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Effect of Concept Mapping and Mind Mapping Instructional Tools on Students' Achievement on Higher-Order Cognitive Ability Tasks and Retention in Secondary School Biology in Benue State

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Abstract
This study comparatively investigated the effect of concept mapping and mind mapping instructional tools on students' achievement on higher-order cognitive tasks and retention in secondary school biology. Two null hypotheses tested at 0.05 level of significance were formulated to guide this study. The population of the study consisted of 19,598 Senior Secondary School II students who studied biology in the 2023/2024 academic session in all the 387 Senior Secondary Schools in Benue State. The design of this study was non-randomized pre-test - post-test quasi-experimental design. A sample of 140 students in four intact classes were purposively selected from secondary schools in the State. Two classes were randomly assigned to the each of the two experimental groups; the concept mapping and mind mapping groups. The instruments for data collection were Biology Achievement Test (BAT) and Biology Retention Test (BRT). Results from data analysis using mean, standard deviation, and independent samples t-test showed that the mean posttest achievement scores of concept mapping and mind mapping were, M=9.59 (SD=3.39) and M=7.94 (SD=3.28) respectively. The mean retention scores of concept mapping and mind mapping were, M=9.40 (SD=2.88 and M=6.18 (SD=3.77) respectively. Result of independent samples t-test revealed that there was a statistically significant difference in the mean achievement scores between concept mapping and mind mapping groups, t (138) = 1.02, p =0.00, 95% CI [0.53, 2.80]. Similarly, there was also a statistically significant difference between the mean retention score of the concept mapping and mind mapping groups, t (139.11) = 5.74, p =0.00, 95% CI [2.13, 4.38]. These results show that concept mapping instructional tool possess greater potentials for developing higher-order cognitive skills in students and retention of knowledge compared to mind mapping. Thus, it therefore incumbent biology teachers to employ concept mapping in their quest to instill critical, creative and innovative cognitive skills in students as well as ensuring the commitment of knowledge to the students' long term memory store. In doing so, students' underachievement challenges in biology can be ameliorated.

Key Words: *Concept mapping, mind mapping Higher order Cognitive skills, Retention.*

Introduction

The subject biology that scientifically studies the forms and processes of living organisms is extremely fundamental to the secondary school students not only as a subject for personal benefit, but also as a very crucial pre-requisite for students desiring to venture into science based careers especially the biological science related disciplines. Hence, there must be concerted efforts to ensure that students are effectively taught to meaningfully learn; learning that should not only equip the students with lower-order cognitive skills (LOCS) that enable students to recall, comprehend and apply what is taught, but learning that should inculcate higher-order cognitive skills (HOCS) that would enable the students to analyse, synthesize, and evaluate as well as retain acquired knowledge in biology as enshrined in the aims and objectives of Senior Secondary School Biology in Nigeria ((Federal Republic of Nigeria, 2013). The realization of meaningful learning of biology lies in the classroom instruction approaches adopted by the effective biology teacher.

Studies on classroom instructional approaches reveal that the generally and commonly too, the persistently used instructional method of teaching by science teachers in Nigeria is the lecture or conventional method (Abass, A. A. 2022; Okoli & Okeke, 2021; Isa, Mammam, Badar & Bala, 2020; Kola & Langenhoven, 2015) This teacher-centred instructional approach that is criticized for fostering passiveness of students, encouraging students' teacher-dependence, and inappropriate for developing science process skills (Saddiqui, 2024; Teacher Institute, 2023).. Thus, lecture instructional method has consistently been identified as being quite unproductive in terms of instilling meaningful learning generally and most importantly in the development of higher-order cognitive skills in science students and long term retention of knowledge. Given this scenario, it is incumbent upon science teachers to find and adopt instructional approaches that would inculcate in students not just lower-order cognitive skills but to a large extent higher-order cognitive skills, since these align more meaningfully with science as a discipline dependent on critical thinking, creativity and innovation for it development. In addition, Zoller and Tsaparlis (1997) submitted developing HOCS in science students is very vital as it enhances their capacity to function in modern complex science and technology-based society

Several instructional approaches such as co-operative learning, problem-solving, and inquiry learning methods have been demonstrated to possess the capacity to instilling LOCS and HOCS however there are obvious constraints to the use of these approaches in most Nigeria's science classrooms. It is therefore quite necessary to adopt instructional approaches that suit our classroom setting, consume little teaching and learning time, and easy to use by most science teachers if not all.

It is in line with this position that this study intended to investigate the efficacy of concept and mind mapping instructional tools on biology students' achievement on higher-order cognitive ability tasks and retention, since these approaches have been shown to impact more on students' achievement and retention compared to the conventional; method of teaching biology. Besides these impact on students' achievement and retention, studies have not clearly investigated the impact of these mapping instructional approaches on higher-order cognitive tasks and retention. This is major crux of this research; to comparatively investigate the effect of concept and mind mapping instructional approaches on secondary school students' achievements on higher-order cognitive tasks and retention capacity in secondary school biology in Benue State.

Statement of the Problem

Studies have consistently establishes that concept and mind mapping instructional approaches are superior to lecture method of teaching biology at the secondary school level globally in both achievement generally and retention. In addition, comparative studies on the impact of the two mapping instructional approaches have yielded inconsistent results regarding their superiority of one over the other. However, there is a paucity of studies that have comparatively investigated the effect of the two mapping instructional approaches biology students' achievement on higher-order cognitive ability tasks and retention distinctly. It is against this backdrop that this study investigated the impact of the two mapping instructional approaches on higher-order academic tasks and retention of secondary school students' in biology.

Research Hypothesis (H_o)

1. There is no statistically significant difference in the mean achievement scores on higher-order cognitive ability tasks between concept mapping and mind mapping students in biology.
2. There is no statistically significant difference in the mean retention scores on higher-order cognitive ability tasks between concept mapping and mind mapping students in biology

Literature Review

Literature has consistently shown that concept and mind mapping instructional tools have positive impacts on students' academic accomplishments that include meaningful learning, critical, creative and analytical thinking, problem solving short and long term retention of knowledge as well as enhancing students' positive attitude towards

Impact of Concept Mapping on Higher-Order Cognitive Skills and Retention

Concept maps are one class of knowledge maps described by Lucid (2019) as diagrams or graphical tools that visually represents relationships between concepts and ideas structured hierarchically and connected with lines and linking words to help explain the connections between concepts. Concept maps have been identified with several learning benefits when appropriately used in the classroom. These among others include; expedites understanding with its visual organization, assist students see relationships between ideas, concepts, or activities, helps memory recall, boosts brainstorming, high-level thinking skills, fosters discovery of new concepts and their connections, provides clear communication of complex ideas, promotes collaborative learning and stimulate creativity (CTL, 2019; Lucid, 2019 & WETA, 2019).

Considering these learning potentials of concept mapping, it is a plausible instructional approach for developing in biology students higher-order cognitive skills (HOCS). These skills are a set of intellectual skills that move students' beyond rote memorization and regurgitating facts into more comprehensive levels of thinking. It tasks students to take facts and information they have memorized, and apply them in new active way like making inferences, connecting ideas into larger concept, analysing, evaluating, generation of knowledge and solving complex problems and to exhibit mastery of subject matter (Bauld, 2024; Cornell, 2024; Sewell, 2023; Wichtowska, 2019; CTL, 2019; Lucid, 2019 &WETA, 2019 & Anonymous, 2017).

Empirical studies have demonstrated the efficacy of concept mapping on students' academic accomplishments. Fonseca et al. (2024) revealed the effectiveness of concept mapping as a potent tool for developing critical thinking and perception in undergraduate medical education students. Aslami, et al. (2021) demonstrated that the medical students taught with concept mapping showed increased critical thinking capacity compared to the those in the control group that were taught

using conventional method. Mohammadi et al. (2019) showed that teaching and learning processes using concept mapping enhanced the development of graduate students' analytical skills to a higher level compared to the traditional instructional method. Bramwell-Lalor and Rainford (2013) found that concept mapping student out-performed their peers in the control group on both lower-order and higher-order cognitive test items in biology.

Regarding the impact of concept mapping on retention, Manas (2023) found that concept mapping had a significant effect on learners' achievement and retention. Concept mapping students' achievement and retention in biology was significantly higher in comparison to the traditional method. Talanki (2015) established that understanding and retention was significantly visible among concept mapping on delayed post-test test than it was among the conventional method students.

Impact of Mind Mapping on Higher-Order Cognitive Skills and Retention

A mind mapping is a graphical thinking tool that uses words and pictures to represent ideas and concepts helping one to better analyze, comprehend, synthesize, recall and generate new ideas (Litemind, 2019; Pinola, 2013).

Mind maps are shown to be associated with several learning benefits that depict its potentials as a veritable tool for inculcating higher-order cognitive skills as well as long term retention of information. The learning assets of mind mapping according to Litemind (2019), MindMeister (2019) and Pinola (2013) include facilitating note taking, studying and recall of information, brainstorming, problem solving, creative thinking and as well as gaining insight on complex subject and having overview of a large subject while also holding large amounts of information. Consequently, mind mapping should possess the potentials of enhancing students' academic achievement on higher cognitive ability tasks, and also increase their knowledge retention capacity.

Studies on the impact of mind mapping on students' academic achievement and retention requiring higher-order cognitive skills have been variously reported. Azizurahmah, et al. (2023) found mind mapping to have a positive influence in improving creative thinking skill and mastery of high school students in biology compared to the conventional instructional method. Hazaymeh, & Alomery (2022) showed that mind mapping strategy significantly increased students' critical thinking skills and reading comprehension ability compared to the control group. Similarly Elasrag & Elsahagh (2020) found that undergraduate nursing students taught using mind mapping showed better critical thinking skills than the control group. However, D'Antoni, Zipp, & Olson, (2010) found mind mapping not to increase critical thinking or short-term recall of information compared to standard note-taking among medical students.

On the issue of the influence of mind mapping knowledge on retention capacity of learner, Wahiba, (2024) clearly indicated that mind mapping had a significant impact on the students' retention of technical vocabulary in construction than the control group. Omosewo and Mohammed (2021) found that mind mapping students had a greater retention capacity in physics compared to the those taught physics using the conventional method. Similarly, Bawaneh (2019) found that mind mapping compared to conventional teaching method had greater impact on immediate achievement and retention in electric energy concepts. Heidari, & Karimi (2015) showed that mind mapping group out-performed the traditional method group on the delayed post-test in learning and vocabulary test.

Comparative Impact of Concept Mapping on Higher-Order Cognitive Skills and Retention

A comparative study of concept and mind mappings instructional tools' influence on higher-order cognitive skills of students by Suardana Redhana & Yunithasari (2020) demonstrated that there was no significant difference in the critical thinking skill of both concept mapping and mind mapping in basic chemistry. However, Peter & Ishak (2020) revealed that the concept mapping group was significantly superior to mind mapping group on creativity ability of students in ecology.

Research Methodology

Design of the Study

The design employed in this study was the non-randomized group pre-test - post-test quasi-experimental design.

Population of the Study

The population of this study consisted of all the 19,598 Senior Secondary School II students who studied Biology in the 2023/2024 academic session in all the 387 Senior Secondary Schools in Benue State (Benue State Government, 2023).

Sample and Sampling Technique

This study employed a sample of 140 students taken from four intact classes with a size of 35 students in four secondary schools in the three Education Zones in Benue State. The purposive sampling technique employed in selecting the schools, and assigning classes to the two experimental groups.

Instruments for Data Collection

Three instruments were used for collecting data in this study. These were two versions Biology Achievement Test (BAT) which were separately used for pretest and posttest. The instruments consisted of 20 Multiple Choice Test question on higher-order cognitive questions drawn from WAEC and NECO past SSCE biology objective test questions on the topic Mammalian Blood Circulatory system, the topic of the lesson. The third instrument was Biology Retention Test (BRT), a third version of BAT. A table of specification was used to determine the number of items in the different higher-order cognitive ability levels.

Validation of Instrument

Biology Achievement Tests (BAT).and Biology Retention Test (BRT) were validated by three experts, a test and measurement expert, a biology educator, and a biology teacher with more than five years teaching experience. The validators determined the face and content validity of the instruments.

Reliability of the Instrument

The reliability of Biology Achievement Test (BAT) and Biology Retention Test (BRT) were determined using Test-Retest reliability, and were found to be 0.8.

Method of Data Collection

This study employed four professionally trained graduate Biology teachers with a minimum of five years on the job experience as research assistants who taught the two groups of students and

administered the pretest, posttest and retention test. The topic of the lesson was Composition of Mammalian Blood Circulatory System using Power-point only. The instructional maps used are shown in Figures 1 concept map, and Figure 2 (mind map).

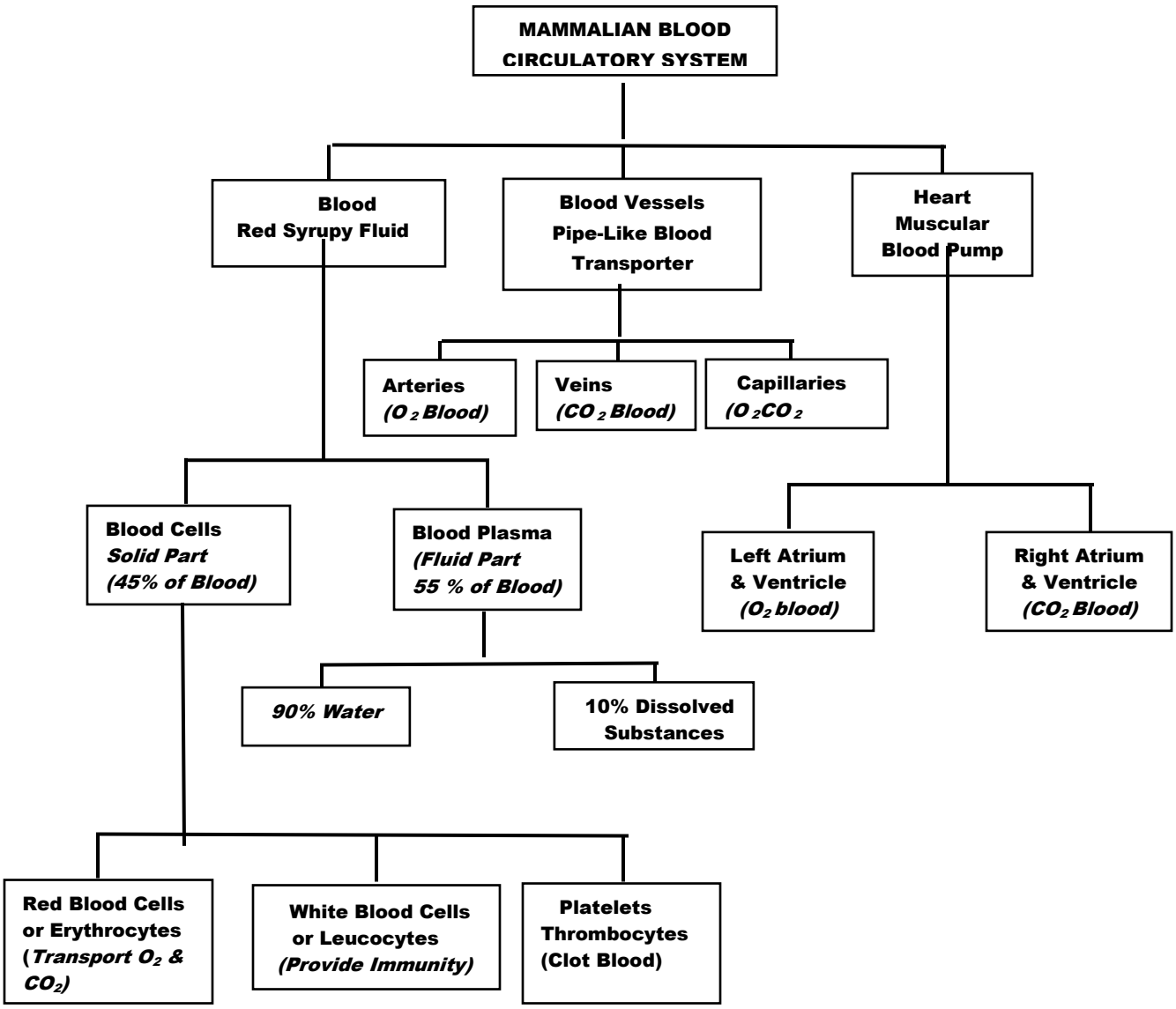

Fig. 1 Concept Map of Mammalian Blood Circulatory System

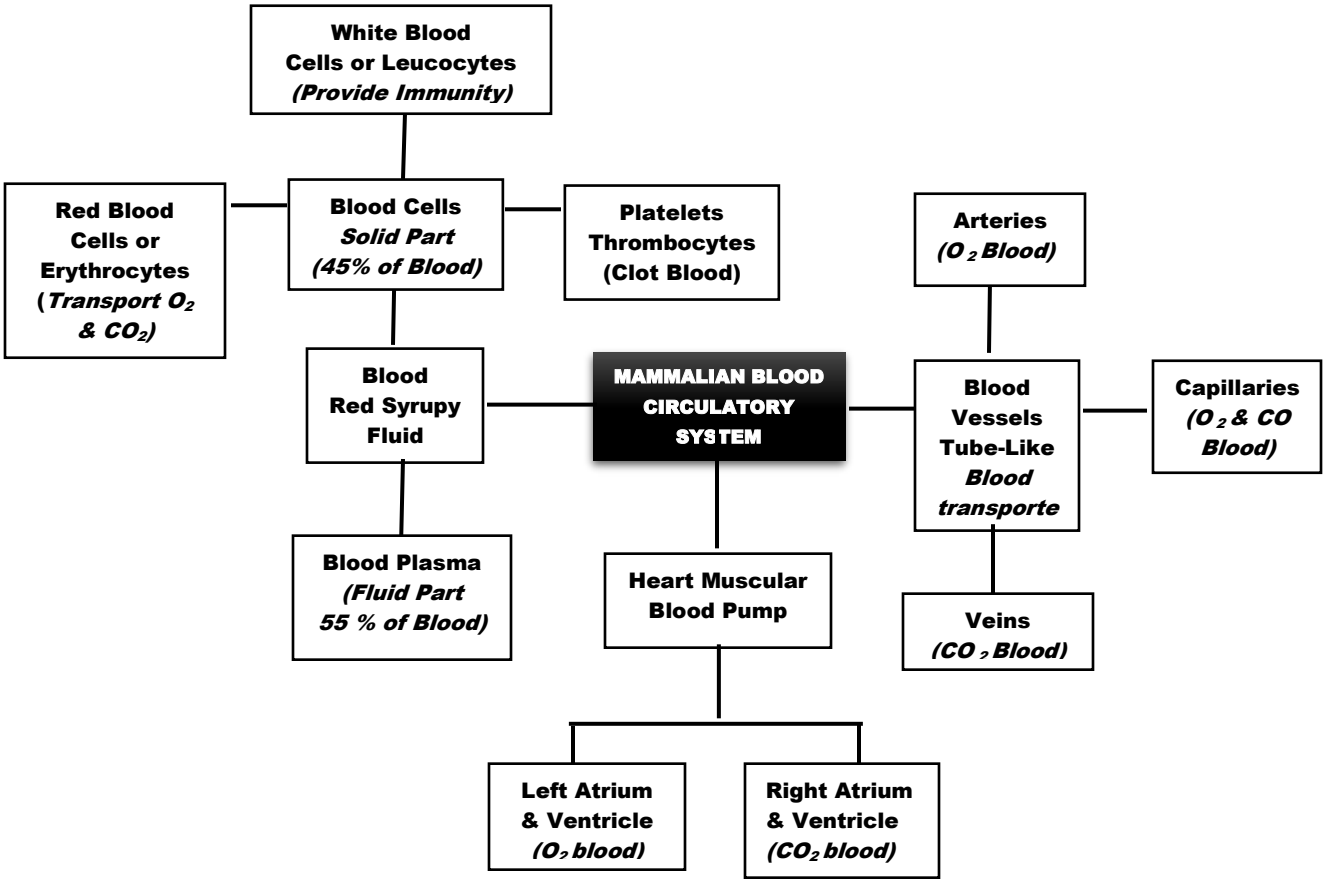

Fig. 2 Mind Map of Mammalian Blood Circulatory System

The pre-tests using one version of BAT was administered prior to treatment that was then followed by post-testing carried out using the second versions of BAT immediately after treatment periods elapsed. After one week from the date of post-testing, BRT was administered to the two groups in order to ascertain the retention power of the two instructional approaches.

Data Analysis

Data in this study consisted of pretest and posttest higher-order cognitive tasks achievement scores generated using using Biology Achievement Test (BAT), and scores of retention test obtained using Biology Retention Test (BRT). Analysis of these data were carried out using mean, standard deviation and independent samples t-test that was used to test the null hypotheses of the study.

Results

Analysis of pretest and posttest data collected on the effect concept mapping and mind mapping on students' highert-order cognitive ability tasks biology is presented in Tables 1.

TABLE 1: PRETEST AND POSTTEST MEAN ACHIEVEMENT SCORES OF, CONCEPT MAPPING AND MIND MAPPING GROUPS ON HIGHER-ORDER COGNITIVE TASKS IN BIOLOGY

Groups	N	Pretest Mean	Posttest Mean	Mean Gain Score
Concept Mapping	70	4.30 (SD= 2.22)	9.59(SD= 3.39)	5.29
Mind mapping	70	3.90 (SD=2.50)	7.94 (SD=3.28)	4.04

As shown in the Table 1, the pretest and posttest mean scores of the concept mapping group were. *M* = 4.30, *SD* = 2.22 and *M* =9.59, *SD* = 3.39 respectively. The concept mapping group's pretest and posttest mean gain score was 5.29. The mind mapping group's pretest mean score was *M*=3.90, *SD* = 2.5 while the posttest mean score was *M* = 7.94, *SD* = 3.28 with a mean gain score of 4.04. Both group of students showed improvement on higher-order cognitive ability tasks.

Hypothesis Testing

Null Hypothesis 1

There is no statistically significant difference in the mean achievement scores on higher-order cognitive ability tasks between concept mapping and mind mapping students in biology.

An independent samples t-test was conducted to examine the difference between the mean posttest achievement scores on higher-order cognitive tasks of concept mapping, (*M* = 9.59, *SD*=3.39) and minding mapping, (*M* = 7.94, *SD*=3.28) groups and results shown in Table 2.

TABLE 2: MEAN POSTTEST ACHIEVEMENT SCORES OF CONCEPT AND MIND MAPPINGS GROUPS ON HIGHER-ORDER COGNITIVE BIOLOGY TASKS

Group	N	Mean	Std. Deviation	Std. Error Mean
Concept Mapping	70	9.59	3.39	0,41
Mind Mapping	70	7.94	3.28	0.39

Levene's of assumption of equal variance test result shown in Table 2 indicated that there was no significant difference in the variance of the two groups. *F*=0.44, p=0.51.

TABLE 3: LEVENE'S AND INDEPENDENT SAMPLE t-TEST RESULTS OF MEAN POSTTEST ACHIEVEMENT SCORES OF CONCEPT AND MIND MAPPING STUDENTS ON HIGHER-ORDER COGNITIVE BIOLOGY TASKS

Group		Levene's Test for Equality of Vari ance		t-test Equality of Means					95% Confidence interval of the Difference	
		F	Sig.	t	df	Sig. 2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
Concept Mapping Mind Mapping	Equal Variance assumed	0.44	0.51	2.92	138	0.00	1.65	0.56	0.53	2.80
	Equal Variance not assumed			2.92	137.86	0.00	1.65	0.56	0.53	2.89

The independent sample t-test outcome revealed that there was a statistically significant difference in the mean scores for concept and mind mapping groups, t (138) = 1.02, p =0.00, 95% *CI* [0.53, 2.80]. This result nullifies the null hypothesis, indicating that there is sufficient evidence to conclude that mean achievement scores of the concept mapping and mind mapping are differ significantly with concept mapping showing superiority over mind mapping on higher-order cognitive ability tasks in biology.

Null hypothesis 2

There is no statistically significant difference in the mean retention scores on higher-order cognitive ability tasks between concept mapping and mind mapping students in biology

An independent samples t-test t was conducted to determine if there was a statistically significance difference in the mean retention scores on higher-order cognitive tasks scores of concept mapping group, (M=9.40, SD = 2.88) and mind mapping group, (M = 6.18, SD = 3.77) as shown in Tables 4.

TABLE 4: MEAN RETENTION SCORES OF CONCEPT AND MIND MAPPINGS GROUPS ON HIGHER-ORDER COGNITIVE BIOLOGY TASKS

Group	N	Mean	Std. Deviation	Std. Error Mean
Concept Mapping	70	9.40	2.88	0.34
Mind Mapping	70	6.18	3.77	0.45

The assumption of equal variances determined using Levene's Test, as well as independent samples t-test results of the concept mapping, and mind mapping groups was shown in Table 5

TABLE 5: LEVENE'S AND INDEPENDENT SAMPLE t-TEST RESULTS OF MEAN RETENTION ACHIEVEMENT SCORES OF CONCEPT AND MIND MAPPING STUDENTS ON HIGHER-ORDER COGNITIVE BIOLOGY TASKS

Group		Levene's Test for Equality of Variance		t-test Equality of Means					95% Confidence interval of the Difference	
		F	Sig.	t	df	Sig. 2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
Concept Mapping Mind Mapping	Equal Variance assumed	8.80	0.00	5.74	138	0.00	3.26	0.57	2.14	4.38
	Equal Variance not assumed			5.74	139.11	0.00	3.26	0.57	2.13	4.38

Results of Levene's test showed that there was a significant difference in the variances of the groups, $F(8.80)$, $p = 0.00$. The independent samples t-test results revealed that assuming unequal variances, there was a statistically significant difference between the mean retention score of the concept mapping and mind mapping groups, $t\ (139.11) = 5.74$, $p = 0.00$, 95% *CI* [2.13, 4.38]. This result rejects the null hypothesis, showing that there is sufficient evidence to conclude that mean retention scores of the concept mapping and mind mapping groups are significantly different with concept mapping group surpassing mind mapping group on retention of higher-order cognitive knowledge in biology.

Discussion

This study comparatively examined the impact of concept mapping and mind mapping instructional tools on student's higher-order cognitive abilities on biology tasks and their retention capacity. Results from data analysis showed that concept mapping has the potentials of promoting students higher-order cognitive abilities as reported by Bauld (2024) Cornell (2024) Sewell (2023) and Wichtowska (2019) and as empirically found (Fonseca et al., 2024; Aslami, et al., 2021; Mohammadi et al. 2019 & Bramwell-Lalor & Rainford, 2013). In respect of the impact of concept mapping on retention of knowledge, this study found that concept mapping positively impacted on students' retention capacity in biology affirming earlier reports (Bauld, 2024; Cornell, 2024; & Sewell, 2023) and empirically found too (Manas, 2023; & Talanki, 2015)

Results of analysis of data regarding mind mapping impact on students' higher-order cognitive ability tasks indicated that mind mapping has the potentials of developing higher-order cognitive skills of students' supporting previous reports (Litemind, 2019; MindMeister, 2019 & Pinola, 2013). The results also affirmed earlier finding of Azizurahmah, et al. (2023), Hazaymeh, & Alomery (2022) and Elasrag & Elsahagh (2020). Similarly, results of analysis on the retention capacity of the mind mapping group students confirmed earlier reports and empirical findings on the knowledge retention potentials of mind mapping (Wahiba, 2024; Omosewo & Mohammed, 2021 & Heidari, & Karimi,2015) However the finding of this study was at variance with the finding of D'Antoni, Zipp, and Olson, (2010) who found that mind mapping had no effect on the achievement or short-term recall of information.

Comparing the impact of concept mapping and mind mapping instructional tools, students' achievement on higher-order cognitive tasks in biology, this study found that the concept mapping

group was superior to the mind mapping group affirming the findings of Peter & Ishak (2020). However, the finding of this study was at variance to the finding of Suardana, Redhana & Yunithasari (2020) that found no significant difference in the effect of concept mapping and mind mapping on higher-order cognitive capacity of students. On the issues of knowledge retention capacity, this study similarly found concept mapping students to out-class mind mapping students on retention capacity of knowledge in biology. This finding may be connected to the greater achievement capacity of concept mapping group over mind mapping group in the biology tasks since studies have shown that a positive correlation exist between achievement and retention (Okeke & Ethel-Echeedo, 2024; Dalyop, 2022;)

Conclusion.

This study comparatively examined the effect of concept mapping and mind mapping instructional tools on students' achievement on higher-order cognitive tasks and retention in biology at the secondary school biology. Data analysis of this study established that concept mapping demonstrated to be more impactful than mind mapping on both achievement on higher-order cognitive tasks and retention capacity

Recommendations

Considering the evident superiority of the concept mapping instructional tool over mind mapping pedagogical tool, this study recommends the use of concept mapping in biology teachers' quest to inculcate in their students critical, analytical, creative, evaluative and innovative cognitive skills as well as enhance the commitment of knowledge to the students' long term memory store. By so doing students' underachievement challenges in biology can be ameliorated

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REFERENCES

Abamba, E. I., Efe, A. H., & Esiekpe, L (2021). Comparative effects of mind and concept mappings on students' academic achievement and retention of concepts of radioactivity and electrolysis in senior secondary school science in Delta State, Nigeria. *River state University Journal of Education* 24(1); 1-12.

Abass, A. A. (2022). The effective use of teaching methodologies in science, technology and mathematics in Nigerian' classroom. *Shodh Sari- An International Multidisciplinary Journal*. 1(1);49 – 68 http://www.academia .edu.com

Agaba, K. C. (2013).Effect of concept mapping instructional strategy on students' retention in biology. *African Education Indices* (1); 1-7 http://www.global academicgroup.com

Akanbi, A. O., Yahaya. W., Omosewo, E. & Mohammed, R. E. (2021). Effect of mind mapping instructional strategy on students' retention in physics in senior secondary schools. *Anatolian Journal of Education* 6 (1); 145-156 DOI: 10293333/aje.2021.6112a

Akbar, R. S. & and Hanan A. Taqi, H. A. (2017). Does mind mapping enhance learning? *International Journal of English Language Teaching. 5* (8), 65-77

Anonymous (2017). *Importance of higher-order cognition* http://www.condo .depaul.edu. outmn444.co.

Areesophonpichet, S (2013). Developing analytical thinking skills of graduate students' by using concept mapping *The Asian Conference on Education* 1 (15) http://www.academia.edu.com.

Aslami M, Dehghani, M; shakumia, ARamezani, G & Kojuri J. (2021) Effect of concept mapping education on critical thinking skills of medical students : a quasi-experimental study .*Ethiopian Journal of Health Sciences*. 31(2); 532-556. http://www.etjhealths.org

Azizurahmah, Sukarso, A. A, Kusmiyati, K. & Handayani, S. (2023). Effect of mind mapping assignment on creative thinking skills and biology concepts mastery in senior high school. *Jurnal Pijar Mipa* 18 (6); 886-891 http://www.jurlfkip.ac.id

Bauld, A. (2024). *Encouraging higher-order thinking skills in students* http://www.xqsuper school.org>teaching-learning

Bawaneh, A. K (2019) the effectiveness of using mind mapping on tenth grade students'' immediate achievement and retention of electric energy concepts *Journal of Turkish Science Education* 16 (1);123-137.http:// www.tused.org

Bawaneh, A. K (2019). The effectiveness of using mind mapping on tenth grade students' immediate achievement and retention of electric energy concepts *Journal of Turkish Science Education* 16 (1);123-137.http:// www.tused.org

Benue State Government (2023). Student enrolment at the secondary school level in Benue State: Directorate of planning, research, statistics and computer.

Bramwell, S. & Rainford M. (2013). The effect of using concept mapping for improving advanced level biology students' lower and higher-order cognitive skills. *International Journal of Science Education* 36(5); 839-864 http:// www.tandfonline.com

Cornel, D. (2024). *63 higher-order thinking skills example.* http://www.helpful professor .com>higher-order-thinking-skill-examples

Dalyop, Y. (2022) Relationship among achievement, motivation, self-efficacy and retention among students of College of Education, Zuba, Nigeria. *Presitige Journalof councelling Psychology* 5(1); 104-111 http://www.openaccessglobal. Com.

D'Antoni, A. V., Zipp, G. P. & Olson, V. G. & Cahill T. F. (2010). Does mind map strategy facilitate information retrieval and critical thinking in medical students? *BMC Medical Education,* 10 (61) 1-11. http://www.Link.springer.com

Elasrag, G. A. A & Elsahagh (2020). The effect of mind mapping on critical thinking skills of undergraduate nursing students taught using mind mapping. *Pharmcophore* 11(1);73-84 http://www.Pharmacop horejournal.com

Federal Republic of Nigeria (2013). *Senior secondary school curriculum*. Lagos: NERDC.

Fonseca, M., Marvao, P., Olivera, B. H., Pedro C-M., ; Nuno N. & Antonio R. (2024).Effectiveness of concept mapping as a tool for developing critical thinking in undergraduate medical education-a BEME: BEME GuideNo 81. *Medical Teacher* 46(9); 1120 -1133 http://www.tandfonline.com

Hanif, J., Kalsoom, T., Khanam, A. (2020). Effect of mind mapping techniques on Fifth grade stduents while teaching and learning science. *Elementary Education Online* 19(4); 3817-3825 DIO10.17051/ilonline.2020.04.764788.

Harris, C & Zha, S. (2013) Concept mapping: A critical thinking technique *Education* 134(2), 207-211 http:www.ingentaconnect.com

Hazaymeh, W& Alomery, M. K (2022). The effectiveness of visual mind mapping strategy for improving English language learners' critical thinking skills and reading ability *European Journal of Educational Research* 11(1);141-150. http://www.eric.ed.gov

Heidari, A. A. & Karimi, L. (2015). The Effect of mind mapping on vocabulary learning and retention. *International Journal of Educational Invetigations* 2(12); 54-72 http://www .ijeionline.com

Isa, S. G., Mammam, M. A; Badar, Y.& Bala, T. (2020). The impact of teaching methods on academic performance of secondary school students in Nigeria. *International Journal of Development Research.* 10(6); 37382 – 37385. Scholar.google.com

Manas, G. E. (2023). Effect of concept map strategy on academic achievement and student retention in biology. *Education Studies in Educational Management* 1(14);1-10 http://doi.org/10.32038/sem.202314.01

Mohammadi, F., Momennasab, M., Rostambeygi, P., & Somayeh, M. (2019). Effect of education through conceptual mapping on critical thinking of nursing students. *Journal of Pakistan Medical Association* 69 (8), 1094-1098 http://www.researchgate.net.

Okeke, A. U. & Ethel-Echedo, E. M. (2024). Relationship between acgievement and retention in business studies among junior secondary school students in Aguata Local Government Area, Anambra State. *UNIZIK Journal of Educational Research and Policy Studies*. 17(1); 1- 9 http://unijerps.org

Peter, D. N & Ishak, N. A (2020) Effect of concept mapping and mind mapping on creativity in ecology of senior secondary school students in Nigeria. *International Journal of Innovation, Creativity and Change* 13(1); 123 – 130 http:// www.ijicc.net

Saddiqui, A. (2024). Mastering the lecture method: Types, benefits, and real-world examples. http://www.suraasa.com.

Suardana I. N., Redhana I, W. & Yunithasari N. P. M. (2020). Students' critical thinking skill comparison in discovery learning-based on constructing concept and mind mapping. 1521 (4); 042089. http://www.iopscience.iop.org [1]

Talanki, R. S. (2015). Effectiveness of concept mapping strategy on understanding and retention among secondary school students. Artha-Journal of Social Sciences 14(1); 15 DOI: 10.12724/ajss.32.2.

Wahiba, A. (2024). Investigating the effectiveness of mind mapping technique in enhancing technical vocabulary learning and retention: The case of Master 1 students of construction. http:// www.Archives.univ-biskra.dz

Wichtowska, S. (2019). *Develop higher-order thinking skills to future-proof your organization.* http://www.go1com>blogdevelop-higher-order-thinking.skills.

Zoller, U & Tsaparlis, G. (1997). Higher and lower-order cognitive skills: The case of chemistry. *Research in Science Education*, 27; 117–130. http://www.ui .adsabs.harvard.edu.