COMPARATIVE EFFECTS OF MASTERY LEARNING AND THINKING MAPS STRATEGIES ON STUDENTS' ACADEMIC PERFORMANCE IN BASIC SCIENCE IN MAKURDI

[1]Emmanuel Eriba Otor and [2]Rachael Terkimbir Shir
Department of Science and Mathematics Education, Rev. Fr. Moses Orshio Adasu University, Makurdi.
Corresponding Author's Email: 080531079sh@mail.com

Abstract

This study examined the comparative effects of the Mastery Learning Strategy (MLS) and Thinking Maps Strategy (TMS) on students' academic performance in Basic Science in Makurdi Local Government Area of Benue State, Nigeria. Three research questions were raised and translated into null hypotheses, tested at the 0.05 level of significance. A quasi-experimental pre-test, post-test, non-equivalent control group design was adopted. The population comprised 1,903 upper basic II students across 31 schools in the 2023/2024 academic session. A sample of 76 students from two intact classes in two schools was selected through multistage sampling. Instructional content covered Basic Science topics such as energy, work, power, and energy transformation. Data were collected using the researcher-developed Basic Science Performance Test (BSPT), validated by experts and found reliable with a KR-20 coefficient of 0.94. The experiment lasted four weeks and was administered by two trained research assistants. Data were analysed using Mean and Standard Deviation for the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses. Findings revealed no significant differences in performance between the MLS and TMS groups [$F(1, 73) = 0.529$, $p = 0.469$], nor between male and female students within each group: MLS [$F(1, 38) = 0.007$, $p = 0.934$] and TMS [$F(1, 32) = 0.764$, $p = 0.389$]. The study concluded that both strategies are effective in improving students' performance. It recommends teacher training and curriculum integration of MLS and TMS to foster better outcomes in Basic Science.

Key words: Mastery Learning, Thinking maps, Performance and Gender

Introduction

Basic Science is a foundational subject in the Nigerian upper basic school curriculum, designed to equip learners with the knowledge, skills, and attitudes required to understand and apply scientific concepts in everyday life. It is regarded as the bedrock of all science subjects, serving as the preparatory ground for the study of core sciences such as Biology, Physics, and Chemistry (Ode & Eriba, 2019). Gallagher et al. (2008) describe Basic Science as a cumulative and integrative discipline that synthesizes perspectives from individual sciences to provide learners with a broad and coherent understanding of scientific principles.

Despite its importance, students' performance in Basic Science has consistently been poor and unstable. Results from the Basic Education Certificate Examination (BECE) between 2018 and 2023 in Benue State, for instance, reveal fluctuating but generally unsatisfactory outcomes, with a large proportion of students scoring below credit level (BECE, 2023) as evident in 2018/2019, 2019/2020, 2020/2021, 2021/2022 and 2022/2023 academic sessions where students achieved below credit with 53.76%, 49.95%, 62.93%, 59.44% and 47.08% respectively

This persistent underperformance particularly in Makurdi Local Government Area, has raised concern among educators, policymakers, and researchers. Several studies have linked students' poor performance in science subjects to various factors, including inadequate teacher content knowledge (Niswah & Qohar, 2020), reliance on ineffective teaching methods such as the lecture approach (Obafemi, 2022), and misconceptions arising from inappropriate instructional strategies. Such factors limit students' ability to understand and apply scientific concepts, contributing to low performance. To address these challenges, researchers have advocated for the adoption of student-centred instructional strategies such as Mastery Learning and Thinking Maps, which emphasize active participation, collaboration, and deeper engagement with content.

Mastery Learning is an instructional strategy that breaks down subject matter into smaller units to ensure students achieve a high level of understanding before moving to more advanced topics (Guskey, 2017). It relies on formative assessments, timely feedback, and corrective activities to promote learning. Adeyemo and Babajide (2014) describe mastery learning as requiring learners to meet a pre-specified performance criterion before progressing, while Furo (2017) emphasizes its potential to prevent failure by giving all learners opportunities to succeed with additional time and support. Empirical studies for example, Yakubu et al. (2023), and Mokuolu and Ojo (2023) have confirmed its effectiveness in improving science achievement, with minimal gender differences reported.

Thinking Maps, on the other hand, are visual tools designed to enhance students' conceptual understanding by graphically representing thinking processes (Hyerle, 2009). They consist of eight types of maps, each linked to a fundamental cognitive skill for example, the bubble map for description, the double bubble map for comparison, and the flow map for sequencing. Research shows that Thinking Maps support comprehension, critical thinking, and problem-solving by encouraging students to externalize and organize their thought processes (DeLorenzo, 2011; Long & Carlson, 2011). Studies like those of Ode and Tartenger (2021), Alabdulaziz and Alhammadi (2021) also indicate that Thinking Maps can enhance academic performance in science subjects, although some findings report outcomes similar to traditional methods.

Academic performance refers to the measurable outcomes of students' learning, often demonstrated through tests, assignments, and examinations. It has remained a persistent concern over the years (Yusuf et al., 2014, as cited in Abaidoo, 2018). Research consistently shows that many students continue to underperform in Basic Science and other science-related subjects, and this underperformance is frequently attributed to the dominance of teacher-centred instructional approaches (Okebukola, 2019; Emaikwu, 2012). Such methods, while efficient for covering large amounts of content, often limit student engagement, critical thinking, and active participation in the learning process.

The challenge of poor academic performance goes beyond low test scores. It reflects students' struggles to master scientific concepts, transfer knowledge to real-life situations, and retain learned materials over time (Abaidoo, 2018).

Gender has also remained a critical variable in educational research due to its perceived influence on performance and participation in science-related fields. While some studies report no significant gender differences in performance when student-centred strategies such as Mastery Learning and Thinking Maps are employed (Mankilik & Dawal, 2015; Tartenger, Omaga & Enemarie, 2023), others for example, Alamri (2018), Kakraba (2020), and Kainuwa et al. (2021) reveal disparities; suggesting that gender effects may depend on context, instructional methods, and socio-cultural factors. Given these gaps and mixed findings, this study investigates the comparative effects of Mastery Learning and Thinking Maps strategies on students' academic performance in Basic Science in Makurdi Metropolis, while also considering the moderating influence of gender.

Statement of Problem

Basic Science plays a pivotal role in laying the foundation for the study of core science subjects such as Biology, Physics, and Chemistry. Despite this significance, students' performance in Basic Science at the Basic Education Certificate Examination (BECE) has remained persistently poor and unstable in Benue State, including Makurdi Local Government Area. For instance, between 2018 and 2023, results consistently showed that a large proportion of students scored below credit level, with percentages of 53.76%, 49.95%, 62.93%, 59.44%, and 47.08% respectively.

This recurring underperformance has been attributed to factors such as teachers' limited content mastery, the continued reliance on teacher-centred approaches like lecture methods, and the absence of effective instructional strategies that promote deep understanding. Consequently, students often struggle with mastering scientific concepts, applying knowledge to real-life situations, and retaining learned materials over time.

To address this challenge, student-centred instructional strategies such as Mastery Learning and Thinking Maps have been recommended. Mastery Learning emphasizes ensuring that all learners attain a high level of understanding before progressing, while Thinking Maps encourage critical thinking through visual representation of thought processes. Although studies have shown positive outcomes for both strategies in improving science performance, the findings are not entirely consistent, particularly regarding gender differences.

This situation raises critical questions: Which of these strategies, Mastery Learning or Thinking Maps, is more effective in enhancing students' performance in Basic Science? Does gender influence how students benefit from these strategies? These unresolved issues form the basis of this study

Objectives of the Study

The study had the following objectives:

1. Determine the comparative effect of academic performance scores of students taught Basic Science using mastery learning and those taught using thinking maps strategies.
2. Compare the effect in academic performance of male and female students taught Basic Science using mastery learning strategy.

3. Compare the effect in performance of male and female students when taught Basic Science using thinking maps teaching strategy.

Research Questions

The following research questions guided the study:

1. What is the difference in the mean academic performance scores of students taught Basic Science using mastery learning with those taught using thinking maps strategies?
2. What is the difference in the mean academic performance scores of male and female students taught Basic Science using mastery learning strategy?
3. What is the difference in mean academic performance scores of male and female students when taught Basic Science using thinking maps strategy?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

1. There is no significant difference in the mean academic performance scores of students taught Basic Science using mastery learning with those taught using thinking maps strategies.
2. There is no significant difference in the mean academic performance scores of male and female students taught Basic Science using mastery learning strategy.
3. There is no significant difference in mean performance scores of male and female students when taught Basic Science using thinking maps strategy.

Method

The study employed a quasi-experimental research design, specifically the pre-test, post-test control group design. This design was considered appropriate because it allowed the researcher to determine the comparative effects of the instructional strategies, Mastery Learning Strategy (MLS) and Thinking Maps Strategy (TMS), on students' academic performance in Basic Science, without random assignment of participants to groups. Intact classes were used to preserve the natural classroom setting and to ensure ecological validity. The target population consisted of 1,903 Upper Basic Education II (UBE II) Basic Science students enrolled in 31 public upper basic schools in Makurdi Local Government Area, Benue State, during the 2023/2024 academic session. A total of 76 students were selected using a multistage sampling procedure. In the first stage, schools within the Local Government Area were stratified based on their location, categorizing them as either urban or rural. At the second stage, two schools were purposively selected based on the availability of qualified Basic Science teachers and similarity in facilities. At the final stage, one intact class was randomly selected from each of the chosen schools, resulting in a total of two intact classes. One class was assigned to the experimental group taught with MLS, while the other was assigned to the experimental group taught with TMS. The intervention spanned four weeks, covering selected Basic Science topics, namely: energy, work, power, and energy transformation. A total of eight lesson plans were developed by the researcher, four based on Mastery Learning Strategy and four based on Thinking Maps Strategy. The lesson plans were validated before implementation. Instruction in each group was facilitated by trained research assistants under the researcher's supervision to ensure fidelity of treatment. The instrument used for data collection was the Basic Science Performance Test (BSPT), developed by the researcher. The BSPT consisted initially of 40 multiple-choice items designed to assess students' knowledge and understanding of the selected topics. The instrument underwent validation by three experts from the Department of Science and Mathematics Education, Benue State University, Makurdi, to establish content and face validity. A pilot test was conducted using 30 UBE II students from a school outside the study sample. Item analysis was carried out, leading to the retention of 30 well-functioning items based on indices of difficulty and discrimination. The reliability of the BSPT was determined using the Kuder–Richardson Formula 21 (KR-21), which yielded a reliability coefficient of 0.94. This high coefficient confirmed the internal consistency and dependability of the instrument for measuring students' academic performance in Basic Science. The BSPT was administered to both groups as a pre-test before the commencement of the intervention and as a post-test after the four-week treatment. The administration of tests was closely monitored to ensure uniformity of conditions across both groups. Mean and Standard Deviation were used to answer the research questions, providing insight into the performance patterns of the students. To test the null hypotheses, Analysis of Covariance (ANCOVA) was employed at the 0.05 level of significance, with the pre-test scores serving as covariates. ANCOVA was considered appropriate because it adjusts for initial group differences and provides a more accurate estimate of the treatment effect.

Result

The results of the study are presented based on the research questions and hypotheses raised and the data collected.

Research Question One

What is the difference in the mean academic performance scores of students taught Basic Science using mastery learning strategy and those taught using thinking maps strategy?

Table 1: *Mean and Standard Deviation of Academic Performance Scores of Students taught Basic Science using Mastery learning Strategy (MAS) and those taught using Thinking Maps strategy (TMS)*

Method		Pre-test	Post-test	Mean gain
Mastery learning strategy	Mean	10.54	20.56	10.02
	N	41	41	
	Std. Deviation	2.73	2.16	0.57
Thinking maps strategy	Mean	9.54	20.11	10.57
	N	35	35	
	Std. Deviation	2.45	2.32	0.13
Mean Difference		1.00	0.45	0.55

Result in Table 1 presents the pre-test and post-test mean scores, mean gains, and standard deviations for two instructional groups: students taught Basic Science using the Mastery Learning Strategy (MLS) and those instructed with the Thinking Maps Strategy (TMS). At the pre-test stage, students in the MLS group had a slightly higher mean score of 10.54 than their TMS counterparts of 9.54, producing a difference of 1.00 in favour of MLS. This indicates that the MLS group started with a marginal advantage in baseline performance. Analysis of the post-test outcomes reveals that the MLS group achieved a marginally higher mean score of 20.56 compared to the TMS group's score of 20.11, reflecting a slight performance advantage of 0.45 in favour of the Mastery Learning approach. Conversely, the TMS group demonstrated a greater mean gain of 10.57 compared to the MLS group's gain of 10.02, indicating a slightly higher degree of improvement from pre-test to post-test for students exposed to the Thinking Maps Strategy. Regarding score dispersion, the MLS group exhibited lower variability in post-test scores, with a standard deviation (SD) of 2.16, compared to the TMS group's SD of 2.32; this suggests a more consistent level of performance among learners in the Mastery Learning condition.

Research Question Two

What is the difference in the mean academic performance scores of male and female students taught Basic Science using mastery learning strategy?

Table 2: *Mean and Standard Deviation of Mean Performance Scores of Male and Female Students taught Basic Science using Mastery Learning Strategy.*

Gender MLS		Pre-test	Post-test	Mean gain
Male	Mean	10.82	20.55	9.73
	N	22	22	
	Std. Deviation	2.65	2.06	0.59
Female	Mean	10.21	20.58	10.37
	N	19	19	
	Std. Deviation	2.86	2.32	0.54
Mean Difference		0.61	0.03	0.64

Result in Table 2 presents the pre-test and post-test mean scores, mean gains, and standard deviations for male and female students taught Basic Science using the mastery learning strategy (MLS). At the pre-test stage, male students obtained a higher mean score of 10.82 than female students of 10.21, resulting in a mean difference of 0.61 in favour of the males. This indicates that before the intervention, male students had a slight performance advantage over their female counterparts. The post-test results indicate that female students achieved a mean score of 20.58, while male students scored a comparable mean of 20.55. The marginal mean difference of 0.03 suggests that both male and female students performed at nearly the same level following the intervention. In terms of learning gains, female students exhibited a slightly higher mean gain of 10.37 compared to 9.73 for male students, resulting in a gain difference of 0.64 in favour of the female group. This suggests that, although both groups benefited from the instructional strategy, female students experienced a slightly greater improvement from pre-test to post-test.

With regard to score variability, male students demonstrated a lower standard deviation in their post-test scores with a Standard Deviation of 2.06 compared to females with 2.32, this indicates a more consistent performance among male students. Nonetheless, the difference in variability of 0.26 is relatively small, implying that score dispersion between the two groups is not substantially different.

Research Question Three
What is the difference in mean academic performance scores of male and female students when taught Basic Science using thinking maps strategy?

Table 3: *Mean and Standard Deviation of Performance of Male and Female Students taught Basic Science using Thinking Maps Strategy*

Gender TMS		Pre-test	Post-test	Mean Gain
Male	Mean	9.53	20.47	10.94
	N	17	17	
	Std. Deviation	2.81	1.97	0.84
Female	Mean	9.56	19.78	10.22
	N	18	18	
	Std. Deviation	2.15	2.63	0.48
Mean Difference		0.03	0.69	0.72

The result in Table 3 presents the pre-test and post-test mean scores, mean gains, and standard deviations for male and female students taught Basic Science using the Thinking Maps Strategy. At the pre-test stage, male students obtained a mean score of 9.53, while female students scored 9.56, yielding a negligible mean difference of 0.03in favour of females. This indicates that both groups began the study at nearly the same performance level, with no meaningful gender-based difference before the intervention. The results indicate that both groups made notable academic progress following the intervention. Male students recorded a mean gain of 10.94, while female students achieved a slightly lower mean gain of 10.22. The mean difference of 0.72 in favour of male students suggests that the strategy may have had a marginally greater effect on their academic performance.

In terms of score consistency, the post-test standard deviation for male students was 1.97, compared to 2.63 for female students. This indicates that male students' post-test scores were more homogeneous, whereas the broader standard deviation among females suggests more variability in their responses to the instructional approach. Despite the observed difference in mean gains, the standard difference of 0.36 is relatively small, implying that the difference in improvement between male and female students may not be statistically significant. Nonetheless, both groups exhibited substantial academic growth, demonstrating the overall effectiveness of the Thinking Maps Strategy.

Hypothesis One
There is no significant difference in the mean academic performance scores of students taught Basic Science using mastery learning and those taught using thinking maps strategies.

Table 4: *ANCOVA of Academic Performance Scores of Students taught Basic Science using Mastery Learning and those taught using Thinking Maps Strategies.*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.866[a]	2	2.933	.583	.561	.016
Intercept	1814.222	1	1814.222	360.335	.000	.832
Pretest	2.099	1	2.099	.417	.521	.006
Method	**2.664**	**1**	**2.664**	**.529**	**.469**	**.007**
Error	367.542	73	5.035			
Total	31863.000	76				
Corrected Total	373.408	75				

a. R Squared = .016 (Adjusted R Squared = -.011)

The data in Table 4 reveals that F (1,73) = 0.529; p = 0.469 > 0.05. Thus, the null hypothesis which state that there is no significant difference in the mean academic performance scores of students taught Basic Science using mastery learning and those taught using thinking maps strategies, is not rejected. This implies that both teaching strategies, Mastery Learning and Thinking Maps, are similarly effective in enhancing academic performance in Basic Science. The partial Eta square of 0.007 implies that only 0.7% of the variation in students' performance is attributable to the teaching strategy used. This is considered a very small effect size, suggesting that both mastery learning and thinking maps had a relatively equivalent effects on performance outcomes.

Hypothesis Two

There is no significant difference in the mean academic performance scores of male and female students taught Basic Science using mastery learning strategy.

Table 5: *ANCOVA of Performance Scores of Male and Female Students taught Basic Science using Mastery Learning Strategy.*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.490[a]	2	.245	.050	.951	.003
Intercept	1013.900	1	1013.900	207.578	.000	.845
Pretest	.478	1	.478	.098	.756	.003
Gender MLS	**.034**	**1**	**.034**	**.007**	**.934**	**.000**
Error	185.608	38	4.884			
Total	17519.000	41				
Corrected Total	186.098	40				

a. R Squared = .003 (Adjusted R Squared = -.050)

The result in Table 5 reveals that F (1,38) = 0.007; p = 0.934 > 0.05. Thus, the null hypothesis which states there is no significant difference in the mean academic performance scores of male and female students taught Basic Science using mastery learning strategy is not rejected. This result implies that mastery learning is a gender-inclusive strategy that provides equitable academic outcomes for both male and female students. The partial eta squared for gender is 0.000, meaning 0% of the variance in academic performance can be attributed to gender differences. This is an extremely small effect size, essentially confirming that gender has no effects on students' performance when taught using mastery learning strategy.

Hypothesis Three

There is no significant difference in mean performance scores of male and female students when taught Basic Science using thinking maps strategy.

Table 6: *ANCOVA of Mean Performance Scores of Male and Female Students taught Basic Science using Thinking Maps Strategy.*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.348[a]	2	3.174	.573	.569	.035
Intercept	774.181	1	774.181	139.811	.000	.814
Pretest	2.152	1	2.152	.389	.537	.012
Gender TMS	**4.229**	**1**	**4.229**	**.764**	**.389**	**.023**
Error	177.195	32	5.537			
Total	14344.000	35				
Corrected Total	183.543	34				

a. R Squared = .035 (Adjusted R Squared = -.026)

The result in Table 6 reveals that F (1,32) = 0.764; p = 0.389 > 0.05. Thus, the null hypothesis which states that there is no significant difference in mean performance scores of male and female students when taught Basic Science using thinking maps strategy is not rejected. This result implies that male and female students performed similarly under the Thinking Maps strategy. In other words, the strategy provides an equitable learning environment in terms of academic performance. The partial eta squared value for gender is 0.023, meaning that only 2.3% of the variance in performance scores can be attributed to gender. This is considered a small effect size and further reinforces that gender differences are minimal.

Discussion of Findings

The study found no statistically significant difference in the mean academic performance scores of students taught Basic Science using Mastery Learning Strategy (MLS) and those taught with Thinking Maps Strategy (TMS). Although the difference was not significant, the findings confirm that both strategies are effective in enhancing students' academic performance. The positive impact of mastery learning on academic achievement has been widely established. This finding aligns with Yakubu, et al (2023), who reported improved academic outcomes among chemistry students in Gombe State following the application of MLS. Similarly, Mokuolu, et al., (2023) observed that MLS significantly enhanced students' achievement in Physics in Ogun State, with students exposed to MLS outperforming those taught through traditional methods.

Umar and Dalaham (2023) also emphasized the benefits of the Peer-Led Mastery Learning (PLML) approach, which improved students' performance and attitudes toward science. These results reinforce the argument of Mitee and Obaitan (2015), Guskey (2017), and Adeyemo and Babajide (2014), who highlighted that MLS supports learners by providing additional learning opportunities, corrective feedback, and continuous assessment factors that lead to deeper understanding and minimize achievement gaps.

Similarly, the study confirmed the effectiveness of Thinking Maps in improving students' performance. This finding supports Ode and Tartenger (2021), who reported no significant difference between Thinking Maps and role-play, suggesting that Thinking Maps are equally effective as other innovative strategies. Alabdulaziz et al. (2021) further found that Thinking Maps enhanced students' mathematical connection skills. Hyerle (2009), Ruba and Alaeddin (2017), and Long et al. (2011) all argue that Thinking Maps promote meaningful learning by enabling students to visualize their thought processes, connect prior knowledge to new content, and strengthen retention.

Taken together, these results suggest that both MLS and TMS are valid student-centred strategies capable of addressing the persistent problem of poor performance in Basic Science.

The findings revealed no significant gender differences in the academic performance of students taught with MLS. This suggests that the strategy provides an inclusive environment that supports both male and female students equally. This result is consistent with Mokuolu et al. (2023) and Umar and Dalaham (2023), who reported no significant gender differences among students taught using MLS or PLML. Similarly, Mankilik et al. (2015), as well as Tartenger, et al. (2023), found that student-centered strategies neutralize gender disparities in Basic Science performance. The inclusive and adaptive features of MLS such as flexible pacing, feedback, and reinforcement likely account for this gender neutrality. However, some studies contradict this finding. Alamri (2018), Eze, et al. (2020), Kakraba (2020), and Kainuwa, et al. (2021) reported significant gender differences in science achievement. These contrasting results highlight the influence of contextual factors such as instructional methods, learning environments, and socio-cultural expectations in shaping gender-related educational outcomes.

The study also found no significant difference between male and female students taught with TMS. This implies that Thinking Maps provide an equitable learning environment where students, regardless of gender, can engage actively and achieve similar outcomes. This finding corroborates Tartenger, et al. (2023), who also found no gender differences when students were taught with Thinking Maps and role-play. Beni-Mosa (2011) similarly reported that while students taught with Thinking Maps outperformed those in traditional classrooms, no gender gap existed within the experimental group. These findings suggest that the visual and participatory nature of Thinking Maps promotes balanced cognitive development, equitable engagement, and critical thinking among both male and female learners.

Conclusion

The study concludes that both Mastery Learning Strategy and Thinking Maps Strategy are effective in enhancing students' academic performance in Basic Science in Makurdi Metropolis. Importantly, gender did not significantly influence performance under either strategy, indicating that they are equitable and gender-inclusive instructional approaches.

Recommendations

Based on the findings, the following recommendations are made:

1. Basic Science teachers should receive structured training on the effective use of Mastery Learning and Thinking Maps strategies to strengthen their pedagogical skills.
2. Educational stakeholders should promote the integration of these strategies into classroom practice to enhance student engagement and performance.
3. Professional associations such as the Science Teachers Association of Nigeria (STAN) should organize regular workshops and conferences on innovative strategies like MLS and TMS, to sensitize and empower teachers for effective implementation.

References

Abaidoo, A. (2018). *Factors contributing to academic performance of students in a junior high school*. https://www.grin.co/450284

Adeyemo, S.A., & Babajide, F.T. (2014). Effects of mastery learning approach on students' achievement in Physics among secondary school students, Lagos State. *International Journal of Scientific & Engineering Research,5*(2), 910-920.

Alabdulaziz M. S., & Alhammadi, A. A. (2021). The effectiveness of using thinking maps through the edmodo network to develop achievement and mathematical connections skills among middle school students. *Journal of Information Technology Education: Research, 20*, 1-34. https://doi.org/10.28945/4681

Alamri, H. R. H. (2018). The effect of using the jigsaw cooperative learning technique on Saudi EFL students' speaking skills. Journal of Education and Practice, 9(6), 65-77.

Beni-Mosa, M. (2011). The effectiveness of using thinking maps to develop creative thinking and academic achievement in engineering among first-year high school students. *Studies in Curriculum and Teaching Methods, 168*, 133–178. https://doi.org/10.28945/4681

Benue State Examination Board. (2023). *Chief examiners' report (2018–2023).* Ministry of Education.

DeLorenzo, E. (2011). *Brain-compatible instructional strategies with thinking maps.* Classroom storytelling with thinking maps. http://eileendelorenzo.com/brain-compatible-instructional-strategies-with-thinking-map/

Emaikwu, S. O. (2012). Assessing the relative effectiveness of three teaching methods in the measurement of students' achievement in Mathematics. *Journal of Emerging Trends in Educational Research and Policy Studies, 3* (4), 179-486.

Furo, K. V., & Eniayeju, P. A. (2014). The effect of concept mapping- guided discovery integrated teaching approach on Chemistry students' achievement and retention. *Educational Research and Review, 9*(22), 1218-1223.

Gallagher, K. T., Gold Haber, M. B., and Ayres, M. A. (2008). *Making the case for Integrated Science: A Sequel to the USGS Science Strategy.*

Hyerle, D. (2009). *Visual tools for transforming information into knowledge*. Corwin Press.

Kainuwa, A., Mayanchi, M. L., & Anya, C. A. (2021) Effects of Mastery Learning and Problem-Solving Approaches on Achievement in Mathematics among Secondary School Students in Gusau, Zamfara State. *Zamfara International Journal of Education, 1*(1), 244-254.

Kakraba, E. Q. (2020). Effects of mastery-based learning approach on pre-service Mathematics teachers' geometry performance in volta region colleges of Education, Ghana. *American Journal of Educational Research*. *8*(9), 615-621. 10.12691/education-8-9-2

Long, D. J., & Carlson, D. (2011). Mind the map: How Thinking Maps affect student achievement. *Networks: An Online Journal for Teacher Research*, *13*(2), 1-7. hpps://newprairiepress.org/ networks/vol13/iss2/2/

Mankilik, M., & Dawal, B. S. (2015). Effect of mastery learning approach (MLA) on the performance of boys and girls in public primary schools in Basic Science and Technology in Jos Metropolis, Nigeria. *Asia Pacific Journal of Multidisciplinary Research 3(*5), 1-7.

Mitee, T. L., & Obaitan, G. N. (2015). Effect of mastery learning on senior secondary school students' cognitive learning outcome in quantitative Chemistry. *Journal of Education and Practice. 6*(5),34-38.

Mokuolu, A.O., & Ojo, K.R. (2023) Interactive effect of mastery learning strategy on academic achievement of secondary school Physics Students in Odeda Local Government, Abeokuta, Ogun State, Nigeria. *International Journal of Novel Research in Education and Learning. 10*(4), 85-91. www.noveltyjournals.com

Niswah, U., & Qohar, A. (2020). Mathematical reasoning in mathematics learning on pyramid volume concepts. *Malikussaleh Journal of Mathematics Learning*, *3*(1), 23-26.

Obafemi, K. E. (2022). Effect of differentiated instruction on the academic achievement of pupils in mathematics in Illorin West Local Government Area, Kwara State. *Kwasu International Journal of Education, 4*(1)*,* 51-59.

Ode, J. O., & Tartenger, T. T. (2021). Effects of thinking maps and role play instructional strategies on student performance and retention in basic science in Makurdi, Nigeria. Benue State University *Journal of Science, Mathematics and Computer Education, 2*(2),30- 39.

Ode, J. O., & Eriba, J. O. (2019). Teaching and learning of Basic Science in a recessed economy. *Education Review letter 4*(9, 8-16. www.mindsourcin.info

Ruba, F. B., & Alaeddin, K. A. (2017). The effects of a thinking maps-based instructional program on Jordanian EFL tenth-grade students' critical reading skills. *Asian EFL Journal*, *101*(2), 30-60. http://www.asian-efl-journal.com.

Tartenger, T. T., Omaga, J. O. & Enemarie, V. (2023). Impact of Thinking maps and role-play instructional strategies on performance in basic science among students in Makurdi, Benue State. *Zamfara International Journal of Education, 3*(3), 90-96

Umar, A. & Dalaham, P. D. (2023) Impact of peer-led mastery learning approach on performance and attitude of senior secondary school science students. *Benue State University Journal of Science, Mathematics and Computer Education*, *3*(2), 65-77.

Yakubu, N. O., Salihu, M. J., Lawal, T. E., & Usman, I. A. (2023). Effect of mastery-learning approach on academic performance in mole concept among secondary school Chemistry students in Gombe Metropolis. *Zamfara International Journal of Education*, *3*(5), 95-100.