Concept Mapping Instructional Strategy regularly in classroom instruction, particularly when circulatory system, as it has been shown to significantly enhance students' academic achievement and retention.
2. Curriculum planners should integrate concept mapping into the biology curriculum and lesson plans as a learner-centered teaching approach to promote meaningful understanding and long-term knowledge retention rather than rote memorization.
3. Professional development programmes, workshops, and seminars should be organized to train teachers on the effective design and use of concept maps, enabling them to implement the strategy competently and maximize its benefits for students' learning outcomes.
4. Instructional materials such as concept map templates, visual aids, and graphic organizers should be provided in schools to support the consistent use of concept mapping and to create enabling learning environments that strengthen students 'comprehension and memory of biological concepts.

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