European Journal of Educational Research
Volume 11, Issue 1, 103 - 116.
ISSN: 2165-8714
https://www.eu-jer.com/

Fostering Students' Retention in Photosynthesis Using Concept Mapping and Cooperative Mastery Learning Instructional Strategies

Emmanuel Bizimana* University of Rwanda, RWANDA
Dieudonné Mutangana University of Rwanda, RWANDA
Adrian Mwesigye Mbarara University of Science and Technology, UGANDA

Received: July 2, 2021 ▪ Revised: August 31, 2021 ▪ Accepted: November 16, 2021

Abstract: The performance in biology at the secondary level has not been as good as expected. This has been a matter of concern. Thus, there has been a continuous focus on exploring newer innovative learner-centered and friendly instructional strategies to enhance understanding and retention in biology. This study, therefore, determined the effects of Concept Mapping (CM) and Cooperative Mastery Learning (CML) on fostering retention in photosynthesis among secondary schools in Nyamagabe district, Rwanda. A pre-test and post-test non-equivalent control group quasi-experimental design was used. Data were obtained from 151 students taught with CM, 144 students taught with CML, and 154 students taught with Conventional Teaching Methods (CTM). The Photosynthesis Retention Test (KR-21= 0.82) was used for data collection. The data were mainly analyze d using mean and Analysis of Covariance (ANCOVA). The results showed that the CM and CML treatment groups outperformed the CTM group in retention in photosynthesis. There was a statistically significant difference in favor of the CM between the two experimental groups. The male and female students taught using CM retained equally in photosynthesis while gender difference was revealed in the mean retention scores of the students exposed to the CML, with females retained significantly higher than males. The study concluded that the CM and CML strategies were more effective than CTM. It was suggested, among other things, that teachers should be encouraged to apply CM and CML strategies when teaching biology.

Keywords: *Concept mapping, conventional teaching methods, cooperative mastery learning, photosynthesis, quasi-experimental design.*

To cite this article: 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

Introduction

Biological science information is very important for the betterment of life since it teaches us about living organisms and their interaction with their surroundings (Joda, 2019; Oluwatosin & Gabriel, 2018; Tsevreni, 2021). Biology knowledge and skills, on the other hand, add to scientific literacy and aid in understanding the world in which we live and can be extremely beneficial to man and society as they play a significant role in enhancing the country's social-economic development (Joda, 2019; Tsevreni, 2021).

Even though biology is important, student performance has been poor in most Sub-Saharan African countries in recent years, and Rwanda is no exception. In Nigeria, for example, the percentage of students that passed biology at credits was extremely low compared to the total number of students (Joda & Mohamed, 2017). Likewise, the performance in secondary school biology has been generally inadequate for many years in Ghana (Kambaila et al., 2019), in Kenya (Orora et al., 2014). Similarly, students in Rwanda continue to perform poorly in biology when compared to other science subjects (Ministry of Education, 2012; Ntawiha, 2016). This is a depressing situation that, if not addressed promptly, could have far-reaching consequences for the entire country, not just in the education sector but also in other areas.

The low performance in biology indicates low retention and this affects negatively students who intended to read biology-related courses in advanced secondary and tertiary levels. Knowledge retention is directly tied to educational success. Consequently, for learners to realize their full potential in biology, they must retain knowledge learned during the teaching/learning process. 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 the context of this

* **Corresponding author:**
Emmanuel Bizimana, University of Rwanda, Rwanda. ✉ Emmanuelbizimana68@gmail.com

study, retention is defined as the ability to remember or keep the information learned about photosynthesis and retrieve it when needed. Hence, for functional biology education, the learners should be able to retain and retrieve what has been taught to them.

Biology as a science subject necessitates establishing the essential provisions for active student participation in the learning process (Anthony & Anka, 2020; Joda, 2019; Moses, 2020). However, different researchers (Byusa et al., 2020; Ndihokubwayo et al., 2020; Nsengimana et al., 2021) submitted that the conventional methods of teaching have continued to dominate science classroom teaching in most Rwandan schools. Although these methods have benefits, they may not be effective instructional methods for improving students' retention in skill-based science subjects because students' active participation is limited and students are forced to rely on their teachers for their learning needs (Ndihokubwayo, 2017).

Moreover, documented empirical studies revealed that photosynthesis is a very challenging concept and it is difficult to learn and understand by students (Etobro & Fabinu, 2017; Eziyi et al., 2016; Hadiprayitno et al., 2019; Kyado et al., 2019; Skribe-Dimec & Strgar, 2017). For instance, Eziyi et al. (2016) noted that the concept of photosynthesis is a rather abstract topic for students because of its biophysical and biological character. He advanced therefore that it necessitates the use of innovative teaching and learning strategies. Likewise, the study by Skribe-Dimec and Strgar (2017) reported that at the high school level, all students learn the concept of photosynthesis through the lecture method. As a result, students have a hard time grasping the concept of this fundamental process.

Numerous studies have also shown that students have a lot of misconceptions about photosynthesis (Eziyi et al., 2016; Nasution, 2018; Svandova, 2014). For instance, students are unable to grasp this concept because they hold misconceptions such as “plants do not breathe out” (when, in fact, they do), “carbon dioxide is harmful to plants” (when, in fact, carbon dioxide is necessary for the plant to make glucose), and “the main role of sunlight for the plant is to make plants more attractive in color” (Eziyi et al., 2016). In other studies (Nasution, 2018; Svandova, 2014), it was revealed that many students have common beliefs that plants obtain their food from the soil. All these studies attributed these misconceptions to the ineffective teaching strategy adopted by teachers of biology. Consequently, the poor students' performance could be linked to the unsuitable, inadequate, and elitist teaching strategies and methods used by biology teachers.

As a remedy, biology teachers are encouraged to implement instructional strategies that enhance students' active participation in their learning particularly for an abstract and difficult concept such as photosynthesis. Concept Mapping (CM) and Cooperative Mastery Learning (CML) are some strategies that have emerged through researches and received widespread success in recent decades (Ajaja, 2011; Awofala, 2016; Keter, 2013; Khan & Masood, 2015; Wang et al., 2017).

The CM is an instructional strategy that assists students to organize and represent knowledge (Novak & Cañas, 2009). The CML on the other hand is a hybridized strategy of cooperative and mastery learning in which students who fail to achieve mastery are required to relearn together in small groups with their peers who have attained the mastery (Keter & Ronoh, 2016; Khan & Masood, 2015).

Many studies have reported that the use of the CM and CML promotes positive outcomes in science, each of which has been established to be greater than conventional teaching methods (Ajaja, 2011, 2013; Khan & Masood, 2015). Although these strategies can enhance students’ achievement in biology in general (Kyado et al., 2019; Udeani & Okafor, 2012; Woldeamanuel et al., 2020), there would appear to be a dearth of research related to their effects on students’ retention in photosynthesis in Rwanda, in particular in the study area. Besides, no study on these promising strategies reported the comparative efficacies focused neither on students from abroad countries nor on Rwandan secondary schools.

Given this research gap and based on the need to improve students’ retention in biology in the country, the current study sought, therefore, to fill it by examining whether the use of CM and CML would be the effective instructional strategies capable to enhance retention in photosynthesis and to find out which of these strategies will yield greater retention outcomes among lower secondary school students in Rwanda.

Gender disparities in science education have long been observed, and they continue to exist today (Jia et al., 2020; Okorie & Ezeh, 2016; Stevenson et al., 2021). According to a recent research review, sex inequalities in student achievement still exist, and they are primarily related to the kind of teaching strategies used by teachers (Adeniran et al., 2018; Ajayi & Angura, 2017; Bot & Eze, 2016; Fatokun & Eniayeju, 2014; Kyado et al., 2019; Odutuyi, 2019; Sor et al., 2018; Uchegbue & Amalu, 2020). Given these variations, as well as disparities in how students learn biology, biology teachers must be aware of them and respond appropriately. In line with this challenge, this study assessed the effects of CM and CML on gender and the interaction effects of the CM and CML and gender on students' retention in photosynthesis.

Research Questions

1. What is the difference in the mean retention scores of students taught photosynthesis using CM, CML, and CTM?
2. What is the difference in the mean retention scores of male and female students taught photosynthesis using CM?
3. What is the difference in the mean retention scores of male and female students taught photosynthesis using CML?
4. What is the interaction effect of instructional strategies and gender on the mean retention scores of students in photosynthesis?

Methodology

Research Design

The study adopted a quasi-experimental design, which included a pre-test, post-test non-equivalent control group design with a delayed post-test to test retention and moderating variable (gender). The moderating variable included two levels of gender (male and female) while the treatment variable had three levels of independent variables (two experimental and one comparison). The pre-test and retention scores were the dependent variables.

Before the treatment, students in both groups (experimental and comparison) were given a pre-test using Photosynthesis Retention Test (O_1). Students in experimental group 1 were exposed to Concept Mapping (X_1), students in experimental group 2 were exposed to Cooperative Mastery Learning (X_2), while students in the comparison group were exposed to Conventional Teaching Methods (X_0). After seven weeks (three weeks after intervention), they were given a retention test (O_2). Table 1 shows the research design layout.

Table 1. Research Design Layout

Group	Pre-test	Treatment	Moderating Variable	Retention Test
EG1	O_1	CM (X_1)	Gender	O_2
EG2	O_1	CML (X_2)	Gender	O_2
CG	O_1	CTM (X_0)	Gender	O_2

Population, Sample, and Data Collection

The target population of this study was 6,707 Senior two Secondary Students (SS2) spread in forty-six secondary schools within Nyamagabe district from the 2020 academic year. The schools that took part in the study were chosen using a purposive sampling technique. This was done basing on equivalence (schools with relatively good standards in terms of infrastructure, teaching resources, and presence of qualified and experienced biology teachers), type of school (Boarding school), School ownership (public and government-aided); gender composition (mixed schools) student enrolment in form two (SS2), school performance at 2019 ordinary level National examination and geographical location of the school. Considering the sampling criteria prescribed above, seven public boarding and co-educational schools made a total of four hundred forty-nine (449) students were sampled for this study. Using a simple random sampling technique, the schools were assigned to the experimental and comparison groups. Table 2 shows the sample distribution for the study.

Table 2. Study's Sample Distribution

Group	Male	Female	Total
Concept Mapping (CM)	74	77	151
Cooperative Mastery Learning (CML)	73	71	144
Conventional Teaching Method (CTM)	78	76	154

Research Instrument

The data was collected using a single instrument called the Photosynthesis Retention Test (PRT). The PRT was given to students as a pre and retention test after the reshuffle to assess their retention. The PRT was developed using a table of the specification to generate 60 items for students' biology tasks. This was based on the unit of photosynthesis as specified in Rwanda's biology curriculum for Senior two Secondary School two (SS2) students focusing on a Competence-Based Curriculum (Rwanda Education Board [REB], 2015). The initial 60 items of PRT were subjected to the expert opinion of two secondary school biology teachers with teaching experience of over 10 years and two experts in measurement and evaluation from the University of Rwanda, College of Education. They ascertained that the PRT items were based on the content and specific objectives of the photosynthesis unit as prescribed in the Lower Secondary School Biology Syllabus (REB, 2015). Their comments led to the modification of the test items and 50 out of the original 60 items were retained for trial testing.

To establish whether the instruments could be used to collect relevant data, to test whether items in the instruments are valid and reliable, and to check whether the instructions in the instrument are understandable to the study subjects, the 50-item PRT was pilot-tested on 50 students (23 female and 27 males). This was accomplished by using a coeducational school that was not included in the main study but had similar features to the sample schools. From the students' responses, the only test items showing a discrimination power of more than 0.40 and a difficult index of 0.40-0.60 were retained (Suruchi & Rana, 2012), and the final PRT comprised 40 items.

The PRT had a 40-item multiple-choice objective test with four options (A-D), one correct, and three distracters. The correct option attracted a 2.5 mark giving a total of 100 marks. From the pilot-testing results, Kuder-Richardson formula 21 (KR-21) was used to estimate the internal consistency of the instrument and it yielded the reliability coefficient of 0.82. This was above the recommended reliability coefficient of 0.7 (Creswell, 2013). Therefore, the PRT instrument was considered reliable for use in the study. The 40 items of the PRT test were supplemented by other questions requesting information about a student's gender and registration class number.

Experimental Procedures

The first week was dedicated to preparing biology teachers to act as research assistants. The biology teachers were trained independently to enable the use of the CM and CM. The training included the study's purpose, the content for treatment, instructional strategies and methods, lesson plans, and the administration of the PRT. Specifically, teachers in the CM group were informed about the CM, its advantages, how it is used to show relationships between concepts, and the steps to be followed while implementing the CM-based teaching strategy, as highlighted by Novak and Gowin (1984). These included: Provide a focal question, allow students to read the textbook and underline the essential concepts, list all concepts on the paper and debate them, order concepts from general to specific, and relate concepts using link words. Following that, 4 hours were spent training instructors on how to implement CM using the concepts they were familiar with but different from the one under the study. The criteria for the scoring concept map were also explained. Besides, various concept maps drawn on photosynthesis and its related concepts were constructed and discussed with the emphasis on the uniqueness of CM. Teachers were provided with reference concept maps prepared on each sub-lesson of photosynthesis for cross-checking their maps. Furthermore, each research assistant was given 40 minutes to mock micro-teaching using an individualized concept mapping lesson plan.

Teachers in the CML group have explained the attributes of cooperative and mastery groups as well as the descriptive information of the procedures of CML. The emphasis was on the grouping of students to allow them to learn together in cooperative learning groups, dividing the content into small topics to be covered one after the other. Besides, a set of quizzes was to be used to envision whether the objectives have been met or whether or not the mastery has been performed before proceeding to the following topic. For those who did no longer attain the anticipated mastery level, remediation would be done by their peers who showed the mastery. Questions were asked and answered. Besides, they were given the model lesson plans designed for the unit of Photosynthesis. There were discussions on these models on the topics of the interventions. Questions were asked and answered. The training ended by micro-teaching using CML lesson plans.

In the first week of the treatment, a research assistant in the CM group trained students on how to develop concept maps using examples. Students created more concept maps using paper-pencil and chalkboard to perfect the procedure. On the first day of the real treatment, the students were given focus questions on the process of photosynthesis and listed key concepts related to the daily lesson. With the help of the teacher, 18 concepts were identified and students individually constructed concept maps. Following that, students were allowed to display their concept maps on the blackboard for discussion and corrections. Students were provided a computer-assisted reference concept map in print form to crosscheck their maps after their practices and teacher's correctional remarks. Figure 1 shows the sample of the reference concept map. The students recognized any misconceptions they had (if any) and followed up with an explanation before correcting their concept maps. During the following weeks of instruction, students were continually guided in building concept maps for each photosynthetic sub-lesson utilizing the same techniques and 77 concepts were identified during the whole treatment period and in total 6 concept maps were constructed. Figure 2 illustrates a sample of a concept map on the leaf's internal structure developed by a student. Students were given the assignment of creating a cumulative concept map using all identified concepts at the end of the treatment to illustrate what they had learned about photosynthesis. Students' concept maps were discussed and compared to a printed computer-assisted reference concept map to determine their knowledge of the photosynthesis themes presented.

Students in the CML group got initial training on cooperative and mastery learning in the first three days of the week. Students were divided into small groups of mixed abilities and instructed on how to work as a team, sharing ideas, and completing the assigned assignment as a group. Students were taught what objectives they needed to accomplish and what level of mastery they should expect (80 percent). Following the initial instruction, students were given a formative task to assess their mastery of the material. Students who did not achieve mastery on the formative task received remedial teaching from their peers who showed mastery. To check mastery, students who had undergone remediation were evaluated again with a parallel task to the initial formative task. After students had reached mastery, instruction

proceeded to a new instruction. The procedures were repeated on all topics of the unit to be taught. Finally, a summative test was provided at the end of treatment to assess learners' progress across all sub-photosynthesis topics.

Students in the comparison group were taught the unit of photosynthesis using traditional teaching methods, which included chalk and talk, note-taking sessions, and teacher demonstrations. This group of students went about their learning as usual, with no formal grouping. Besides, no concept mapping or cooperative mastery learning activities were present. Students were taught the photosynthesis unit until the end of the treatment, after which they were given an introduction, a presentation, a demonstration, a summary, and an evaluation of the lessons. The experimental groups had the same implementation timeframes for four weeks as the control groups. The research assistants were supervised throughout the treatment period to guarantee seamless learning and the proper execution of teaching methods and procedures in all classes.

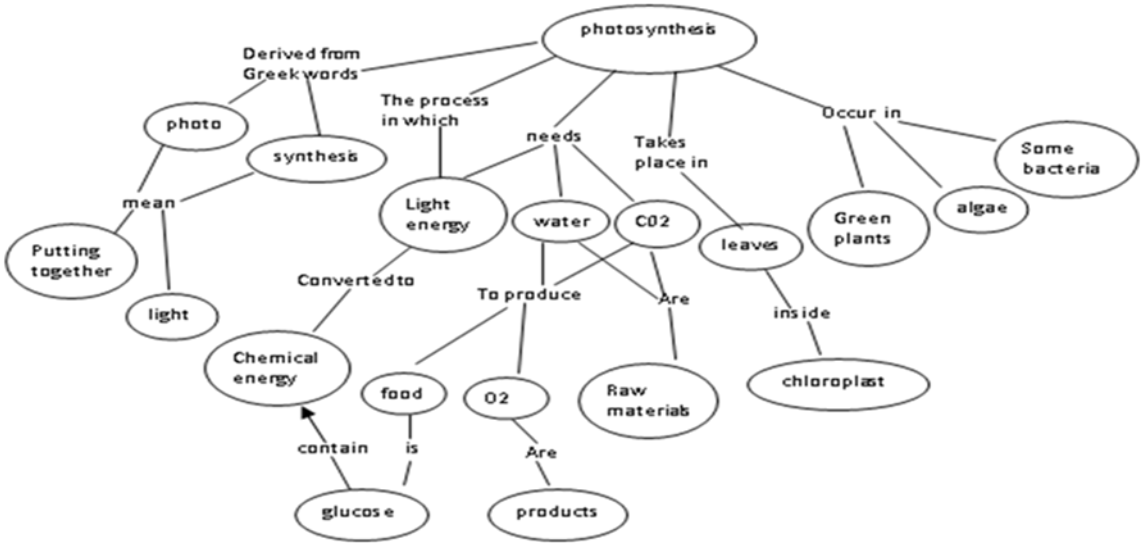

Figure 1. A Concept Map Constructed to Show the Links to the Concept of Photosynthesis

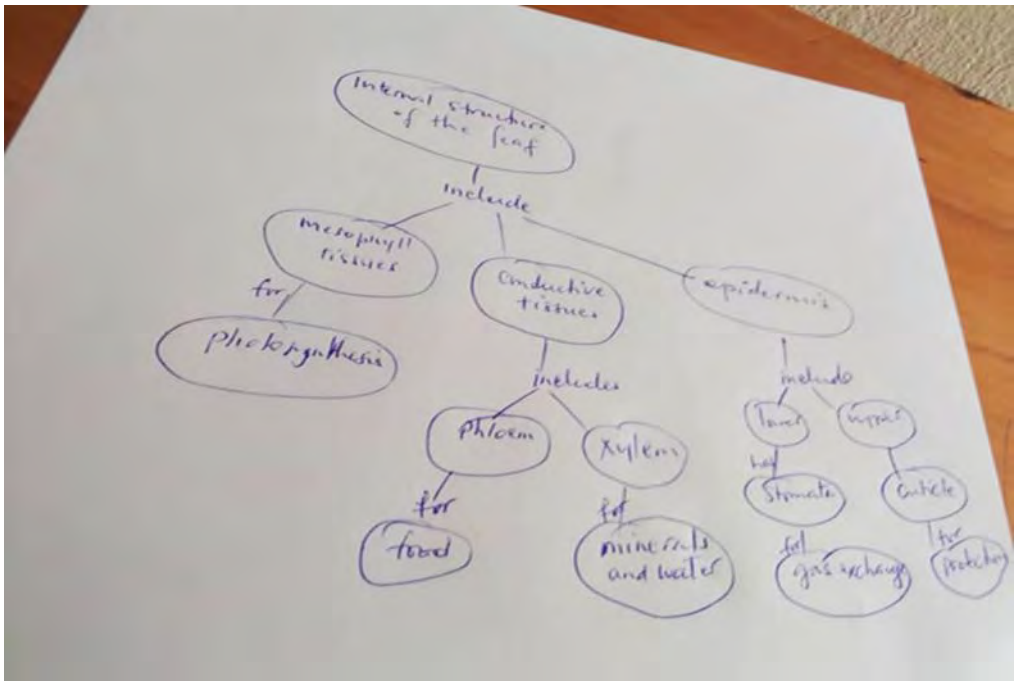

Figure 2. Sample of Concept Map Constructed by Student about Internal Structure of the Leaf

The instrument PRT was given as the retention test after the actual treatment, which lasted four weeks and included fourteen periods of 40 minutes each. The researchers took a three-week break after the actual teaching which lasted four weeks and included fourteen periods of 40 minutes each to see if the knowledge gained was retained (as recommended by Tuckman, 1975). The PRT instrument was again reshuffled and used as a retention test to assess student retention in each group.

Analyzing of Data

Mean and Standard Deviation scores as well as the Analysis of Covariance (ANCOVA) at the 0.05 level of significance with pre-test scores as covariates were used to analyze data. The ANCOVA was used to control the initial differences between groups and to improve precision due to extraneous variables (Creswell, 2013; Samba et al., 2020). Bonferroni post hoc analysis was run to identify the source of significant differences where they appeared. Besides, the effect size f was used to assess the strength of the treatment (Cohen, 2013). The following Cohen's rough formula was used: f=.1 for a small effect size, f=.25 for a medium impact size, and f=.4 for a high effect size. Moreover, the distribution of the scores from the pre-test and retention test was examined by calculating the coefficients of skewness and kurtosis and these were -.21 and -.211 and -.422 and -.744 respectively. Based on these statistical data, the scores appeared to be normally distributed (Hinton et al., 2014).

Findings

Prior to treatment, the study established the homogeneity of the study groups. To achieve this, an ANOVA test was used to compare the pre-test scores of the experimental and comparison groups (Table 3).

Table 3. Analysis of Variance (ANOVA) of Pre-test Scores

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	229.887	2	114.943	2.624	.074
Within Groups	19536.332	446	43.803		
Total	19766.218	448			

Table 3 shows that before the treatment, there was no significant difference in the mean achievement scores in the three groups ($F_{(2,446)} = 2.624$, $p=0.074>0.05$). This signifies that the F-value is not significant at the 0.05 level, and the mean square between groups is not significantly bigger than the mean square within groups. It was, therefore, ascertained that before the start of the treatment, students in three groups had comparable abilities. This enables treatment effects to be inferred (Argaw et al., 2016).

To determine whether there was a difference between experimental and experimental groups, mean and SD retention scores were used. Table 4 shows the results of the retention test for the CM, CML, and CTM.

Table 4. Mean Retention Scores of students Taught Photosynthesis Using CM, CML, and CTM

Group	N	Mean	SD	Mean difference between Groups
CM	151	78.90	6.01	32.05
CTM	154	46.58	10.98	
CML	144	67.15	8.03	20.57
CTM	154	46.58	10.98	
CM	151	78.90	6.08	11.75
CML	144	67.15	8.10	

Data in Table 4 show that the difference in the mean retention scores between the CM and CTM groups was 32.05 in favor of CM. Similarly, the difference in the mean retention scores between students in CML and CTM groups was 20.57 in favor of the CML strategy. In the same vein, the difference in the mean retention scores between CM and CML groups was 11.75 in favor of CM. These findings show that the students taught photosynthesis using CM retained higher than those taught using CML, while students taught using CML retained higher than those taught using the CTM group.

Table 5. Mean Retention Scores of Male and Female Students Taught Photosynthesis Using CM and those Taught Using CML

Group	Gender	N	Mean	SD	Mean difference between gender
CM	Male	74	79.78	5.27	1.72
	Female	77	78.06	6.47	
CML	Male	73	65.11	7.33	4.14
	Female	71	69.25	8.21	

Data in Table 5 show that the mean retention scores of male students taught using CM was 79.78 with SD of 5.27 while that of female students was 78.06 with SD of 6.57. The difference in the mean retention scores of the males and females was 1.72. This difference though small was in favor of male students. This implies that male students retained slightly higher than their female counterparts in the CM group. Again, data in Table 5 show that the male students taught using CML had a mean retention score of 65.11 with SD of 7.33, whereas female students had a mean retention score of 69.25

SD 8.21. The difference between males and females in the mean retention scores was 4.14 in favor of female students. Although the difference was slight, it favored female students. This means that female students in the CML group retained slightly more than their male peers. To determine whether there was an interaction effect between instructional strategies (treatment) and gender, the following plot was computed (Figure 3).

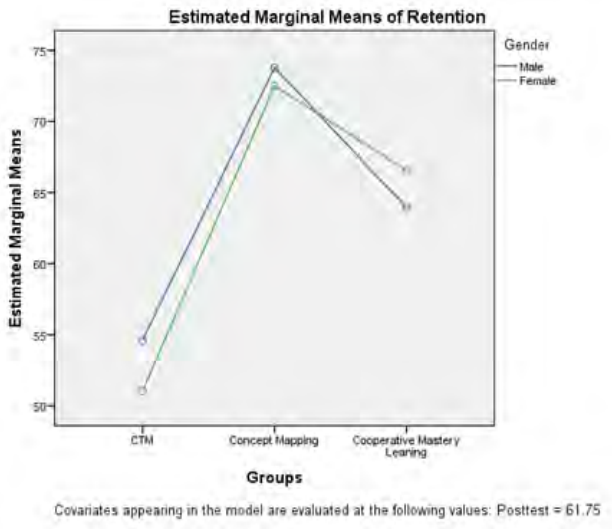

Figure 3. Interactive Effect of Treatment and Gender on Students' Retention of Leant Photosynthesis Content

The profile plot in Figure 3 depicts the interaction effect of treatment and gender on student retention of biology knowledge. The plots for male and female students were intercepted, as evidenced by the interaction patterns. This suggests that there is a chance that treatment and gender have an interaction effect on students' retention.

To determine whether the difference in photosynthesis retention between groups after treatment was statistically significant, the ANCOVA test was used. The PRT results for the experimental and comparison group classes are shown in Table 6.

Table 6. ANCOVA for Retention Scores of Students Taught Photosynthesis Using CM, CML, and CTM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	82754.819[a]	6	13792.470	190.219	.000	.721
Intercept	79211.935	1	79211.935	1092.452	.000	.712
Pretest	75.884	1	75.884	1.047	.307	.002
Method	80512.465	2	40256.233	555.194	.000	.715
Gender	4.615E-006	1	4.615E-006	.000	1.000	.000
Method * Gender	1003.654	2	501.827	6.921	.001	.030
Error	32048.699	442	72.508			
Total	1956596.500	449				
Corrected Total	114803.518	448				

a. R Squared = .721 (Adjusted R Squared = .717)

According to data in Table 6, the observed mean difference in retention scores between the groups was statistically significant ($F_{(2,442)} = 555.194$, $p < 0.05$). This indicates that the mean retention scores in the study groups differed significantly. The effect size was .715, according to the associated partial eta squared value. This indicates that the treatment has a large statistical effect size. According to the value, the treatment accounted for 71.5 percent of the entire variance in the mean retention scores between the groups. However, the finding in Table 6 does not show the origin of the differences found in the ANCOVA test. To determine which group accounted for this difference, the Bonferroni post-hoc test of multiple comparisons was used to analyze paired contrast (Table 7).

Table 7. Bonferroni Post Hoc Comparison for Mean Retention Scores of Students Taught Photosynthesis using CM, CML, and CTM

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.
CM	CTM	32.249*	.981	.000
CM	CML	11.665*	.994	.000
CML	CTM	20.584*	.988	.000

*. The mean difference is significant at the .05 level

Data in Table 7 reveal that the mean difference (I-J) between CM and CTM is 32.249 and this is significant at $p<0.05$ in favor of the CM group. Similarly, the results show that the mean difference (I-J) between CML and CTM is 20.584 and this is significant at $p<0.05$ in favor of students in the CML group. Moreover, the paired comparison of CM and CML shows a mean difference of 11.665 and this is significant at $p<0.05$ in favor of the CM group.

Table 8. ANCOVA Result for Retention Scores of Male and Female Students Taught Photosynthesis using CM Strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	119.295[a]	2	59.647	1.666	.193	.022
Intercept	46315.867	1	46315.867	1293.296	.000	.897
Pretest	7.843	1	7.843	.219	.640	.001
Gender	112.181	1	112.181	3.132	.079	.021
Error	5300.215	148	35.812			
Total	945442.000	151				
Corrected Total	5419.510	150				

a. R Squared = .022 (Adjusted R Squared = .009)

ANCOVA (Table 8) test result reveals that no significant difference existed between the male and female students in the CM group ($F_{(1,148)}=3.132$, $p>0.05$). This suggests that the CM improved photosynthesis retention in both male and female students equally. The effect size was estimated to be .021, according to the calculated partial eta squared value. This suggests a small effect size for treatment on gender. According to the value, the effect of treatment on gender accounted for 2.1 percent of the entire variance in the mean retention scores between the genders.

Table 9. ANCOVA Result for Retention of Male and Female Students Taught Photosynthesis using CML Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1034.527[a]	2	517.263	8.917	.000	.112
Intercept	32645.189	1	32645.189	562.737	.000	.800
Pretest	416.448	1	416.448	7.179	.008	.048
Gender	476.431	1	476.431	8.213	.005	.055
Error	8179.612	141	58.011			
Total	658581.500	144				
Corrected Total	9214.139	143				

a. R Squared = .112 (Adjusted R Squared = .100)

ANCOVA (Table 9) test result reveals a significant difference between male and female students in the CML group ($F_{(1,141)}=8.213$, $p<0.05$). This means that CML enhanced differently male and female students' retention in photosynthesis. According to the partial eta squared value, the effect size was .055. This means that the influence of CML on gender only accounted for 5.5 percent of the total considering the overall variation in photosynthesis retention scores across genders. To determine where the significance of the gender differences lies, the Bonferroni post-hoc test of multiple comparisons among the groups was performed (Table 10).

Table 10. Bonferroni Post Hoc Comparison for Mean Retention Scores of Male and Female Students Taught Photosynthesis using CML

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[b]
Male	Female	-3.673*	1.282	.005
Female	Male	3.673*	1.282	.005

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Data in Table 10 reveal that the mean difference (I-J) between male and female students is 3.673 and this is significant at $p<0.05$. This implies that there is a significant difference in the mean retention scores between the male and female students taught photosynthesis using CML in favor of female students.

In terms of the interaction between gender and methods of instruction on retention, Table 6 shows a statistically significant interaction effect ($F_{(2,442).} = 6.921$, $p < .05$. This suggests that the students' gender, in combination with the instructional methods, influenced their retention scores in the various instructional groups.

Summary of the Findings

Based on the analysis of the results, the findings are summarized and presented as follows:

1. The CM and CML strategies were both superior to the CTM in enhancing students' retention of the learned photosynthesis content. However, the CM strategy had a significantly higher effect on students' retention than both CML and CTM.
2. The mean retention scores of male and female students taught photosynthesis utilizing the CM approach did not differ significantly.
3. Male and female students taught photosynthesis using the CML had significantly different mean retention scores, with female students having a greater mean retention.
4. The interaction effect of treatment and gender on students' mean retention scores in photosynthesis was statistically significant.

Discussion

The findings of study revealed that students in the CM and CML groups retained significantly better than students in the CTM groups in photosynthesis. This finding is consistent with prior research findings, which show that CM and CML are better than CTM at enhancing students' retention of science concepts (Bawaneh, 2019; Keter, 2013; Khan & Masood, 2015). The students' superior success in CM and CLM over CTM can be attributed to their active involvement in the teaching and learning process. The students were engaged in activities that were designed to attract their attention, get them thinking about the material being taught, stimulate thinking through collaborative activities, and activate their prior knowledge as well as elucidating the intricate relationship among the concept by applying these instructional strategies. However, in the CTM group, these learning opportunities were limited since students were mostly passive listeners.

The findings of the study also indicated that students in the CM group had significantly higher retention scores than their counterparts in the CTM group. This finding coincides with the works of Ajaja (2011, 2013), Martins-Omole et al. (2016) who found in their separate studies that students exposed to learning photosynthesis by CM strategy, retained better than their counterparts in CTM. Also, the finding equally tallies with the work of Adeniran et al. (2018), Ajayi and Angura (2017, Bawaneh (2019), Fatokun and Eniayeju (2014) who reported in their individual and collective studies that students taught Physics, Basic science, and Chemistry using CM, their retention ability are better enhanced than those taught with CTM. The considerable difference in mean retention scores between the CM and CTM groups could be ascribed to the fact that students in the CM group have actively participated in the teaching and learning process while creating concept maps, which may promote higher retention than students in the CTM group who were passively taught (Novak & Cañas, 2009).

The findings also revealed that students who learned photosynthesis content using the CML strategy had significantly higher retention than those taught using CTM. This finding agrees with Keter (2013), Khan and Masood (2015) who found that CML was more effective in enhancing students' achievement than CTM in chemistry and biology concepts respectively. The superiority of CML over CTM could be explained by the fact that CML is characterized by clear objectives, initial instruction followed by formative testing, remediation and correction in groups, and summative testing (Guskey, 1990; Keter, 2013). Besides, the CML facilitated a better students' understanding of the content as it enables them to learn new lessons after the previous one was well understood. Also, the CML is interactive and student-centered (Goreyshi et al., 2013). These characteristics of CML allow students to learn better and retain the content taught than when they become passive listeners in the use of CTM. In the latter, the teacher transfers thoughts and meaning to the learners leaving little room for students' questions as well as interaction among themselves (Oluwatosin & Bello, 2015). Furthermore, cooperative learning as perceived in CML allows students to work and learn actively together in small groups where they explore the ideas, clarify them to one another, expand and finally make them their own, and hereby improving retention than in CTM.

Likewise, it was revealed that the difference in the retention between students taught photosynthesis using CM and those taught using CML was statistically significant in favor of the CM group. Studies were scarce on comparison between CM and CML strategies on students' retention in science subjects before. However, the finding disagrees with Oluwatosin and Bello (2015) who found no significant effect of treatment in the retention ability of students taught Physics with mastery learning and mind-mapping strategies. The superiority of the CM group over the CML group can be attributed to the organization of the concepts in concept map construction. While students were constructing concept maps, they organized concepts in a hierarchy showing a meaningful relationship among the concepts. This helped them integrate the concepts learned. Besides, the use of concept maps helped students graphically visualize connections among the concepts from the most concrete to the abstract ones. This in turn helped them meaningful learn and retain the concepts

taught. This is in line with Romero et al.'s (2017) submission that information is better retained and recalled when it is communicated verbally and visually. Subsequently, the observed difference in mean retention scores in photosynthesis between CM and CML groups in favor of CM might be the result of the CM being more efficacious in enhancing students' retention of the concepts than CML does.

The study revealed that female students had slightly higher mean retention scores than their male counterparts when taught photosynthesis using CM. However, the ANCOVA test showed no significant difference in the mean retention score of students by gender. This means that CM enhanced equally male and female students' retention in photosynthesis. This finding agrees with that of Adeniran et al. (2018), Bawaneh (2019), Doris (2018) who reported insignificant differences in the mean retention scores of male and female students after being exposed to CM in Physics and Basic Science respectively. However, the findings contradict those of Sor et al. (2018), Udeani, and Okafor (2012), Orora et al. (2007) who found a statistically significant difference between genders in chemistry and biology due to CM in favor of female students.

Moreover, the findings on gender difference in the CML group showed a statistically significant difference in mean retention scores between male and female students in favour of females. This finding is supported by Okoro (2011) who argued that female students attained better than their male counterparts when cooperative learning strategy was used. According to the author, female students tend to be better at exploiting the benefits and synergy of collaborative learning through mutual evaluation, reflection, and information flow among intelligent students. The CML in this study through the use of cooperative discussion groups, allowed the female students the opportunity to talk and share meanings about the concepts taught from those who showed mastery. This, therefore, promotes the females' acquisition and retention of the concepts covered.

Finally, the study revealed that there was a significant interaction effect of treatment given to students and gender concerning their retention in photosynthesis concepts. This implies that the combination of students' gender and instructional strategies influenced retention in photosynthesis. This simply means that the observed difference in mean retention scores among the students exposed to CM, CML and CTM was linked to both gender and the instructional methods used. This finding lends credibility to the work of Iorzua (2017), which at different times yielded similar results. However, this finding tends to contradict the results obtained by Omenka Omenka (2019 who reported different results.

Conclusion

According to the findings of the study, students in lower secondary schools benefit more from the use of CM and CML than from the use of CTM in learning, understanding, and retention of photosynthesis-related knowledge with students in the CM group outperforming those in the CML group. Besides, when exposed to CM, both male and female students retained similarly; however, when exposed to CML, female students retained more than their male counterparts in studying photosynthesis. Specifically, male and female students retained significantly equally in photosynthesis when CM is used while females retained significantly higher than males when CML is employed. Therefore, it follows that both CM and CML are effective instructional strategies that can be employed by biology teachers to foster student retention in abstract and difficult biology topics such as photosynthesis.

Recommendations

Biology teachers, particularly those at the lower secondary level, should use CM and CML as instructional strategies. This will allow students to engage actively in biology learning using novel ways that have a high likelihood of increasing retention of concepts and meanings in biology, hence improving their performance in the subject. As some biology topics are difficult for students to understand because they are too abstract, this problem might be solved, according to the conclusions of this study, by adopting some innovative instructional strategies like the CM and CML, which have been shown to be beneficial in learning biology topics like Photosynthesis, which is the subject of this study. This will assist them in embracing the abilities of these instructional strategies for excellent biology instruction. It will also help them reduce their reliance on traditional teaching methods, which do not ensure successful teaching and learning as well as high student retention in the subject. Finally, future researchers should do quantitative and qualitative replications of this study in different content areas, with students from various academic backgrounds, to investigate how CM and CML might be used to track students' retention of various types of knowledge.

Limitations

This study has two major limitations that would be considered in future research. First, the research focused on one of Rwanda's 30 districts. Second, no students from day secondary schools were included in this study to compare boarding and day schools.

Acknowledgments

The authors thank the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) for their financial support, as well as the biology teachers and secondary school students who actively participated in the study.

Authorship Contribution Statement

Bizimana: Conceptualization, design, data collection, analysis and writing. Mutangana: Reviewing, supervision. Mwesigye: Reviewing, supervision.

References

Adeniran, S. A., Ochu, A. N., & Atoo, S. F. (2018). Effect of concept mapping strategy on students' retention in basic science in Benue State, Nigeria. *International Journal of Research & Review*, *5*(5), 193-200. https://bit.ly/3Bk4kQx

Ajaja, O. P. (2011). Concept mapping as a study skill: Effects on students' achievement in biology. *International Journal of Educational Sciences*, *3*(1), 49-57. https://doi.org/10.1080/09751122.2011.11890008

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. https://bit.ly/3npCGwa

Ajayi, O. V., & Angura, T. M. (2017). Improving senior secondary students' retention in electrolysis using collaborative concept mapping instructional strategy (CCMIS). *Greener Journal of Educational Research*, *7*(6), 87-92. https://doi.org/10.15580/gjer.2017.6.092417140

Angura, M. T., & Abakpa, V. O. (2018). Impact of cooperative instructional strategies and conventional teaching methods on students achievement and interest in upper basic education science and technology in Nigeria. *International Journal of Innovative Research and Development*, *7*(2), 38–45. https://doi.org/10.24940/ijird/2018/v7/i2/jan18085

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. https://doi.org/10.21276/ijircst.2020.8.3.35

Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2016). The effect of problem-based learning (PBL) instruction on students' motivation and problem-solving skills of physics. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(3), 857-871. https://doi.org/10.12973/eurasia.2017.00647a

Awofala, A. O. (2016). Effect of concept mapping strategy on students' achievement in junior secondary school mathematics. *International Journal of Mathematics Trends and Technology*, *2*(3), 11–16. http://ijmttjournal.org/Volume-2/issue-3/IJMTT-V2I3P504.pdf

Bawaneh, A. (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), 123-138. https://bit.ly/3vBhV4o

Bot, T. D., & Eze, J. E. (2016). Comparative effects of concept mapping and cooperative learning strategies on senior secondary school students' achievement in mathematics-trigonometry in Kano state, Nigeria. *European Journal of Science and Mathematics Education*, *4*(1), 56-66. https://doi.org/10.30935/scimath/9453

Byusa, E., Kampire, E., & Mwesigye, A. R. (2020). Analysis of teaching techniques and scheme of work in teaching chemistry in Rwandan secondary schools. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(6), 1-9. https://doi.org/10.29333/ejmste/7833

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approach* (4th ed.). SAGE Publications, Inc.

Doris, O. M. (2018). Effect of concept mapping in teaching physics in senior secondary schools in Port Harcourt local government area Rivers State. *European Scientific Journal, 14*(31), 71-81. https://doi.org/10.19044/esj.2018.v14n31p71

Etobro, A. B., & Fabinu, O. E. (2017). Students' perceptions of difficult concepts in biology in senior secondary schools in Lagos State. *Global Journal of Educational Research*, *16*(2), 139-147. https://doi.org/10.4314/gjedr.v16i2.8

Eziyi, M. E., Mumuni, A. A., & Nwanekezi, A. U., (2016). Effects of guided inquiry and cooperative instructional strategies on senior secondary one students' academic achievement in conceptual understanding of photosynthesis. *IOSR Journal of Engineering*, *6*(8), 1-11. https://doi.org/10.9790/3021-068010111

Fatokun, K. V. F., & Eniayeju, P. A. (2014). The effect of concept mapping-guided discovery integrated teaching approach on Chemistry students' achievement and retention. *Academic journal*, *9*(22), 1218-1223. https://bit.ly/3m5UVaz

Goreyshi, M. K., kargar, F. R., Noohi, S., & Ajilchi, B. (2013). Effect of combined mastery-cooperative learning on emotional intelligence, self-esteem, and academic achievement in grade skipping. *Procedia-Social and Behavioral Sciences*, *84*, 470-474. https://doi.org/10.1016/j.sbspro.2013.06.586

Guskey, T. R. (1990). Cooperative mastery learning strategies. *The Elementary School Journal*, *91*(1), 33-42. https://doi.org/10.1086/461636

Hadiprayitno, G., Muhlis, & Kusmiyati. (2019). Problems in learning biology for senior high schools in Lombok island. *Journal of Physics: Conference Series*, *1241*, 012054. https://doi.org/10.1088/1742-6596/1241/1/012054

Hinton, P. R., McMurray, I., & Brownlow, C. (2014). *SPSS explained*. Routledge.

Iorzua, A. J. (2017). *Effects of semantic and concept mapping strategies of teaching vocabulary on senior secondary two students' achievement in reading comprehension* [Unpublished doctoral dissertation]. Benue State University.

Jia, C., Yang, T., Qian, Y., & Wu, X. (2020). The gender differences in science achievement, interest, habit, and creativity: A national representative evidence from China. *Science Education International*, *31*(2), 195-202. https://doi.org/10.33828/sei.v31.i2.9

Joda, F. M. (2019). Effects of instructional scaffolding strategy on senior secondary biology students' academic achievement and retention in Taraba state, Nigeria. *Education Quarterly Reviews*, *2*(2), 269-275. https://doi.org/10.31014/aior.1993.02.02.59

Joda, F. M., & Mohamed, A. A. (2017). Effect of guided inquiry teaching method on senior secondary school biology students academic achievement and retention in Yola Education Zone, Adamawa State, Nigeria. *Multidisciplinary Journal of Science, Technology and Vocational Education*, *5*(1), 89–96. https://bit.ly/3nkUJUu

Kambaila, C. M., Kasali, G., & Kayamba, F. (2019). Assessing the effects of biology practical activities on academic performance of senior secondary school students. *Journal of Education and Practice, 10*(20), 116–121. https://doi.org/10.7176/jep/10-24-15

Keter, J. K. (2013). *Effects of cooperative mastery learning approach on secondary school students' motivation and achievement in chemistry in Bomet County, Kenya* [Unpublished master's thesis]. Egerton University.

Keter, J. K., & Ronoh, K. P. (2016). Impact of cooperative mastery learning approach on students' academic achievement in chemistry by gender in Bomet County, Kenya. *American Journal of Education and Practice*, *1*(1), 49-58. https://doi.org/10.47672/ajep.92

Khan, F. M., & Masood, M. (2015). The effectiveness of interactive multimedia courseware with a cooperative mastery approach in enhancing higher-order thinking skills in learning cellular respiration. *Procedia - Social and Behavioral Sciences*, *176* (2015), 977-984. https://doi.org/10.1016/j.sbspro.2015.01.567

Kyado, J. J., O. Abah, C., & Samba, R. M. (2019). Effect of collaborative concept mapping instructional strategy on secondary students' achievement in difficult biology concepts. *American Journal of Social Sciences and Humanities*, *4*(3), 434-447. https://doi.org/10.20448/801.43.434.447

Martins-Omole, M. I., Yusuf, H. O., & Guga, A. (2016). Effects of concept mapping and experimental techniques in teaching biology in secondary schools in Federal Capital Territory Abuja, Nigeria. *European Journal of Education Studies*, *2*(6), 119-130. https://bit.ly/3m4Wvd0

Ministry of Education. (2012). *2013 Education statistics yearbook*. https://bit.ly/3E3L4Iy

Moses, D. (2020). Effects of reflective inquiry teaching method on students' retention ability in domestic installation module in technical colleges of Yobe state, Nigeria. *International Journal of Social Sciences and Educational Studies*, *9*(9), 919-923. https://doi.org/10.23918/ijsses.v7i3p52ma

Nasution, M. K. (2018). Student assessment and misconceptions of photosynthesis: A notion of shifting perspective. *Journal As-Salam*, *2*(2), 106-112. https://doi.org/10.37249/as-salam.v2i2.39

Ndihokubwayo, K. (2017). *Research on improvised experiment materials for science lesson in Rwanda* [Unpublished master's thesis]. Hiroshima University.

Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020). Implementation of competency-based learning in Rwandan physics classrooms: First assessment based on the reformed teaching observation protocol. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(9), 1-8. https://doi.org/10.29333/ejmste/8395

Novak J. D., & Cañas A. J. (2009). The development and evolution of the concept mapping tool leading to a new model for mathematics education. In K. Afamasaga-Fuata'i (Eds.), *Concept Mapping in Mathematics* (pp. 3-16). Springer. https://doi.org/10.1007/978-0-387-89194-1_1

Novak, J.D., & Gowin B., (1984). *Learning how to learn*. Cambridge University Press. https://doi.org/10.1017/CBO9781139173469

Nsengimana, T., Mugabo, L. R., Ozawa, H., & Nkundabakura, P. (2021). Science competence-based curriculum implementation in Rwanda: A multiple case study of the relationship between a school's profile of implementation and its capacity to innovate. *African Journal of Research in Mathematics, Science and Technology Education*, *25*(1), 38-51. https://doi.org/10.1080/18117295.2021.1888020

Ntawiha, P. (2016). *Educational inputs and their implications for output in public secondary schools in Nyarugenge and Nyamasheke districts, Rwanda* [Unpublished doctoral dissertation]. Kenyatta University.

Odutuyi, M. O. (2019). Effects of activity-based approach and expository method on students' academic achievement in basic science. *Scientific Research Journal*, *7*(1), 1-9. https://doi.org/10.31364/scirj/v7.i1.2019.p0119598

Okorie, E. U., & Ezeh, D. N. (2016). Influence of gender and location on students' achievement in chemical bonding. *Mediterranean Journal of Social Sciences*, *7*(3), 309–318. https://doi.org/10.5901/mjss.2016.v7n3p309

Okoro, A. U. (2011). *Effect of interaction patterns on achievement and interest in biology among secondary school students in Enugu State Nigeria* [Unpublished master's thesis]. University of Nigeria.

Oluwatosin, O. B., & Bello, T. O. (2015). Comparative effect of mastery learning and mind mapping approaches in improving secondary school students' learning outcomes in physics. *Science Journal of Education*, *3*(4), 78-84. https://doi.org/10.11648/j.sjedu.20150304.12

Oluwatoyin, A. B., & Gabriel, M. T. (2018). Two innovative teaching strategies and academic performance of senior secondary school students in biology : Ekiti State Experience. *American Journal of Educational Science 4*(4), 127–135. https://bit.ly/2ZkFfrq

Omenka Omenka, D. (2019). *Effects of mastery learning approach on senior secondary students' interest, achievement, and retention in genetics in Benue State, Nigeria* [Unpublished doctoral dissertation]. University Makurdi.

Orora, W., Wachanga, S. W., & Keraro, F. N. (2007). Effects of cooperative concept mapping teaching approach on secondary school students' achievement in biology in Gucha District, Kenya. *Zimbabwe Journal of Educational Research*, *17*(1), 1-18. https://doi.org/10.4314/zjer.v17i1.26052

Orora, W., Wachanga, S. W., & Keraro, F. N. (2014). Effects of cooperative e-learning teaching strategy on students' achievement in secondary school biology in Nakuru County, Kenya. *Sky Journal of Education*, *2*(1), 1–9. https://doi.org/10.4314/zjer.v17i1.26052

Romero, C., Cazorla, M., & Buzón, O. (2017). Meaningful learning using concept maps as a learning strategy. *Journal of Technology and Science Education*, *7*(3), 313-332. https://doi.org/10.3926/jotse.276

Rwanda Education Board. (2015). *Competency based curriculum-summary of curriculum framework pre-primary to upper secondary*. Ministry of Education. https://bit.ly/30W3dd9

Samba, R. M., Achor, E. E., Bash, A. E., & Iota, S. O. (2020). Fostering students' critical thinking and achievement in basic science using graphic organizers and experiential learning strategies with feedback. *Science Education International*, *31*(2), 220-225. https://doi.org/10.33828/sei.v31.i2.12

Skribe-Dimec, D., & Strgar, J. (2017). Scientific conceptions of photosynthesis among primary school pupils and student teachers of biology. *Center for Educational Policy Studies Journal*, *7*(1), 49-68. https://doi.org/10.26529/cepsj.14

Sor, E. N., Jamabo, T. M., & Igwe, C. (2018). Effects of cooperative and concept mapping strategies on students' achievement in chemistry in selected secondary schools, River state. *International Journal of Innovative Social & Science Education Research*, *6*(3), 11-20. https://bit.ly/3juzlLq

Stevenson, K. T., Szczytko, R. E., Carrier, S. J., & Peterson, M. N. (2021). How outdoor science education can help girls stay engaged with science. *International Journal of Science Education*, *43*(7), 1090–1111. https://doi.org/10.1080/09500693.2021.1900948

Suruchi, S., & Rana, S. S. (2012). Test item analysis and relationship between difficulty level and discrimination index of test items in an achievement test in biology. *Paripex -Indian Journal of Research*, *3*(6), 56-58. https://doi.org/10.15373/22501991/june2014/18

Svandova, K. (2014). Secondary school students' misconceptions about photosynthesis and plant respiration: Preliminary results. *EURASIA Journal of Mathematics, Science and Technology Education*, *10*(1), 59-67. https://doi.org/10.12973/eurasia.2014.1018a

Tsevreni, I. (2021). Allying with the plants: A pedagogical path towards the Planthroposcene. *Interdisciplinary Journal of Environmental and Science Education*, *17*(4), 1-9. https://doi.org/10.21601/ijese/10985

Tuckman, B. W. (1975). *Measuring educational outcomes: Fundamentals of testing*. Houghton Mifflin Harcourt P.

Uchegbue, H. O., & Amalu, M. N. (2020). An assessment of sex, school type, and retention ability in basic technology achievement among senior secondary school students. *Global Journal of Educational Research*, *19*(1), 1-7. https://doi.org/10.4314/gjedr.v19i1.2

Udeani, U., & Okafor, P. U. (2012). The effect of concept mapping instructional strategy on the biology achievement of senior secondary school slow learners. *Journal of Emerging Trends in Educational Research and Policy Studies*, *3*(2), 137-142. https://bit.ly/3E6lKBO

Wang, Y., Chiou, C., Lee, L., & Tien, L. (2017). Analyzing the effects of various concept mapping techniques on learning achievement under different learning styles. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(7), 3687-3708. https://doi.org/10.12973/eurasia.2017.00753a

Woldeamanuel, Y. W., Abate, N. T., & Berhane, D. E. (2020). Effectiveness of concept mapping based teaching methods on grade eight students' conceptual understanding of photosynthesis at Ewket Fana primary school, Bahir DAR, Ethiopia. *Eurasia Journal of Mathematics, Science and Technology Education, 16(12), 1-16.* https://doi.org/10.29333/ejmste/9276