Enhancing students' attitude towards biology using concept mapping and cooperative mastery learning instructional strategies: Implication on gender

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The effects of Concept Mapping (CM) and Cooperative Mastery Learning (CML) strategies on students' attitudes towards biology were investigated in this study to instill a positive attitude in students toward biology. The study adopted a quasi-experimental, non-equivalent control group design with pre-and post-tests. A total of 449 senior secondary students (SS2) from Nyamagabe District, Rwanda was studied. Pre- and post-administration of biology Attitude Questionnaire (BAQ) with the reliability (α= 0.95) was used to obtain data. Mean, standard deviation, analysis of covariance, and Bonferroni test were applied for data analysis. The findings showed that students exposed to the CM and CLM strategies have a significantly higher attitude towards biology than those taught using conventional teaching methods (CTM) ($F_{(2, 445)}$ =26.717, p=.000<.05). There was no significant difference in mean attitude scores between male and female students who were taught biology using CM ($F_{(1,148)}$ =.635, p=.427>0.05) and CML ($F_{(1,141)}$ =. 670, p=.796>0.05). Also, the results showed no significant interaction effect of treatment and gender on the attitude of students towards biology ($F_{(2,442)}$ =.586, p=.557>0.05). The study concluded that the CM and CML are effective teaching strategies in raising students' attitudes towards biology regardless of gender. It is recommended among other things that biology teachers should adopt the CM and CML strategies during instruction to help students develop a positive attitude toward biology.

Keywords: Attitude, concept mapping, cooperative mastery learning, instructional strategy

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1 Introduction

Biology is the study of living organisms, both plants and animals, and their interaction with environment (Joda, 2019). Biology knowledge and skills, on the other hand, contribute to scientific literacy and aid in understanding the world in which we live (Umaru, 2011). Moreover, it plays an important role in enhancing the country's social-economic development (Oluwatosin & Achor, 2017; Tsevreni, 2021).

The biological content taught at the secondary level forms the prerequisite for many life related-fields of study at the tertiary level including biogenetics, biochemistry, ecology, physiology, zoology, botany, molecular biology, life sciences, biotechnology, and engineering (Osuafor & Amaefuna, 2016). These fields offer jobs in economic sectors specifically in the health, pharmacy, food industries among others. Therefore, it appears from the foregoing that for any developing country like Rwanda to advance socio-economically, a considerable number of students should be enrolled in biology and biology-related subjects. This could be realized if biology students develop positive attitudes towards learning biology.

Despite its obvious importance and application in various fields, biology is not appealing to most students, and their performance in the subject, particularly in lower secondary schools in most developing countries, including Rwanda, has been poor over the years (Joda & Mohamed, 2017; Kambaila et al., 2019 Orora et al., 2014). For instance, in Rwanda, the percentage of students who failed biology in the Senior Three National Examination (S3NE) was 35.9% and 36.4% in 2009 and 2010 respectively (Ministry of Education, 2012, Rwanda). The poor performance continued even in the year 2016 through up to 2018. Besides, in the year 2016, Ntawiha (2016) found biology was worse performed with a mean of 3.8 compared to Chemistry (mean=4.9) and Physics (mean=5.6) in S3NE among lower public secondary schools in Nyamasheke and Nyarugenge districts, Rwanda. Likewise, the results of the S3NE Biology National Examination in 2018 among lower public secondary schools in Nyamagabe district, Rwanda indicated that only 51% obtained credit passes while 49% failed (Bizimana et al., 2022).

Different researchers have attributed the low performance to the negative attitude of students towards learning biology (Hacieminoglu, 2016; Marcela & Malá, 2016; Nja et al., 2022). This attitude is mostly caused by the ineffective instructional strategies adopted by teachers principally while teaching difficult and abstract biology concepts (Cimer, 2012; Etobro & Fabinu, 2017; Fatoke, & Olaoluwa, 2014; Kyado et al., 2019). According to Cimer (2012), one of the reasons students find biology concepts difficult is their negative attitudes. The author reported that the students do not like biology due to teacher-centered methods predominated by chalk and talk commonly while teaching biology concepts.

Attitude has been characterized by scientists from various parts of the world as a person's predisposition to think, feel, or prefer something depending on their belief about the object, which can be positive or negative (Oghenevwede, 2019; Mazana et al., 2018; Hacieminoglu, 2016). They all came to the same conclusion that attitudes toward science are a mix of personal values, sentiments, and beliefs. Likewise, attitudes are cognitive, emotional, and action tendencies to a particular behavioral intent (Jain, 2014). They are also the feeling of like or dislike of an object, person, or event that characterizes a human being (Karpudewan & Meng, 2017).

Furthermore, attitudes are regarded as outcomes that can be gained through the learning process (Fatoke & Olaoluwa, 2014; Vlckova et al., 2019; Omeiza, 2019). Therefore, students' attitudes alter as a result of their learning environment, either directly or indirectly. Consequently, teachers' teaching methods, parents, and peer characteristics, all play a role in changing students' attitudes towards learning subjects.

The above premise suggests that instructional strategies are important determinants of students' attitudes towards school subjects. This is due to the fact that various topics to be taught, as well as students' cognitive readiness, behaviour, and abilities to be developed, necessitate a wide range of teaching methodologies. To this effect, researchers (Njoku & Nwagbo, 2020; Omeiza, 2019; Okoro, 2011) propose the use of innovative rather than teacher-centered instructional methods. The authors maintained that innovative teaching strategies stand a greater chance of positively promoting learners' positive attitudes towards the school subjects. Hence, it is relevant for biology teachers to adopt innovative instructional strategies to help students develop positive attitudes.

Some of the innovative instructional strategies advanced include concept mapping (Ajaja, 2013; Otor & Achor, 2013; Özgün & Yalçin, 2014) and cooperative mastery learning (Keter, 2013; Goreyshi et al., 2013; Hutcheson, 2015), among others. Concept Mapping (CM) is a model of instruction strategy developed by Novak and his associates at Cornell University in the early 70s as a means of organizing and representing knowledge (Novak, 1998). It is a strategy by which concepts are organized by showing their relationship from more inclusive to more specific concepts using concept maps (Novak & Gowin, 1984; Chiou, Lee, & Wang, 2017). This enables both teachers and students not only to select, organize, and represent subject matter concisely but also to observe, infer, classify and construct meanings from concepts in hierarchy easily and meaningfully (Filgona et al., 2016).

As forms of graphical organizers, concept maps help students to visualize the relationship between various concepts and their meanings and how the concepts are exemplified in theory and practice. To make a decent concept map, the author proposes connecting the concepts with a line and labeling the lines with one of a few linking words that clarify the relationship between the two concepts so that they may be interpreted as a statement or proposition (Novak, 1998).

Cooperative Mastery Learning (CML) is an instructional strategy that combines the features of both cooperative learning and mastery learning strategies to teach. This strategy is therefore likely to motivate learners by bringing in the benefits of mastery learning and cooperative learning (Keter, 2013). Due to its interactive nature, CML is always known to be an effective teaching method. It involves having students work in teams or groups on the problem under conditions; it assures both positive interdependence and individual accountability, the success of one or a group of students helps others to succeed too, and it promotes the principles of shared leadership and responsibility (Keter & Ronoth, 2016). Besides, prior studies have indicated that using a cooperative approach usually boosts engagement, attention, and motivation in students (Hashmi et al., 2020; Lin et al., 2016).

1.1 Theoretical framework

This study was underpinned by the operant conditioning theory of attitude change propounded by Thorndike, Pavlov, and Skinner in 1914. According to the theory, attitudes are created through the use of rewords (reinforcers). Thorndike (1914) discovered that animals learn not just through thinking or instinct, but also by the application of reactions to specific stimuli. If these stimuli, which he referred to as physical (psychomotor), mental will (cognitive), and attitude (affective), are adequately combined, a favorable attitude will result.

Thorndike used a puzzle box, which was a small chamber. He put an animal in the puzzle box, and if it did the right thing (pulled a rope, pressed a lever, or stepped on a platform), the door would swing open, and the animal would be rewarded with food from just outside the cage. When an animal initially entered the puzzle box, it took a long time for it to make the response necessary to open the door. However, it would eventually make the correct answer by chance and obtain its reward: escape and food. Thorndike would repeatedly insert the same animal in the puzzle box, resulting in a faster and faster accurate response. Soon, the animal would just need a few seconds to get its prize (Thorndike, 1914).

Based on these observations, Thorndike developed a theory he called the Law of Effect. According to this law, behaviors that result in favorable effects are strengthened and are more likely to occur in the future. Behaviors that are accompanied by negative consequences, on the other hand, will be weakened and are less likely to be repeated in the future. Thorndike's law of effect is a term used by modern psychologists to describe what is now known as operant conditioning (Thorndike, 1914).

The implication of this theory to this study is that a positive attitude cannot be created sufficiently without a positive stimulus (instructional strategy and the learning objects). Therefore, biology teachers must make appropriate instructional strategies and learning objects (reinforcement) on the biology knowledge they want their students to achieve. This will assist in achieving the needed attitudinal adjustment in the learning of biology.

1.2 Literature review

Researchers have evaluated the effectiveness of using the CM in enhancing secondary school students' attitudes towards different school subjects. The results generally tend to favor students who were taught and made to learn through the use of CM as opposed to conventional teaching methods (CTM). For instance, Alebiosu and Micheal (2013) in Physics discovered that CM had a substantial main effect on students' attitudes, implying that concept maps were more helpful in enhancing students' attitudes toward physics. In a similar vein, Otor and Achor (2013) found that students who were taught chemistry using the CM had considerably higher attitude rating scores than those who were taught using the CTM. The study also revealed that female students had higher positive attitude rating scores than their male counterparts.

Özgün and Yalçin (2014) detected a significant effect in the CM group than the conventional group in students' attitudes towards the biology course. Similarly, Omeiza (2019) found significant differences in the attitude mean rank responses in Algebra among low, medium, and high ability level students exposed to CM and those exposed to CTM such that the difference in the attitude mean rank responses in Algebra between the subject in each of the three ability levels exposed to CM before and after treatment is significant among others. Also, Bii and Chris (2019) revealed a statistically significant difference in students' attitudes towards mathematics in favor of collaborative CM between students exposed to collaborative CM and those taught using CTM. Furthermore, Luchembe et al. (2014) revealed an encouraging effect of CM on students' positive attitude when learning the Physics topic of circular and rotation motion. Alebiosu and Micheal (2013) observed that CM was more effective in improving students' attitudes towards Physics than CTM.

On the other hand, documented research studies have indicated that the use of the CML in the teaching and learning process has yielded more students' positive attitudes in various school subjects than in non-cooperative mastery learning. For instance, Keter (2013) found out that the motivation level was significantly higher for students taught chemistry using CML compared to those taught using CTM. Likewise, Goreyshi et al. (2013) found that combining mastery and cooperative learning increased students' emotional intelligence and self-esteem significantly in grade skipping. Also, Guzver and Emin (2005) found that the CML improved students' achievement and yielded greater positive attitudes towards mathematics.

Although various researches have highlighted the benefits of employing CM and CML as effective instructional strategies in improving students' attitudes toward science in general, and biology in particular, no study has integrated both strategies in a single study in the world and Rwanda, particularly in the study areas. Besides, the evaluated literature, in particular, did not address the comparative impacts of CM and CML on students' attitudes towards biology while they are used to teach a difficult and abstract concept like photosynthesis. Therefore, the current study makes a significant contribution to the literature by investigating the attitudinal change of lower secondary school students to learn biology after being exposed to the CM and CML instructional strategies while learning the photosynthesis concept.

Gender is another variable that must not be left out in considering students' attitudes because of the influence it exercises on biology learning. Gender as a variable is believed to influence students learning and may also affect students' attitudes towards science, biology inclusive. However, the uncertainty over the extent to which this attitude is dependent on gender appears not to have been solved. For instance, Hussaini et al. (2015), Uitto (2014), Nasr and Soltani (2011) did not find out a significant difference in the attitudes towards biology between the boy and girl students. However, Vlckova et al. (2019), Zeidan and Jayosi (2014) in their separate studies reported that girls had a more positive attitude towards biology than boys. Therefore, it appears that the effect of gender and the attitudes of students towards biology is still inconclusive. This situation further underscores the necessity for this study, to determine any sex differential in students' attitudes towards biology when CM and CML are used in teaching.

Furthermore, empirical studies (Ozoji, 2020; Çömek et al., 2016; Blessing & Olufunke, 2015) revealed that the relative effects of CM and CML are not gender-based. However, Karakuyu (2010), Omenka Omenka (2019) indicated that gender differences have effects of CM and CML on students' attitudes towards science. This contradictory evidence in the attitudes of students has resulted in the need to determine the effects of CM and CML on students' attitudes towards biology and their implications on gender.

1.3 Research questions

The following four research questions were answered:

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

1.4 Hypotheses

The following null hypotheses were tested at a 0.05 level of significance:

1. There is no significant difference in students' mean attitude scores when CM, CML, and CTM are used for teaching biology.
2. There is no significant difference in the mean attitude scores of male and female students taught biology using CM.
3. There is no significant difference in the mean attitude scores of male and female students taught biology using CML.
4. There is no significant interaction effect of treatment (CM, CML, and CTM) and gender on students' attitudes towards biology.

2 Methodology

2.1 Research design

The study used a quasi-experimental, non-equivalent pre-test, post-test design among eleven intact classes to assess the effects of CM and CML instructional strategies on students' attitudes toward biology in lower secondary schools. The design was deemed appropriate for this study as the participants came from intact classes in a natural school setting where the random assignment was not allowed to avoid the distraction of class structure (Creswell, 2014). Two instructional groups served as the independent variables in the design. One group was assigned to the experimental group (EG), while the other was assigned to the comparison group (CG). The EG was then divided into two subgroups namely EG1 and EG2. The dependent variable was the attitude towards biology. Hence, there were three groups altogether in this study as illustrated in Table 1 below.

Table 1. Experimental Design Patterns

Intact Groups	Pre-BAQ	Treatment	Post-BAQ
Experimental 1	O_1	CM	O_2
Experimental 2	O_1	CML	O_2
Comparison group	O_1	CTM	O_2

Note: O_1 =Pre-attitude; O_2= Post-attitude

2.2 Sample and sampling techniques

All lower secondary school senior two (SS2) students in 46 secondary schools in Nyamagabe District, Rwanda who had enrolled for the academic year 2020 made up the study's population. The reason for employing SS2 students was that they are more stable than SS1 students who were freshly introduced to secondary biology, and not preparing for any end of terminal examination as was the case of SS3. Additionally, they are in a readiness position to react towards any activity in biology subject as they possess certain skills and competencies acquired in previous years of the study and they have shaped their attitudes towards the subject.

Only co-educational secondary schools took part in the study. These schools were chosen using purposive sampling. The District Education Office provided a list of secondary schools in Nyamagabe district, from which a sample was chosen. The following conditions were taken into account when making the selection: 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), geographical location of the school and having presented students in National Examination. Boarding schools were chosen over day schools to maintain the same school qualities such as structure, infrastructure, and student aptitude, as boarding schools admit the highest performers (Bizimana et al., 2022).

Seven secondary schools with a total of 490 SS2 students from 11 intact classes were sampled for this study using the above-mentioned sampling criteria. The experimental and comparison groups were then assigned to the designated schools at random. As a result, 151 students (Male = 74, Female = 77) were assigned to the CM group, 144 students (Male = 73, Female = 71) were assigned to the CML group, while 154 (Male = 78, Female = 76) were assigned to the CTM group.

2.3 Data collection tools

The students' attitudes toward biology were assessed using the Biology Attitude Questionnaire (BAQ) before and after exposure to CM, CML, and CTM. After obtaining permission by email to utilize their scale items, BAQ statements were built using the scales produced by Prokop et al. (2007), Zeidan (2010). These items were based on the following sources: Items 1-18 in Zeidan (2010) and 19-30 in Prokop et al. (2007). A total of 30 questionnaire items were assigned to four axes as follows: 9 items on interest, 6 items on career, 5 items on importance, and 10 items on enjoyment. These four axes constituted the four attitude dimensions of the BAQ.

The items were scored by assigning a score of 5 to strongly agree, 4 to agree, 3 Undecided, 2 disagree, and 1 to strongly disagree for the positively phrased items. The negatively phrased statements were scored in reverse order, with 1 to strongly agree, 2 to agree, 3 being undecided, 4 to disagree, and 5 to strongly disagree. Two Measurement and Evaluation experts from the University of Rwanda helped in checking the face validity of the instrument. They were asked to check the clarity and correctness of the statements. Following their advice, the appropriate corrections and adjustments were made. To check the internal consistency of BAQ, the questionnaire was pilot-tested on 50 SS2 students (27 males and 23 females) from the school not destined for the main study, but with similar characteristics.

The estimated Cronbach's Alpha (α=.95) indicated a high degree of reliability of the instrument (Creswell, 2014). The internal consistency of the scale dimensions was also estimated by the use of Cronbach's Alpha (interest α =.80, career α =.67, importance α =.92 and enjoyment α =.97) and these reliabilities made the instrument appropriate to be used in this study. The 30 items of the questionnaire were supplemented by other questions giving information about a student's gender, and school code indicating their membership groups.

2.4 Data collection procedures

The regular teachers of biology from the sampled schools who acted as research assistants were given five-day orientation training before the commencement of the treatment. Teachers in the experimental schools received separate training on the necessary processes for using and practicing the CM and CML. The teachers in the comparison schools were not given any training on CM and CML and were instead instructed to continue teaching using their usual techniques, which included lectures, group discussions, and practical practice. They were, however, told of the research's goal, the use of the lesson plans, the biology concepts to be taught, the procedures for administering the pre-and-post-BAQ, and the study's overall conduct. The BAQ was administered to students in all groups before treatment. Following that, for the four weeks of the instructions, the three groups were taught by their respective biology teachers.

The students in the CM group received one week of training on CM and how to create concept maps properly. After the students completed the activities to ensure that they understand the concept mapping technique, the teachers began the photosynthesis unit instructions. In the CML group, students were divided into mixed-ability groups and were given cooperative learning skills training by the teachers for one week before the treatment period. Following that, using a combination of cooperative and mastery learning methodologies, students were taught the same unit as the CM group. The teachers in the comparison group introduced the lesson and taught the participants using the lesson plans that included the teachers' usual teaching approaches (lecture, group work, demonstration).

The classrooms in the selected schools were visited during the treatment period to ensure that the CM, CML, and CTM were being implemented as prescribed. Even though each group was taught by a different teacher, every attempt was made to minimize discrepancies. This was accomplished by using identical lesson plans, the teacher's handbook, the same textbooks, teaching aids, and practical works. At the end of the treatment, which lasted four weeks, the BAQ was then administered to students in all three groups as a post-BAQ. This helped to measure the effect of treatment on students' attitudes towards biology as a result of the intervention.

2.5 Data analysis

The data from the BAQ were analyzed using the SPSS package program version 21.0. Statistical analysis such as mean and standard deviation and analysis of covariance (ANCOVA) were used to analyze data. Mean and standard deviation for pre and post attitude scores were used to answer the research questions, while the ANCOVA were used to test the hypotheses. Besides, the Bonferroni test was performed to figure out where the differences came from. In the analysis of all test results, the significance level was set at p<05. Since the intact classes were used for the study, the ANCOVA was preferred because of its high power to partial out the initial discrepancies in the inherent pre-attitude scores (Ary et al., 2013). Furthermore, a graph plot was used to explain the interaction effect between instructional strategies and gender on students' attitudes towards biology.

3 Findings and Discussion

3.1 Findings

In this section, the findings obtained from the BAQ pre and post-test scores of the experimental and comparison groups were presented and compared to determine the effects of treatment.

3.1.1 Findings for the First Research Question

In line with the first research question, the BAQ pre-and post-attitude scores were computed for experimental and control groups. The results of pre-and post-attitude mean scores of the study groups are presented in Table 2.

Table 2. Pre- and Post-attitude Scores of Study Groups

Treatment Group	Pre-Attitude			Post-Attitude		Mean Gain
	N	Mean	SD	Mean	SD	
CM	151	91.90	9.09	112.51	12.21	20.61
CML	144	93.42	9.73	109.02	13.21	15.60
CTM	154	91.70	10.54	102.21	13.38	10.51

Table 2 shows that the mean attitude scores of the students taught with the CM increased by 20.61 points, that of the CML increased by 15.60 points while that of the CTM increased by 10.51 points from the pre- to post-BAQ. The results reveal that the

CM, CML and CTM had effects on students' attitudes towards Biology. However, the CM strategy appears to have the greater effect on students' attitudes towards biology. This is followed by the CML while the CTM had the least effect.

To determine whether these observed differences in the mean attitude scores among the study groups were statistically significant, the hypothesis one was tested using the ANCOVA test at 0.005 level of significance. The ANCOVA results are presented in Table 3.

Table 3. Post-attitude ANCOVA of Students' Post attitudes due to Treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	15384.866[a]	3	5128.289	33.866	.000	.186
Intercept	24909.400	1	24909.400	164.497	.000	.270
Pre-Attitude	6989.366	1	6989.366	46.157	.000	.094
Treatment	8091.406	2	4045.703	26.717	.000	.107
Error	67385.116	445	151.427			
Total	5306954.000	449				
Corrected Total	82769.982	448				

a. R Squared = .186 (Adjusted R Squared = .180)

From Table 3, the results show that F (2, 445) = 26.717with p = .000 was significant at 0.000 and also significant at .05 level of probability. This implies that the null hypothesis which speculated that there is no significant mean difference in attitudes among students who were taught biology using the CM, CML, and CTM is rejected. The alternate hypothesis is accepted. The effect size was estimated to be 0.1, according to the calculated partial eta squared value. The partial eta-squared (Ƞ2) value of 0.1 corresponds to the small effect size, which indicates that the use of CM and CML accounts for 10.7% (.107 x 100) of the difference between experimental and control groups.

However, the results presented in Table 3 do not show the origin of the significant difference, therefore, a multiple comparison analysis was conducted using Bonferroni's test. The result is presented in Table 4 below.

Table 4. Pair-wise Comparisons of Students' Attitude Scores

(I) Group of students	(J) Group of students	Mean Difference (I-J)	Std. Error	Sig.[b]
CTM	CM	-10.230*	1.409	.000
	CML	-6.107*	1.430	.000
CM	CTM	10.230*	1.409	.000
	CML	4.123*	1.436	.013
CML	CTM	6.107*	1.430	.000
	CM	-4.123*	1.436	.013

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni

As shown in Table 4, the difference in the overall BAQ post-test mean scores between students in the CM and CML groups was significant at $p=0.05$ in favor of students in the CM group. Similarly, the difference in the BAQ post-test mean scores between CM and CTM students was significant at $p=0.05$ in favor of the CM group. Again, when the CML and CTM were compared pair-wise, the difference in the BAQ post-test mean scores was significant at p0.05 in favor of CML. The results suggest that the significant difference in post-attitude mean scores is attributable to differences not only between experimental groups (CM and CML) but also between treatment and comparison groups.

3.1.2 Findings for the second research question

In line with the second research question, the BAQ pre-and post-attitude mean scores were computed for CM group and gender. The results are shown in Table 5.

Table 5. Mean and Standard Deviation of Students' Attitude Sores by CM and Gender

Teaching strategy	Gender	Pre-test			Post-test		Mean Gain
		N	Mean	SD	Mean	SD	
CM	Male	74	91.10	8.62	111.02	13.05	19.92
	Female	77	92.66	9.53	113.42	11.67	20.76

When the results in Table 5 are broken down by gender, females appear to score better attitude mean scores in the CM group. From pre-BAT to post-BAT, the males increased their mean score by 19.92 points, while the females increased it by 20.76 points. To determine whether there was a significant difference in the BAQ post-mean scores between male and female students taught using the CM, the mean attitude scores were subjected to the ANCOVA. Tables 6 shows the results of analysis.

Table 6. ANCOVA Results of Male and Female students in CM Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4953.364[a]	2	2476.682	20.293	.000	.215
Intercept	4419.254	1	4419.254	36.209	.000	.197
Pre attitude	4735.730	1	4735.730	38.802	.000	.208
Gender	77.485	1	77.485	.635	.427	.004
Error	18063.073	148	122.048			
Total	1925682.000	151				
Corrected Total	23016.437	150				

a. R Squared = .215 (Adjusted R Squared = .205)

The analysis of the results in Table 6 shows that the main effect of CM treatment on gender produced an $F_{(1,148)} = .635$, $p = .427 > 0.05$. This indicated that there was no significant difference in the attitudes of male and female students taught using CM. As a result, the second null hypothesis was not rejected. This suggests that CM improved alike the attitudes of both male and female students toward biology.

3.1.3 Findings for the third research question

In line with the third research question, the BAQ pre-and post-attitude mean scores were computed for CML group and gender. The results are shown in Table 7.

Table 7. Mean and Standard Deviation of Students' Attitude Sores by CML and Gender

Teaching strategy	Gender	Pre-test			Post-test		Mean Gain
		N	Mean	SD	Mean	SD	
CML	Male	73	94.67	10.40	110.18	12.48	15.51
	Female	71	92.14	9.73	107.83	13.91	15.69

When the results in Table 7 are broken down by gender, males appear to score better attitude mean scores in the CML group than females. From pre-BAT to post-BAT mean scores, the males increased their mean scores by 15.51 points, while the females increased it by 15.69 points. To determine whether there was a significant difference in BAQ post mean scores between male and female students taught using the CML, the mean attitude scores were subjected to the ANCOVA. Tables 8 shows the results of analysis.

Table 8. ANCOVA Results of Male and Female students in CML Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7404.034[a]	2	3702.017	29.717	.000	.297
Intercept	2455.266	1	2455.266	19.709	.000	.123
Pre-attitude	7205.754	1	7205.754	57.843	.000	.291
Gender	8.362	1	8.362	.067	.796	.000
Error	17564.903	141	124.574			
Total	1736487.000	144				
Corrected Total	24968.938	143				

a. R Squared = .297 (Adjusted R Squared = .287)

Table 8 shows that the main effect of CML treatment on gender produced an $F_{(1,141)}$ =.670, p=.796>0.05. Thus, there is no significant difference in overall mean attitude scores between male and female students who were taught biology using CML As a result, the third null hypothesis was not rejected. This suggests that CML improved the attitudes of both male and female students about biology.

3.1.4 Findings for the Fourth Research Question

To find out the interaction effect of treatment and gender on students' attitudes towards biology, the graph plot was used (Figure 1). According to Figure 1, the graph lines for male and female students intersected. This indicates that treatment and gender had an interaction effect on students' attitudes toward biology.

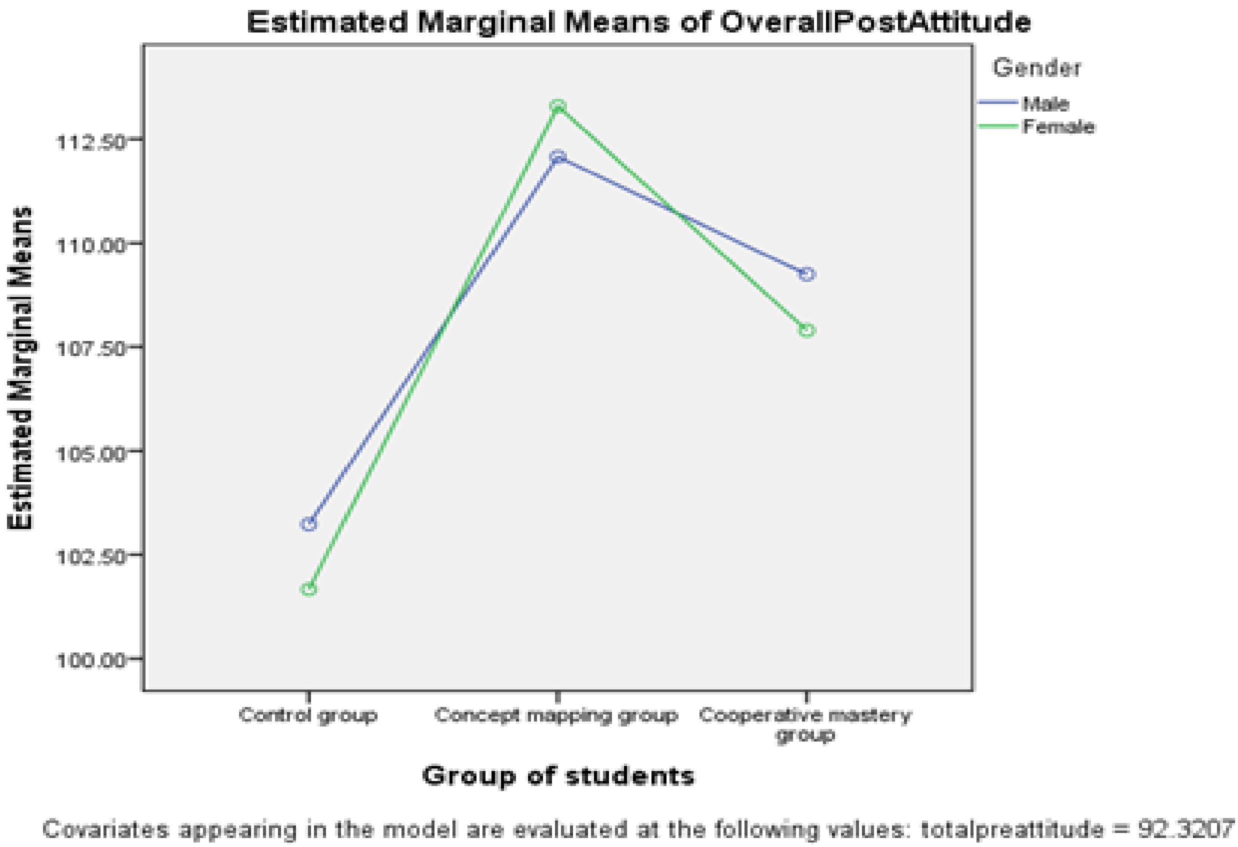

Figure 1. A plot of the Interaction of Treatments and Gender on Students' Post-Attitude Mean Scores in BAQ

To ascertain whether this interaction effect was significant, a two-way ANCOVA test was conducted and the results were presented in Table 9. The result showed that the interaction effect of treatment and gender was not statistically significant ($F_{(2,442)} = .586$, $p = .557 > 0.05$), As a result of this finding, the fourth null hypothesis which speculated that no significant interaction effect of treatment (CM, CML, and CTM) and gender on students' attitudes towards Biology was retained. This suggests that the treatment and gender did not combine to influence students' attitudes. Therefore, the observed increase in the students' post-attitude mean scores is not related to gender, but rather to the teaching strategies used.

Table 9. ANCOVA for Interaction Effect of Treatment and Gender on Students' Attitudes towards Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	15589.382[a]	6	2598.230	17.094	.000	.188
Intercept	25074.546	1	25074.546	164.972	.000	.272
Pre attitude	6617.726	1	6617.726	43.540	.000	.090
Treatment	8082.825	2	4041.412	26.590	.000	.107
Gender	35.101	1	35.101	.231	.631	.001
Treatment * Gender	178.110	2	89.055	.586	.557	.003
Error	67180.600	442	151.992			
Total	5306954.000	449				
Corrected Total	82769.982	448				

a. R Squared = .188 (Adjusted R Squared = .177)

3.2 Discussion

The findings of this study revealed that the difference in the post-attitude mean scores among students taught biology using the CM, CML and CTM were statistically significant. According to the post-hoc comparison of post-attitude mean scores among the groups, students taught using CM had significantly higher attitudes than their counterparts taught using the CTM. This finding is in line with Özgün and Yalçin's (2014) findings that the CM significantly enhances students' attitudes towards biology when compared to CTM. In other related studies such as Bii and Chris (2019) in mathematics, Lin et al. (2016), Luchembe et al. (2014) in physics, Otor and Achor (2013) in chemistry, it was found that CM significantly enhanced students' attitudes than CTM. However, the finding is contradictory to that of Çömek et al. (2016) and Karakuyu (2010).

The likely justification of this finding may be attributed to the fact that the CM helps students to be actively involved in the teaching and learning process while constructing the concept maps and hereby their curiosities, as well as enthusiasm, are enhanced. Besides, the CM uses illustrations and diagrams as well as analogy to present the abstract concepts into concrete and to show concepts and ideas and the relationship among them. This helps learners easily understand, remember and develop higher-level thinking skills which enhance students' positive attitudes. Corroborating these views, Wang et al. (2017) submitted that CM not only represents knowledge but also makes it flexible and interesting for learners.

Moreover, the post-hoc comparison of attitude scores among the groups also revealed that students who were taught biology using the CML strategy had significantly higher attitudes towards biology than those taught using CTM. This finding agrees with Damavandi and Kashani (2010), Krank and Moon (2001), Guzver and Emin (2005) who all found that CML was more effective in enhancing students' attitudes towards Chemistry and Mathematics than CTM respectively. Several factors may explain this finding. One might be the active nature of CML which impressed students. The CML involves students studying in heterogeneous groups of students (those who showed mastery and those who did not) where cooperation among these students is emphasized. Then, the interest in the ideas and experience sharing, discussion as well as problem-solving in the learning material is aroused.

This above-mentioned active participation increases the students' understanding as well as an achievement which in turn enhances their attitudes towards the content (subject) being taught. This idea agrees with Sushma, (2020), Hacieminoglu (2016) who all posited that increased achievement in biology is a necessary prediction for improved students' attitudes towards biology. The second is the social constructivism perspective of the CML. The CML enables students to construct knowledge by engaging them in collaborative thinking and sharing ideas with group members. According to Khan and Masood (2015), social interaction strengthens motivation and reduces students' anxiety. This might have also changed positively their attitudes. Furthermore, small-group learning, such as in CML, encourages students to help and encourage one another (Sa'adu Matazu & Julius, 2018; Adu & Galloway, 2015), which might have improved their attitudes towards the subject.

Moreover, the post-hoc comparison for the overall mean attitude scores among the groups further displayed that the difference in the attitudes between students taught biology using the CM and those taught using the CML was statistically significant. Studies were scarce on comparison between CM and CML strategies on students' attitudes in science subjects before. However, the finding agrees with Olufunke and Blessing (2014) who found that CM improved students' attitudes towards physics better than mastery learning strategy.

The noticeable differential effect of CM over the CML recorded in this study could be attributed to the characteristics inherent in their use in the teaching-learning process. Although both CM and CML are learner-centered instructional strategies, students taught using CM apart from being active participants in the teaching-learning process as in the CML; they also get an opportunity to visualize the relationship among the concepts taught through concept maps. This opportunity is unlike in the CML group. Therefore, this visual representation of the concepts through the concept map constructions might have enhanced the conceptual understanding of students in the CM group, which in turn may have accounted for the superiority of CM over CML in enhancing students' attitudes.

Furthermore, the study revealed that female students had slightly higher mean attitude scores than their male counterparts when taught biology using CM, but the ANCOVA test results revealed no significant difference in students’ attitudes by gender. This suggests that CM enhanced similarly the attitudes of both male and female students towards biology. This finding agrees with Abdulkarim and Raburu (2013), Ongowo et al. (2011) who found that the CM enhanced students’ attitudes towards biology regardless of gender. However, the finding contrasts that of Otor and Achor (2013), who found that when students were taught via CM, female students exhibited better attitudes toward Chemistry than their male counterparts.

The study also found that male students had slightly better attitudes than their female counterparts when taught biology using the CML. The ANCOVA test results on the other hand revealed that the difference was not statistically significant. This suggests that CML improved the attitudes of both male and female students toward biology. This finding is in accordance with the earlier study by Keter (2013) which revealed that CML significantly enhanced both male and female students' motivation to learn as they are actively engaged during the teaching and learning process. Besides, recent previous studies have displayed that cooperative and mastery learning strategies usually enhance students’ attitudes towards Science, biology included irrespective of gender (Alraddadi, 2020; Sa'adu Matazu & Julius, 2018). The authors claimed that both male and female students who are exposed to these instructional strategies develop positive attitudes. However, the findings contradict Chan and Bauer's (2015) claim that when male students are exposed to cooperative learning strategies, they have a more positive attitude than female students.

Finally, the study's finding depicts the interaction effect of treatment and gender on students' attitudes toward biology. However, according to the ANCOVA test results, this interaction was not statistically significant. The results appear to indicate that when boys and girls are treated similarly in terms of the teaching process using active teaching methods, their attitudes towards learning biology do not differ. In this study, the interaction effect of gender and teaching strategies was reduced by employing the CM and CML, which ensured the active participation of all students regardless of gender.

The finding is in agreement with Njoku and Nwagbo (2020), who found that there was no significant interaction between peer tutoring and group tutoring teaching strategies and gender on students' attitudes towards biology. It is also in consonance with Ozoji (2020), Çömek et al. (2016), Olufunke & Blessing (2014) submission that there was no significant interaction between gender and method when the researchers investigated the effect of CM and mastery learning strategies respectively on students' attitude in science education. This finding, however, is not in line with the finding of Karakuyu (2010) who reported no interaction effects of treatment (CM and CTM) and gender on students' attitudes towards Physics.

4 Conclusion and Recommendations

4.1 Conclusions

The results of this study demonstrated that compared to the CTM, CM and CML had more positive effects on students' attitudes towards biology when used in the teaching and learning process. Accordingly, the findings give empirical proof that using the CM and CML would increase students' attitudes towards learning biology more than other conventional teaching methods. Besides, the findings of this study revealed that the use of the CM and CML in teaching and learning biology did not produce a statistically significant gender difference in student attitudes toward the subject. The attitude mean scores of both boys and girls who were taught using CM and CML did not differ significantly. Therefore, it follows that both CM and CML are effective in raising students' attitudes towards biology regardless of gender. Hence, the implementation of these innovative teaching strategies in Rwandan classrooms seems to provide an alternative answer to minimize the gender difference in attitude towards biology.

4.2 Recommendations

The findings from this study have proven the effectiveness of the CM and CML strategies in enhancing students' attitudes towards biology regardless of gender. Therefore, biology teachers and science teachers, in general, are encouraged to use CM and CML in the teaching and learning process as an alternative to CTM to minimize the gender differences in attitudes towards biology. On the other hand, it is recommended that in-service and pre-service teacher education training programs provide training on CM and CML strategies. This will ensure that those science teachers are well-grounded in effective teaching and learning strategies for positive attitudes towards biology, and academic achievement in the subject as well.

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