Cooperative Mastery Learning as an Instructional Strategy for Sustaining Students' Retention of learned content in Biology

Salaam Ibrahim Oladoja[1]

Kareem Saliu Adeyemi[2]

Abstract

The study investigated Cooperative Mastery Learning as an Instructional Strategy for sustaining students' retention of learned content in Biology in Lagos State secondary schools, Nigeria. The research design adopted Solomon's four groups, a non-randomised pre-test, post-test, control group quasi-experimental design. The population comprised all senior secondary 2 students offering biology in public senior secondary schools, Lagos State. The sample comprised one hundred and sixty-three (163) senior secondary 2 students offering biology, drawn from four selected public senior secondary schools in Educational District II in Lagos State. Modified Biology Achievement Test (BAT) with a 0.90 reliability index was used for data collection. The result showed a significant effect of the instructional strategy on students' retention in senior secondary biology $F_{(3, 147)} = 21.653$, $p < 0.05$). However, result showed no significant effect of peer relations on students' retention of Biology content ($F_{(1, 150)} = 0.562$, $p > 0.05$). In addition, the interaction effect of instructional strategy and peer relation was not significant on the students' retention of Biology content ($F_{(3, 147)} = 1.057$, $p > 0.05$). The study hence concluded that cooperative mastery learning led to students' knowledge retention in biology, and it 55.3% of the variance in students' retention scores. It was recommended that teachers should adopt the use of cooperative mastery learning to improve students' retention in Biology

Key words: Biology, Cooperative Mastery Learning, Peer Relations, Retention

1. Introduction

In view of its importance, the teaching of science and technology in all institutions is emphasised by the Federal Government of Nigeria as contained in the National Policy on Education (FRN, 2013). Biology is a science subject offered in senior secondary school in Nigeria, which studies living organisms (Martin & Robert, 2015). Biology is a very important subject that enables living things to understand themselves and their environment (Twan et al., 2022).

Biology has witnessed high enrolment compared to any other science-based subject in the final year of external examinations without a corresponding increase in the students' academic performance (Piwuna & Mankilik, 2023; Twan et al., 2022). The WAEC and NECO Chief Examiners have consistently lamented the poor performance of candidates in biology for more than twenty years, by using phrases like, "not satisfactory"; "downward trend"; "abysmal/dismal performance" "decline in pass rate"; "fluctuating performance"; and persistent failure"; in describing the performance of students.

The continuous decline in performance alongside the annual recommendation of the Chief Examiners report which is presumed to hold the solution to low performance in biology recorded in Nigeria, reasons by Akubuilo (2012), Ajaja (2013), Sakiyo (2015);

[1] Salaam Ibrahim Oladoja PhD candidate, Department of Science and Technology Education. Olabisi Onabanjo University, Ago Iwoye, Ogun State, Nigeria. Email: ibrosalam21@yahoo.com

[2] Kareem Saliu Adeyemi (Phd). Biology Department, Federal College of Education (Special), Oyo, Nigeria. Email: Kareemsalihu3@gmail.com

Twan et al. (2022) attributed to issues such as teacher preparation, overcrowding, poor instructional methods, insufficient laboratory.

Meanwhile, low performance in Biology indicates low retention, negatively affecting students who intend to read Biology-related courses at tertiary level. Knowledge retention is directly tied to educational success (Bizimana et al. 2022). Consequently, learners must retain knowledge learned during the teaching/learning process to realise their full potential in Biology. Retention is the learner's cognitive information processing, which involves understanding, information processing, and storing within memory (Lutz & Huitt, 2018). It is the ability to retain information in mind. Preserving the after-effects of experience and learning makes recall or recognition possible (Ahlam & Gaber,2014). According to Anthony and Anka (2020), retention is the process through which long-term memory saves information so that it may be found, identified, and retrieved accurately in the future. In education, learning retention plays a vital role for a learner to successfully learn the concepts taught inside or outside the classroom. Hence, for functional Biology education, the learners should be able to retain and retrieve what has been taught. Choosing a teaching strategy that results in learners' knowledge retention can be challenging for educators (Roya et al., 2014).

One of the major contributory factors to students' underachievement in Biology examinations is the use of conventional methods in teaching secondary school Biology. The most commonly used is the lecture method. Ahmadzaide and Shojoe (2013) criticised the Lecture Method, which seems to be the most frequently used method by teachers, because only hardworking students can benefit from it. Okeke (2006) claims that the lecture method is ineffective in science instruction. It is therefore imperative to employ the use of innovative strategies that could improve the performance of students in Biology examinations. On the part of Thomas and Israel (2013), it was maintained that to facilitate the process of knowledge transmission, teachers need to apply appropriate teaching approaches that best suit specific objectives that constitute good teaching and learning. Such teaching methods should be learner-centred instead of the conventional teacher-focused method.

Mastery learning is an instructional method that presumes all learners can learn if they are provided with the appropriate learning conditions. Specifically, mastery learning is a method whereby students are not advanced to a subsequent learning objective until they demonstrate proficiency with the current one (Obidiegwu & Ojo-Ajibare, 2016). While Cooperative learning is based on the sociocultural perspective, the thoughts are based on Vygotsky's theory that learning is a social process that arises in interaction with others (Vygotsky, 2017). Cooperative learning continues today to be a valuable tool for learning in academic institutions, as well as provides benefits for both students and instructors. It represents a shift in educational approach from competitive-based to collaborative-based instruction in order to address diversity in the classroom (Slavin, 2011). Cooperative learning is grounded in the belief that learning is most effective when students are actively involved in sharing ideas and working cooperatively to complete academic tasks. Thus, the cooperative mastery learning (CML) strategy engages a small group of students working collaboratively on a common task, fostering interdependence and cooperation to enhance learning outcomes (Mehta & Kulshrestha, 2014). Typically, these groups consist of three to five students, ensuring that each member actively participates in the clearly structured task (Appiah-Twumasi et al., 2020). Through sharing ideas and materials, students divide responsibilities to complete the task, encouraging deeper understanding through peer interaction and support. CML emphasises cooperation over competition, allowing students to explore and discuss concepts in an engaging, hands-on environment (Keter, 2013).
To this extent, the objective of this study was to investigate the effectiveness of the cooperative mastery learning strategy in sustaining students' retention in biology using Solomon's research design. Specific objectives of the study were to:

I. Investigate the effect of cooperative mastery learning on students' retention in biology content;
II. determine the effect of peer relations on students' retention in biology content after exposure to an instructional strategy;

III. determine the interaction effect of cooperative mastery learning and peer relation on students' retention in biology content.

Research questions

1. What is the effect of the pr-test on students' retention in biology retention in senior secondary schools?

Statement of Hypotheses

$H_0$1: There is no significant effect of instructional strategy (cooperative mastery learning and conventional) on the students' retention of biology in senior secondary schools.

$H_0$2: There is no significant effect of peer relations on the students' retention of biology in senior secondary schools.

$H_0$3: There is no significant interaction effect of instructional strategy and peer relations on the students' retention of biology in senior secondary schools

2. Methodology

2.1 Method

The research design adopted was a Solomon four-group, a non-randomised pre-test, post-test, control group, quasi-experimental design. This design enables discerning confirmation of whether observed changes result from the application of the treatment.

Table 1. Solomon Four-Group Design Layout

Schools	Groups	Pretest	Treatment	Posttest
School 1	Experimental	O1	X	O2
School 2	Control	O3		O4
School 3	Experimental		X	O5
School 4	Control			O6

Source: Adapted from Frankel and Wallen (2000).

Where:

O1 Pretest in the first experimental group,

X Treatment in the first experimental group (Cooperative Mastery Learning)

O2 Posttest in the first experimental group

O3 Pretest in the first control group

O4 Posttest in the first control group

X Treatment in the second experimental group (Cooperative Mastery Learning)

O5 Posttest in the second experimental group

O6 Posttest in the second control group

2.2 Participants and Instruments

The target population for this study comprised all senior secondary II students offering biology in public senior secondary schools in Lagos State. The sample for this study comprised one hundred and sixty-three (163) senior secondary 2 (SS 2) students offering biology, drawn from four selected public senior secondary schools in Educational District II in Lagos State. Two of the four selected schools were randomly assigned to the experimental group and the remaining two to the control group. Students offering biology in each intact class selected were used for the study. The Biology Achievement Test (BAT), Perceived Peer Relationship Scale (PPRS), and the Cooperative Mastery Learning instructional guide were the main instruments used. The Biology Achievement Test (BAT) is a 40-question multiple-choice test covering topics on the reproductive systems in flowering plants, pollination, fruits, and ecology. Test blue print was constructed to guide in the construction of the test. The BAT was administered to assess students' retention of knowledge of the topics taught in the study. The instrument was reviewed by experienced biology teachers and experts in test and measurement to ensure face and content validity. Suggestions from these reviews were implemented before submitting the instrument to the supervisors for further scrutiny and approval. Reliability was assessed using the Pearson Product-Moment Correlation, correlating the two sets of results, which yielded a reliability coefficient of 0.93.

The Peer-Relationship Perception Scale (PPRS) was adapted from the work of Aydogdu (2022). Each statement has four options on an agreement–disagreement continuum: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). The four-point scale instrument had an initial reliability index of 0.85, calculated using the split-half method. The instrument was reviewed by a team of experts for validation, including a test and measurement expert and a sociologist. Following validation, some PPRS items were revised. These adjustments were incorporated into the final version of the instrument, which was then administered to thirty students offering biology who were not involved in the main study. The results indicated a reliability coefficient of 0.83 using Cronbach's Alpha.

The Cooperative Mastery Learning (CML) instructional guide was designed to help educators implement a structured, collaborative learning approach, enabling students to master content through group activities, formative assessments, and targeted support. This guide offers a detailed, step-by-step framework that teachers can use to create an effective learning environment rooted in cooperative learning and mastery of subject matter. The instructional guide incorporated formative assessments, with provisions for re-teaching and remediation as part of the mastery learning approach. The Cooperative Mastery Learning lesson plan was characterised by clear objectives, initial instruction, formative testing, re-teaching, and remediation, aligning with mastery learning principles to support all students in achieving a high level of comprehension. In essence, the guide was to enhance the internal validity of the study.

2.3 Procedure

Teachers in control groups were not given any specific lesson guide but were asked to teach the topics scheduled for this study using their usual teaching method (conventional method). However, throughout the experiment period, the researcher moved around to monitor the teacher's classroom activities. This was to ascertain that CML was not used in the control group. At the pre-experimental stage, the researcher trained the biology teachers who served as research assistants. The assistants were professional teachers in the participating schools with either a B. Ed or B.Sc (Ed) qualification. The teachers for the experimental groups were trained on the practical implementation of the Cooperative Mastery Learning Approach, while teachers in the conventional classroom were not trained. Afterwards, the researcher administered the Biology Achievement Test (BAT) as a pre-test to one experimental and one control group. Similarly, the Perceived Peer Relation Scale was administered to all the groups during the first week. Before administering the treatment, pre-test scores were compared to determine if the experimental and control groups were equivalent.

The experimental groups were exposed to the treatment for six weeks, while the control group received no treatment and was also monitored for six (6) weeks. After the treatment, a post-test was administered to the four (4) groups to determine their achievements. Thereafter, two (2) weeks after the post-test, the post-test was also re-administered to all the groups to determine the retention ability of the participants. The scores for the experimental and control groups were recorded accordingly and analysed using appropriate statistical tools. Mean and Standard Deviation were used to answer the research at $p \leq 0.05$ level of significance.

2.4 Results and Analysis

1. Will there be a difference between the groups pre-tested and the groups that did not receive a pre-test in the retention of Biology contents?

Table 2: Difference (*t*-test) in the Retention Scores of Pre-tested & Not Pre-tested Groups

Groups	N	Mean	Std. D.	*t*	df	Sig. (2-tailed)
Pre-tested	62	13.87	5.62	2.36	161	.020*
No pre-test	101	16.14	6.16			

*** Indicate significant *t* at .05 level**

Table 2 presents the results of the t-test analysis determining the difference between the post-test mean retention scores of the groups exposed to a pre-test and those not pre-tested before treatment (cooperative mastery learning strategy). The findings reveal that the group exposed to the pre-test (N=62) recorded a post-test mean retention score of 13.87 (SD = 5.62), while the group not exposed to the pre-test (N=101) recorded a mean score of 16.14 (SD = 6.16). This outcome indicates a difference in post-test mean retention scores, favouring the group that did not receive the pre-test. Additionally, Table 2 shows that this difference is statistically significant ($t = 2.36$, $p < .05$), highlighting a potential pre-test effect on the instructional strategy.

$H_0$1: There is no significant effect of instructional strategy (cooperative mastery learning and conventional) on the students' retention of Biology contents.

Table 3: Summary of Analysis of Covariance of Students' Retention of Biology Contents According to Strategy and Peer Retention

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig. of F
Main Effects	**1842.017**	**5**	**368.403**	**13.852**	**.000**
Covariates (pre-test)	26779.276	1	26779.276	1006.935	.000
Instructional Strategy (I.S)	1727.538	3	575.846	21.653	.000*
Peer Relation	14.949	1	14.949	.562	.455
2 Way Interactions	**75.432**	**7**	**10.776**	**.405**	**.898**
I. Strategy * Peer Relation	84.371	3	28.124	1.057	.369
Gender * Peer Relation	2.487	1	2.487	.094	.760
3 Way Interactions	**97.684**	**3**	**32.561**	**1.224**	**.303**
I.S. * Gender * Peer Relation	97.684	3	32.561	1.224	.303
Explained	**20 15.134**	**12**	**134.342**	**5.051**	**.000**
Residual	**3909.442**	**150**	**26.596**		
Corrected Total	**5924.577**	**162**			

*** indicate significant F at the .05 level**

The table presents the analysis results conducted to test the main effect of the instructional strategy (i.e., treatment and the conventional method) on students' retention of learned Biology knowledge. The result reveals a statistically significant outcome ($F(3, 147) = 21.653$, $p < 0.05$), indicating that there is a significant difference in the students' post-test mean retention scores after exposure to the four levels of instructional strategies at the 0.05 level of significance. As a result, the null hypothesis (H02) is rejected. This finding suggests that the instructional strategy significantly influenced students' retention of Biology content, with various strategies yielding different outcomes regarding how well students retained the material.

The magnitudes of the post-test mean retention scores of the students across the levels of instructional strategy and peer relation by order is presented in the multiple classification analysis (MCA) that follows in Table 4.

Table 4: Multiple Classification Analysis of Students' Retention Scores According to Instructional Strategy, Gender and Peer Relation

Grand Mean = 15.61

Variable + Category	**N**	**Unadjusted Deviation**	**Eta**	**Adjusted for Independent + Covariates**	**Beta**
Instructional Strategy					
1. Experimental 1 (with pre-test)	31	-.41		- .14	
2. Control 1(with pre-test)	31	-2.41		-2.44	
3. Experimental 2 (No pre-test)	70	-1.71		-1.83	
4. Control 2 (No pre-test)	31	6.66	**.54**	6.71	**.55**
Gender					
Peer Relation					
1. Low	68	-.34		-.47	
2. High	95	.24	**.05**	.34	**.07**
Multiple R Squared					**.311**
Multiple R					**.558**

Table 4 provides a detailed analysis of the magnitudes of the post-test mean retention scores of the students across different levels of instructional strategy and peer relations. The analysis shows that, with a grand mean of 15.61, the students in the second control group (no pre-test, no treatment) recorded the highest adjusted post-test mean retention score of 22.32 (15.61 + 6.71), while the students in the first experimental group (pre-test before treatment) had the next highest score of 15.47. Those exposed to the instructional strategy in the second experimental group (no pre-test before treatment) had an adjusted post-test mean retention score of 13.78, and the students in the first control group (pre-test but no treatment) recorded the lowest adjusted post-test mean retention score of 13.17 (15.61 - 2.44).

This outcome indicates that, in terms of post-test retention scores, students exposed to the conventional method in the second control group (no pre-test, no treatment) performed the best. In contrast, students in the first control group (pre-test but no treatment) performed the worst.

The results further show that the treatment (instructional strategy) alone accounted for 55.3% of the variance in students' retention scores.

Table 5: Scheffe Pair-wise Comparisons of Retention Scores on Instructional Strategy

Mean	**Treatment (Inst. Strategy)**	**(Exp.1)**	**(CG.1)**	**(Exp.2)**	**(CG.2)**
14.74	**Experimental 1 (Exp.1)**				*
13.28	**Control Group 1 (CG.1)**				*
12.45	**Experimental 2 (Exp.2)**				*
21.96	**Control Group 2 (CG.2)**	*	*	*	

* denotes pairs of groups that are significantly different at $P < 0.05$

These findings suggest that the students in control group 2 performed significantly better in retention compared to the other groups. However, no significant differences were found between the following pairs: Experimental group 1 and control group 1, Experimental group 1 and experimental group 2, Experimental group 2 and control group 1. Thus, the significant differences in retention scores are primarily explained by comparing control group 2 and the other groups. This indicates that the students in control group 2, which involved no pre-test and no treatment, had better retention than those in the other groups, which were exposed to various instructional strategies. The significant effect of the CML on students' retention of Biology content further confirms the effectiveness of the instructional strategies used in this study.

$H_0$2: There is no significant main effect of peer relations on students' retention of Biology content.

The analysis of covariance (ANCOVA) results in Table 2 show no significant main effect of peer relation on students' retention of Biology content ($F_{(1, 150)} = 0.562$, $p > 0.05$). This implies that there is no significant difference between the post-test mean retention scores of the sampled students with low and high peer relation influence after exposure to the four levels of instructional strategy used in the study. Hence, null hypothesis two (H02) is retained. The results of the multiple classification analysis (MCA) on peer relation in Table 4 show that, with a grand mean of 15.61, students with high peer relation recorded a higher adjusted post-test mean retention score of 15.95 (i.e., 15.61 + 0.34) than their counterparts with low peer relation, who recorded an adjusted post-test mean retention score of 15.14. This outcome shows that when the order of magnitude of the post-test mean retention scores of Biology content is considered, students with high peer relations recorded higher scores than students with low peer relations. Table 4 further shows that peer relation, as a moderator variable, accounted for 6.7% of the variance in students' retention of Biology content scores.

$H_0$3: There is no significant interaction effect of instructional strategy and peer relations on the students' retention of Biology content.

The result of the 2-way interaction effect in Table 2 shows no significant interaction effect of instructional strategy and peer relation on the students' retention of Biology content ($F_{(3, 150)} = 1.057$, $p > 0.05$). This outcome implies that the students' post-test mean retention scores across the four levels of instructional strategy used in the study do not vary significantly across the two levels of peer relation (high and low). Hence, the null hypothesis ten ($H_0$10) is retained. This implies that the effect of instructional strategy is the same across the levels of peer relation in explaining the students' retention of Biology content.

3. Discussion

These findings suggest a significant difference in biology knowledge retention between the pre-tested and non-pre-tested groups. The results imply that the pre-test effect may not substantially influence students' retention in Biology within this study. Instead, the outcome might be attributed to students' independent study habits, supporting the strategy's effectiveness in sustaining knowledge even without pre-testing. This result differs from Richland et al. (2009), who reported that students performed better on questions they had previously encountered in a pre-test than on new questions in the post-test.

On the significant effect of the treatment on retention, several factors may explain the positive outcomes in retention: the use of formative assessments during lessons allowed for continuous feedback and helped students integrate the concepts they were learning; the cooperative learning approach used in the experimental groups facilitated peer interactions, which may have enhanced understanding and retention. Students could learn from and assist each other, providing remediation when needed;

the freedom students had to learn from their peers and the active participation encouraged by the cooperative learning strategy may have significantly improved retention. However, it is worth noting that this finding contradicts the results of Oluwatosin and Bello (2015), who found no significant effect of treatment on students' retention ability when taught Physics using mastery learning and mind-mapping strategies. On the other hand, this study's findings are consistent with previous research supporting the efficacy of cooperative and mastery learning strategies in promoting retention. Laney et al. (1996) found that the cooperative-mastery learning method was superior in promoting the acquisition and retention of concepts in first and second-grade students. Furthermore, the findings align with Oladayo and Olumilua (2021), who reported a significant effect of treatment on students' achievement and retention in Social Studies, and with Raji et al. (2018), who found that cooperative and mastery learning strategies improved both achievement and retention in Mathematics. Thus, the study's results provide strong evidence of the effectiveness of the instructional strategy (cooperative mastery learning) in enhancing students' retention of Biology content. The significant differences observed in post-test mean retention scores suggest that students exposed to these strategies retained the material more effectively than those in traditional methods. The findings also highlight the importance of interactive, student-centred approaches, such as cooperative learning, in promoting long-term retention. These results contribute to the growing body of literature supporting cooperative and mastery learning strategies in various academic disciplines to enhance students' learning outcomes.

The result showed that peer relation was not a major player in students' learning retention. There are many reasons for poor academic achievement and retention, including the potential negative effects of peer rejection or being ignored by peers, which can lead to emotional changes in students and negatively impact their academic performance. Interpersonal relationships continue to shape a range of social skills, behaviours, attitudes, and emotional responses. The assumption is that, as adolescents become less dependent on their parents, the influence of peers becomes more pronounced, serving as an important socialising environment outside of the family that can influence academic outcomes. The result, however, is inconsistent with the findings of Gallardo et al. (2016), who found peer acceptance (measured by free nominations) to positively predict subsequent academic achievement, the effect being stronger for early adolescents than for mid-adolescents. In another study (Kingery et al., 2011), it was shown that pretransition peer acceptance (measured by peer ratings) and number of reciprocated friends (measured by an unlimited nomination procedure) predicted the post-transition academic achievement, with the most robust links being between peer acceptance and early adolescents' academic achievement. It also does not align with Chen et al. (2001), who found that peer relationships have a direct impact on students' academic performance. Wentzel et al. (2004) also reported that positive peer relationships can have a beneficial effect on academic performance, a conclusion not supported by this study's results. There are also studies indicating that peer acceptance (measured by the number of restricted nominations) did not predict students' subsequent academic achievement during primary or middle school (Véronneau et al., 2010). Additionally, Liu et al. (2023) affirmed that the quality of friendship, the number of friends, and the academic achievement of friends are positively correlated with the academic performance of high school students, which contrasts with the findings of this study.

On the interaction effect of strategy and peer relations, given the amount of time students spend with their classmates and friends in school, they are likely to be influenced by them. The guiding assumption is that positive relationships with schoolmates facilitate a sense of belonging to school. It is presumed that both peer relationships and a sense of belonging to school are related to student engagement and academic achievement, with peer relationships contributing to both the sense of belonging and student engagement. Thus, a strong association between peer acceptance and school belonging (Adelabu, 2007) suggests that school-based relationships are critical. Although both relationships with teachers and peers are likely to matter (Furrer & Skinner, 2003), the need to "fit in" with one's peers is especially pronounced during adolescence (Lafontana & Cillessen, 2010). Nevertheless, studies have identified that large classes and heavy curriculum content seem to discourage academic staff from prioritising peer interaction from a pedagogical perspective, so planned and intentional fostering of interaction is limited (Arkoudis et al., 2010). Therefore, a potential obstacle to peer interaction is most likely caused by teaching practices. Literature suggests that effective teaching strategies enhance peer connections in the classroom, increase rapport, and promote adjustment (Prosser & Trigwell, 2006; Westwood, 2008).

This finding refutes Buhs' et al. (2006) conclusion that students who reported being excluded by their peers were less likely to participate in class. In a cross-sectional study of sixth and seventh graders, Lopez and DuBois (2005) showed that students who felt disapproved of by their peers had lower grade point averages and were absent from school on more days than students who felt accepted. Omwirhiren (2015) opined that retention may be limited by the use of conventional teaching methods in physics, which could explain students' low achievement in the SSCE. High-quality friendships typically involve positive features such as support, companionship, and commitment, as well as low levels of conflict (Berndt, 2002).

4. Conclusion and Recommendations

In spite of the importance and popularity of biology as a subject among secondary school students, performance in the subject level remain fluctuating. To advance ways out of these challenges, the study thus achieved its stated objectives through empirical investigation on the effect of cooperative mastery learning strategy on the students' learning retention in Biology. The study hence concluded that there is a significant effect of instructional strategy (cooperative mastery learning and conventional) on the students' retention of Biology contents, and it accounted for 55.3% of the variance in the students' scores in the retention. However, peer relations did not make a major contribution to students' retention when cooperative mastery learning was used. It was recommended that teachers should adopt the use of cooperative mastery learning to improve students' retention in Biology. Also, Teachers should pay attention to peer relationships when placing students in groups for the cooperative.

References

Adelabu, D. H. (2007). Time perspective and school membership as correlates to academic achievement among African American adolescents. *Adolescence*, *42*(167), 525–538.

Ahlam, E.S., & Gaber, H. (2014). Impact of problem-based learning on students' critical thinking dispositions, knowledge acquisition and retention. *Journal of Education and Practice*, *5*(14) 74-83.

Ahmadzaide, L., & Shojoe, M. (2013). Investigating the Relationship between Cognitive Style (Field dependence/Independence and Academic Achievement in Male and Female Students of Behbahn Islamic Azad University. *Journal of Life Science Biomed*, *3*(3), 245-249.

Ajaja, O. P. (2013). Which Strategy Best Suits Biology Teaching? Lecturing, Concept Mapping, Cooperative Learning or Learning Cycle. *Electronic Journal of Science Education*, *17*(1), 1-37.

Akubuilo, D. U. (2012). Effects of Two Modes of Instructional Treatment on Students' Achievement and Attitude in Biology. *IJSAR Journal of Advancement in Education and Computing, 4*(2), 184-193.

Anthony, A., & Anka, S. S. (2020). Effects of Two Modes of Computer-Assisted Instruction on Pupils' Achievement and Retention in English Language Spelling In Niger State, Nigeria. *International Journal of Innovative Research in Computer Science & Technology,8*(3), 231-241.

Appiah-Twumasi, E., Antwi, V., Anderson, I.K., & Sakyi-Hagan, N. (2020). Comparative Effect of Cooperative Learning on Students' Performance in Mechanics Concepts: A Case of Two Secondary Schools in Berekum Municipality, Ghana. *East African Journal of Education and Social Sciences*, *1*(1), 139-151.

Aydoğdu, F. (2022). Developing a Peer Relationship Scale for Adolescents: a validity and reliability study. *Current Issues in Personality Psychology, 10*(2), 164–176.

Arkoudis, S., Yu, X., Baik, C., Borland, H., Chang, S., Lang, I., Lang, J., Pearce, A., & Watty, K. (2010). Finding common ground: Enhancing interaction between domestic and international students. Australian Learning and Teaching Council.

Berndt, T. J. (2002). Friendship quality and social development. *Current Directions in Psychological Science*, *11*(1), 7–10.

Bizimana, E., Mutangana, D., & Mwesigye, A. (2022). Fostering students' retention in photosynthesis using concept mapping and cooperative mastery learning instructional strategies. *European Journal of Educational Research*, *11*(1), 103-116. https://doi.org/10.12973/eu-jer.11.1.107

Buhs, E. S., Ladd, G. W., & Herald, S. L. (2006). Peer exclusion and victimization: Processes that mediate the relation between peer group rejection and children's classroom engagement and achievement?. *Journal of Educational Psychology, 98*(1), 1.

Chen, H.C., Wang, Q.H. & Chen, X.Y. (2001). Cross-lag analysis between students' academic achievement and social behaviour. *Psychological Abstract*, *33*(06), 53-57.

Furrer, C., & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology*, *95*(1), 148–163.

Gallardo L. O., Barrasa A., & Guevara-Viejo F. (2016). Positive peer relationships and academic achievement across early and midadolescence. *Soc. Behav. Pers*. 44, 1637–1648. doi: 10.2224/sbp.2016.44.10.1637

Keter, J. (2013). *Effects of Cooperative Mastery Learning Approach on Secondary School Students' Motivation and Achievement in Chemistry in Bomet County*, Kenya. (Unpublished Med Thesis). Njoro, Kenya: Egerton University.

Kingery, J. N., Erdley, C. A., & Marshall, K. C. (2011). Peer acceptance and friendship as predictors of early adolescents' adjustment across the middle school transition. *Merrill-Palmer Quarterly, 57*(3), 215–243.

LaFontana, K. M., & Cillessen, A. H. N. (2010). Developmental changes in the priority of perceived status in childhood and adolescence. *Social Development, 19*(1), 130–147.

Laney, J. D., Frerichs, D. K., Frerichs, L. P., & Pat, L. K. (1996). The Effect of Cooperative and Mastery Learning Methods on Primary Grade Students' Learning and Retention of Economic Concepts. *Early Education and Development, 7*(3), 253–276. https://doi.org/10.1207/S15566935EED0703_4

Liu, J., Peng, P., Zhao, B., & Luo, L. (2022). Socioeconomic status and academic achievement in primary and secondary education: A meta-analytic review. *Educational Psychology Review, 34*(4), 2867-2896.

Lopez, C., & DuBois, D. D. (2005). Peer victimisation and rejection: Investigation of an integrative model of effects on emotional, behavioral, and academic adjustments in early adolescence. *Journal of Clinical Child and Adolescent Psychology, 34, 25-36.*

Lutz, S. T., & Huitt, W. G. (2018). Information Processing and Memory: Theory and Application. In W. Huitt (Ed.), Becoming a Brilliant Star: Twelve core ideas supporting holistic education (25-43). La Vergne, TN: IngramSpark.

Mehta, S., & Kulshrestha, A. (2014). Implementation of Cooperative Learning in Science: A Developmental-cum-Experimental study. *Education Research International*, *20*(14), 1–7.

Obidiegwu, U. J., & Ojo-Ajibare, J. O. (2007). Bloom's Mastery Learning Theory: Implications for Adult Education. ble at: http://works.bepress.com/druche_obidiegwu/2/

Okeke, Z.O. (2006). Women in Science, Technology and Mathematics Education in Nigeria. A Keynote Address at the 42nd Annual Conference Proceedings.

Oladayo, D., & Olumilua, B. (2021). Effects of Mastery Learning on Students' Achievement and Retention in Social Studies. *International Journal of Educational Research*, *4*(7), 15-19.

Omwirhiren, E. M. (2015). Enhancing Academic Achievement And Retention In Senior Secondary School Chemistry Through Discussion And Lecture Methods: A Case Study Of Some Selected Secondary Schools In Gboko, Benue State, Nigeria. *Journal of Education and Practice, 6*(21), 155-161.

Piwuna, C.N., & Mankilik, M. (2023). The effect of the implementation of WAEC and NECO chief examiners' reports on senior secondary II students' motivation in Jos South =, Plateau State, Nigeria. *Educational Research and Policy Journal, 9*(2), 62-71.

Prosser, M., & Trigwell, K. (2006). Confirmatory factor analysis of the 'Approaches to teaching inventory'. *British Journal of Educational Psychology*, 76(2), 405-419. http://dx.doi.org/10.1348/000709905X43571

Raji, R. A. (2017). *Sequential Teaching Model with Enhanced Cognitive Entry Characteristics as Strategy for Improving Learning Outcomes in Ecology Among Secondary School Students*. Unpublished Ph.D. Thesis Submitted to the Department of Science and Technology Education, Olabisi Onabanjo University, Ago- Iwoye.

Raji, O. M., Gimba, R. W., & Abdulrahman, M. A. (2018). Impact of Cooperative and Mastery \\ Learning Strategies on Mathematics Achievement and Retention of Senior School Students in Minna Metropolis, Niger State, Nigeria. *Journal of Science, Technology, Mathematics and Education, 14*(4), 134-139.

Richland, L. E., Kornell, N., & Kao, L. S. (2009). The pretesting effect: do unsuccessful retrieval attempts enhance learning?. Journal of Experimental Psychology. *Applied, 15*(3), 243–257. https://doi.org/10.1037/a0016496

Roya, S., Sedaghat, M. M., &. Ahmadi, F. S. (2014). Comparison of the effect of lecture and blended teaching methods on students' learning and satisfaction. *Journal of Advances in Medical Education and Professionalism*, *2*(4), 146-150.

Sakiyo, J. (2015). Assessment of the Trend of Secondary School Students' Academic Performance in the Sciences, Mathematics and English: Implications for the Attainment of the Millennium Development Goals in Nigeria. *Advance in Social Sciences Research Journal*, 2(2), https://doi.org/10.14738/assrj.22.805

Slavin, R.E. (2015). Cooperative learning in elementary schools. *International Journal of Primary, Elementary and Early Years Education*, *43*(1), 5-14.

Slavin, R. E. (2011). Instruction Based on Cooperative Learning. In R. E. Mayer & P. A. Alexander (Eds.), Handbook of

Thomas, O. O., & Israel, O. O. (2013). Assessing the relative effectiveness of three teaching methods in the measurement of students' performance in Physics. *International Journal of Materials, Methods, and Technologies*, *1*(8), 116–125.

Twan, S. M., Danjuma, G. S., & Useni, B. (2022). Effects of Think Pair Share Instructional Strategy on Interest and Performance in Biology Among Secondary Schools Students in Akko Education Zone, Gombe State, Nigeria. *Journal of Science, Mathematics and Entrepreneurial Education*, *1*(5), 220-228.

Véronneau, M. H., Vitaro, F., Brendgen, M., Dishion, T. J., & Tremblay, R. E. (2010). Transactional analysis of the reciprocal links between peer experiences and academic achievement from middle childhood to early adolescence. Dev. Psychol. 46, 773–790.

Vygotsky, L. S. (2017). Mind in society: The development of higher psychological processing. Cambridge, MA: Harvard University Press.

WAEC (2016). May/June Chief Examiners Report, Ikeja Lagos. West African Examination Council (WAEC), (2019). Analysis of Result, Lagos WAEC.

Wentzel, K. R., Barry, C. M., & Caldwell, K. A. (2004). Friendships in middle school: Influences on motivation and school adjustment. *Journal of Educational Psychology*, 96, 195–203.

Westwood, P. (2008). What teachers need to know about teaching methods. Camberwell, Vic.: ACER Press.