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Enhancing Students' Perceptions of Biology Classroom Learning Environment in an Active Learning Environment: A Comparative Effect of Two Constructivist Teaching and Learning Strategies

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Abstract

In this study, the effects of concept mapping (CM) and cooperative mastery learning (CML) strategies on students' perceptions of the classroom learning environment were compared. To achieve this, a sample of 295 students from nine intact Biology classes in coeducational boarding schools in Nyamagabe District, Rwanda, was selected using purposive sampling and taught Biology using the CM and CML strategies. The Biology Classroom Learning Environment Questionnaire (BCLEQ) was used to collect data before and after teaching activities. Data were analyzed through descriptive statistics (mean and SD) and a multivariate analysis of variance (MANOVA). The results revealed that both strategies promoted students' perceptions of CLE, with CM enhancing the learning environment more than the CML strategy. Besides, there was no significant gender difference in the perceptions of the BCLE. Moreover, neither teaching strategy nor gender interacted with students' perceptions of the classroom learning environment. It was concluded that the use of CM and CML in teaching and learning Biology improves students' perceptions of the classroom learning environment. Therefore, it is recommended for Biology teachers to promote a pleasant classroom learning environment by adopting the CM and CML teaching strategies.

Keywords: Concept mapping, cooperative mastery learning, classroom learning environment, gender, interaction effect

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Introduction

The importance of science in a country's overall growth is widely accepted. This has been acknowledged by some notable scholars. For example, Ogunleye and Babajide (2020) asserted that a country without a scientifically educated population cannot be expected to make rational socio-economic and political decisions. Adikwu (2012) supported this assertion, asserting that any country that wishes to develop economically must invest heavily in science education. This illustrates that high-quality science education is critical to the country's social and economic development. To this effect, for Rwanda, a developing country, to achieve the required level of scientific growth, a strong foundation in science skills is required.

The importance of science is anchored in Biology as one of the core subjects in science education. Biology is a prerequisite for important fields such as medicine, agriculture, nursing, pharmacy, and education, among others (Joda, 2019). It is also used in the production and processing of medicines, foods, and insecticides, among other things (Rwanda Education Board [REB], 2015). These descriptions and attributions demonstrate the importance of Biology as a veritable tool for sustainable development.

Recognizing the central role of Biology in achieving its long-term development plans, the Government of Rwanda has included Biology as a compulsory and examinable subject in the lower secondary school curriculum (REB, 2015). It is also a requirement for students' admission to upper secondary Biology-related combinations as well as worthwhile tertiary education programs such as Nursing, Medicine, Pharmacy, and Agriculture, among others (REB, 2015).

To increase the quality of education and to stimulate students' interest in learning science, Rwanda has embarked on curriculum reforms. The change from a knowledge-based to a competency-based curriculum was a recent part of these reforms (REB, 2015; Ndihokubwayo & Habiyaremye, 2018). In the context of this new teaching and learning paradigm, students are encouraged to participate actively in learning activities, resulting in the acquisition of not just knowledge but also skills that can be applied in everyday life (Byusa et al., 2020; Ndihokubwayo et al., 2020; Nsengimana, 2021).

According to REB (2015), Rwanda's Biology CBC aims to engage students' interest in Biology while also developing skills considered necessary in everyday life. It also strives to foster positive attitudes, values, and environmental awareness in students, as well as improve experimentation using a variety of scientific and technological tools to reach acceptable conclusions. The mission and orientation of the lower-level Biology curriculum of 2015 are translated into educational practice, with the explicit goal of ensuring that students acquire the necessary competencies for today's and tomorrow's lives. These competencies include critical thinking, creativity and innovation, research and problem-solving, cooperation, interpersonal skills, and lifelong learning (REB, 2015).

Despite the importance of Biology and the intervention efforts, students are still plagued with poor results and low performance in Biology, especially in lower secondary schools (REB, 2018; Bizimana et al., 2022). The students' low performance demonstrates that teaching and learning have not been successful. Further, it indicates a lack of skill acquisition and retention, which could result from learners' insufficient exposure to active teaching and learning strategies (Odutuyi, 2015; Otukile-Mongwaketse, 2018). This situation indicates a deficit in the Biology teaching and learning process that needs to be investigated and remedied to achieve the goal of the Biology curriculum.

Studies have shown that the biology achievement gap is present in lower secondary education and persists into upper secondary education (Bizimana et al., 2022; Ntawiha, 2016). Lower academic performance in biology among secondary school students is often explained by postulating the lack of or inadequate laboratory equipment, unfavorable attitudes towards Biology (Ndihokubwayo, 2017) (Ugwu et al., 2020), and teachers' use of traditional teaching methods (Muema et al., 2018). Accordingly, research has shown that the use of traditional teaching methods does not actively involve students in the teaching and learning process and seems to deprive them of the ability to take ownership of their learning, which is among the reasons why students perform poorly academically and struggle to understand scientific concepts (Sushma, 2020). As a result of teachers' predominantly using traditional teaching methods, an overabundance of theoretical instruction renders the subject matter intangible, making learners bored and, thereafter, degrading their academic standing.

According to Byusa et al. (2020), science teachers have been implementing various practices that reduce the cognitive demands of educational tasks. These practices include providing notes, which leave students with little work to do, group work where students copy from one another, and giving more marks to memory tasks than to reflective ones. Similarly, Ndihokubwayo (2017) found that science teachers in Rwanda tend to emphasize rote learning and recall over reflective experiences, resulting in less meaningful learning and fewer practical knowledge and skills. In a similar vein, the study by Nkundabakura *et al.* (2023) revealed that, in science education, students' engagement with traditional science education was stagnating. They claimed that small groups and demonstration methods were the most popular in secondary science education, but that these methods lack pedagogical support in the context of teaching science in this era. The use of such traditional methods may be the main cause of students' poor academic performance in biology.

The above situation may arise because Biology, as a science subject, is one among others that many students, including secondary school students, find its concepts challenging and difficult to learn while also teachers find them difficult to teach (Byukusenge et al., 2022; Chukwuemeka & Dorgu, 2019; Etobro & Fabinu, 2017; Kyado et al., 2019; Wan Nasriha et al., 2021). Accordingly, some of those concepts include, among others, genetics, respiration and photosynthesis, protein synthesis, DNA replication, and cell division, and genetics. These difficulties may cause learners to lose interest in learning Biology, leading to negative attitudes towards the subject. This leads to the belief that Biology is difficult to learn, although they should have a sound conceptual understanding of the subject at this secondary education level to lay the groundwork for learning it at the advanced level.

To overcome the above challenges and break down barriers to meaningful learning, biology teachers must create a teaching and learning environment that values students' active participation, stimulates students' interest, appeals to multiple senses, addresses students' diverse learning needs, and provides a variety of learning opportunities. They should also help students with learning activities that encourage them to think deeply about the content being taught at an appropriate level. This will engage students in the lesson topic, capture their attention, simplify the material, and make it more understandable and memorable. This is a requirement based on biological principles and concepts, as many of which are experimental and require students' active participation to understand and work on them (Klein *et al.*, 2019; Odutuyi, 2015; Yağci & Güneyli, 2018).

Moreover, students' prior knowledge should be taken into account and expanded upon, where learners are actively involved in creating suitable connections between new concepts with old ones.

They should also be encouraged to discuss and share their thoughts with their peers. This is because a student's ability to learn and perform is heavily influenced by prior knowledge (Otukile-Mongwaketse, 2018; Udo and Ubana, 2016; van Riesen *et al.*, 2019). This is consistent with the constructivism paradigm, which holds that learning involves both conceptual transformation and active cognitive knowledge production (Fernando & Marikar, 2017).

In the active learning environment, teachers should serve as facilitators, with the primary goal of helping students become active learners by building on their prior experiences to acquire knowledge. This is because, according to Ndihokubwayo et al. (2020) and Tural (2015), learning science, including Biology, is not just about memorizing information, concepts, principles, rules, or theories; rather, it is about meaningful learning, with learners experiencing it firsthand.

This notion of learning by knowledge construction, in which learners seek to make sense of their learning, where the learner is an active figure in knowledge construction based on his/her prior knowledge, is commonly known as a constructivist-based pedagogic learning environment (Langley et al., 2018; Oluwatoyin & Gabriel, 2018). In a constructivist classroom learning environment, knowledge is not transferred from one person to another, nor is it constructed passively; rather, it is formed through interaction, the language used, and the social structure. This is related to pedagogical approaches that promote active learning. The latter entails involving students in higher-order tasks, an important component of the learner-centred teaching paradigm (Elliott *et al.*, 2017). As a result, to promote and maintain the active engagement of students, effective teaching strategies/ methods must be carefully selected and used.

Studies have indicated that conventional teaching approaches have not provided students with opportunities to actively engage in cognitive processing of knowledge during learning (Njoku; Onu et al., 2020). In response to this concern, experts in science education have recommended adopting active learning and student-centred, interactive, and collaborative instructional strategies. Some of these strategies, underpinned by the constructivist theory of learning, include, among others, concept mapping, cooperative mastery learning (Awofala, 2016; Bii & Chris, 2019; Keter, 2018; Ozoji, 2020; Sakiyo & Waziri, 2015).

Concept Mapping (CM), an instructional strategy, was developed by Novak and his colleagues at Cornell University in the early 1970s as a method for organizing and displaying knowledge (Novak & Canas, 2006). It is a strategy for organizing concepts by showing their relationships from more inclusive to more specific concepts using concept maps (Novak & Gowin, 1984). Concept maps are graphical organizers that allow students to perceive relationships among concepts through a diagrammatic representation using keywords (Filgona *et al.*, 2016).

The literature shows various advantages of CM when used in science teaching. For instance (Ajayi & Angura, 2017; Machado & Carvalho, 2020; Ozoji, 2020; Woldeamanuel et al., 2020). These studies have commonly concluded that the use of CM yielded better conceptual understanding, meaningful learning, and a higher-order understanding of the concepts taught, leading to better academic outcomes. Besides, recent studies have indicated that the CM has a positive impact on students' learning quality and knowledge retention, helps students understand concepts clearly, enhances brainstorming, helps students learn different concepts in meaningful ways, and transforms abstract knowledge into more concrete knowledge (Zandvakili *et al.*, 2018).

Cooperative Mastery Learning (CML) is an instructional strategy that combines cooperative and mastery learning (Keter, 2013; Khan & Masood, 2015). Due to its interactive nature, CML is an effective teaching method as it involves having students work in teams or groups on the problem under certain conditions. Besides, it assures both positive interdependence and individual accountability. To this end, the success of one or a group of students helps others succeed, too (Keter, 2013; Keter & Ronoth, 2016). Empirical studies on CML have revealed that the implementation of CML, among other things, improved collaborative learning, social interaction, and critical thinking, which in turn provided higher learning outcomes (Ghoreishi et al., 2013; Kaur & Singh, 2015; Keter, 2013; Keter & Ronoth, 2016; Khan & Masood, 2015).

Although extensive research has been done on these instructional strategies, little attention has been paid to which strategy best promotes a favourable classroom learning environment, how students perceive the learning environment in CM and CML classrooms, and how gender affects students' perceptions of the learning environment in CM and CML classrooms. Therefore, this study was set to examine the effects of CM and CML strategies on students' perceptions of the classroom learning environment.

Moreover, long-standing current studies have shown that there are still gender differences in science education (Jia *et al.*, 2020; Stevenson *et al.*, 2021). Besides, students' attitudes toward learning science, particularly Biology, are significantly influenced by their gender (Bizimana et al., 2022a; Manishimwe et al., 2023; Nnenna & Adukwu, 2018). Moreover, researchers have noted gender disparities in how learners perceive classroom learning environment. For instance, Fraser (2012) found that male and female students perceive their classroom learning environment differently. Peer and Fraser (2015) examined sex differences in students' perceptions of the classroom learning environment. According to this study, in general, male students had, to some extent, more positive perceptions of the classroom learning environment than the female ones. Moreover, Fraser et al. (2010) undertook a cross-national study of secondary science classroom environments in Australia and Indonesia. They found that differences in perception of the classroom learning environment existed among male and female students.

In other studies by Cohn and Fraser (2016) and Rogers and Fraser (2022), similar findings were reported, with females holding a higher perception of the classroom learning environment than their male peers. Although in some studies female students displayed more positive attitudes, in others males did, and all concluded that the instructional strategies used by teachers cause the observed sex disparities. Hence, it appears that the effect of gender on students' attitudes and perceptions of their classroom learning environment remains inconclusive. Therefore, there is a need for further research to expand on and clarify this controversial situation.

According to the aforementioned premises, it is clear that teaching methods significantly impact the learning environment. Again, a good learning environment positively influences cognitive outcomes (Aluri and Fraser, 2019) and non-cognitive outcomes, such as epistemological beliefs, self-efficacy, and attitudes towards science learning (Khine et al., 2020) among students. However, little is known about how constructivist instructional strategies, such as the CM and CM, can enhance students' perceptions of the classroom learning environment. Therefore, the purpose of this work was to assess the effects of students' perceptions of the CM of the classroom learning environment.

To address the above knowledge gap, this study compared CM and CML students' perceptions of the Biology classroom learning environment and how these perceptions differed by gender. This would serve as guidance for policymakers and teachers looking to improve Biology instruction. Furthermore, the findings of the study could aid teachers in identifying the key factors that contribute to the creation of a favourable classroom learning environment for students' learning outcomes in the subject. Based on the problem mentioned above, the study answered the following research questions:

1. What is the level of students' perception of the Biology classroom learning environment in the CM and CML classrooms?
2. Is there a gender difference in the effectiveness of CM and CML exposure in Biology classes for male and female students in terms of the students' perception of the learning environment in biology classrooms?
3. What is the interaction effect of teaching strategies (CM and CML) and gender on students' perceptions of the classroom learning environment?

Methodology

Research Design

This research employed a pre-test–post-test non-equivalent comparison group design, which is considered a quasi-experimental research design (Creswell, 2014). Since the students were instructed within their original intact classes, random assignment was not feasible. Consequently, this design was deemed both suitable and appropriate for the study, as it allowed for meaningful comparisons between the study groups while maintaining the natural classroom setting.

Study participants

The research was carried out in Nyamagabe District, Southern Province, Rwanda. The district was chosen because it was ranked at the top among districts with students who performed poorly in Biology in the 2018 Lower National Examination(REB, 2018), and it is the third to have the largest number of students enrolled in secondary among 8 districts in the Province(Ministry of Education [MINEDUC], 2018). Purposive sampling was used to choose four out of seven boarding coeducational secondary schools based on the following criteria: (i) laboratory facilities, (ii) boarding schools, (iii) public or government-aided, (iv) mixed school, (v) offering the chosen photosynthesis concept, and (vi) having Senior Secondary Two Students (SS2 students). The four schools, with a total of 295 SS2 students, were randomly assigned to one of two groups: one taught using the CM and the other using the CML, using a simple random sampling technique. The study included all intact classes of SS2 students from each of the chosen schools. The CM group included 151 students (74 males and 77 females) from four intact classes, while the CML group had 144 students (73 males and 71 females) from three intact classrooms. The SS2 students were chosen for the study because they are more statistically stable than SS1 and SS3 students (Omwirhiren & Khalil, 2016). Furthermore, this is the form in which students decide whether or not to continue Biology in the future (REB, 2015). They have also covered enough Biology content at this point to allow them to make decisions. Therefore, their perception and attitudes towards Biology are all important.

Data Collection Instrument

The Biology Classroom Learning Environment Questionnaire (BCLEQ) was used to collect data. The BCLEQ was designed by adapting items from the What Is Happening In this Class? (WIHIC), a well-established and valid measure that may be used in Biology (Aldridge et al., 199). Students' cohesiveness (SC), Teacher Support (TS), Cooperation (CO), Involvement (IN), Task Orientation (TO), and Equity (EQ) were all measured on the BCLEQ's six eight-item subscales. The 48 Likert-type items contained statements about the fundamental issues and asked students to respond on a five-point scale indicating their feelings on a five-point response scale (1= Never, 2= Rarely, 3= Sometimes, 4= Often, and 5= Very often).

Although "WIHIC", the foundation of BCLEQ was validated in different countries with a variety of languages and educational systems: (Zeidan, 2010) in Palestine, Shadreck (2012) in Zimbabwe, Aldridge et al. (1999) in Taiwan, Robinson and Fraser (2013) in the USA, and Amponsah *et al.* (2018) in South Africa. The BCLEQ was presented to experts in science education from the University of Rwanda, College of Education, for examination and recommendation. This enabled the appropriateness of the language used to be checked so that students could understand it. It also allowed for rewording unclear items and double-checking them to confirm that they measured what they claimed to measure.

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 instruments' instructions are understandable to the study subjects, the BCLEQ was pilot-tested also on 50 students (23 females and 27 males) using a coeducational school that was not part of the study but had comparable characteristics as the sample schools. Before conducting this research, the instrument's reliability was assessed using Cronbach's alpha. The data collected exhibited consistently high reliability, with a Cronbach alpha coefficient ranging from 0.70 to 0.83, which aligns with the criteria established by Cohen et al. (2018). The Cronbach's alpha coefficient for the entire BCLEQ subscales was 0.96, and was 0.77, 0.79, 0.78. 0.84. 0.79 and 0.72 for the six BCLEQ sub-scales, respectively. Therefore, the BCLEQ was deemed satisfactory and had acceptable reliability (Creswell, 2014).

Data Collection Procedures

Data for this study were obtained from 295 students. The students were taught in their respective groups using CM and CML, with the help of their biology regular teachers, who served as research assistants and had been trained in the use of CM and CML strategies separately within one week. Before teaching activities in each study group, the data collection tool was administered as a pre-test. The instructional activities in all groups covered four weeks, after which the BCLEQ was administered to the students during school hours with the help of a research assistant as well.

The students in the CM group received one week of training on CM and how to create concept maps properly. The teaching procedures were created using the standardized procedures from Novak and Gowin's study (1984, pp. 32-34). After the students completed the activities to ensure they understood the concept-mapping technique, the teachers began the photosynthesis unit. Over four weeks of treatment, students constructed concept maps based on the content learned about photosynthesis. The teachers helped students answer their questions about their concept maps. Besides, students were provided with computer-generated concept maps for each sub-topic of photosynthesis as a reference for cross-checking. The teaching activities in CM classes lasted for four weeks.

In the CML group, students were divided into mixed-ability groups and received teacher-led cooperative learning skills training 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 within four weeks for a total of 16 hours. The week following the treatment, research assistants administered the 2-hour BCLEQ as post-tests. During the teaching period and instrument administration, adequate supervision was provided to ensure the effective implementation of teaching strategies in each group and to prevent cheating and other forms of malpractice.

Data Analysis

Descriptive statistics, such as mean and Standard Deviation (SD), were used to examine variations in students' perceptions of the Biology Classroom Learning Environment (BCLE) when taught using CM and CML strategies. A multivariate analysis of variance (MANOVA) was used to assess whether there were statistically significant differences between students in the CM and CML groups. 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 = 0.1 for a small effect size, f = 0.25 for a medium effect size, and f = 0.4 for a high effect size. To investigate gender-based differences in the CM and CML groups, MANOVA was computed. Data normality distribution was checked using the Skewness and Kurtosis tests. The skewness and kurtosis values of the subscales were between -1.96 and +1.96, confirming that the data had a normal distribution (Creswell, 2014).

Results

Effectiveness of CM and CML on Students' Perception of Classroom Learning Environment, Attitudes, and Academic Achievement in Biology

The study investigated the effectiveness of CM and CML strategies in enhancing students' perceptions of the BCLE. To achieve this, mean and SD scores for the pre- and post-test of the BCLEQ scales were computed and compared. Furthermore, a one-way multivariate analysis of variance (MANOVA) with repeated measures was conducted to determine whether statistically significant differences existed between the pre- and post-test scores on BCLEQ (Table 1).

Table 1: Students' Perception of Biology Learning Environment by Study Group

Scales BCLEQ	Group	Pre-Mean (SD)	Post-Mean (SD)	Difference F	Effect size
Student cohesiveness (SC)	1	1.45 (0.49)	4.46 (0.69)	171.66*	0.36
	2	1.22 (0.51)	3.46 (0.61)		
Teacher support (TS)	1	1.64 (0.59)	4.46 (0.70)	249.44*	0.46
	2	1.61 (0.73)	3.30 (0.53)		
Involvement (IN)	1	1.32 (0.46)	4.33 (0.67)	1.43	0.00
	2	1.22 (0.44)	4.43 (0.85)		
Task orientation (TO)	1	1.35 (0.48)	4.50 (0.71)	81.16*	0.21
	2	1.49 (0.61)	3.68 (0.86)		
Cooperation (CO)	1	1.35 (0.48)	4.10 (0.77)	12.13*	0.04
	2	1.32 (0.55)	4.44 (0.93)		
Equity (EQ)	1	1.47 (0.76)	4.31 (0.80)	1.48	0.00
	2	1.37 (0.57)	4.18 (0.93)		

*p< .05, 1=CM, 2=CML

According to the results presented in Table 1, students' mean scores improved following the implementation of CM and CML teaching strategies in the teaching and learning of biology. Notably, the mean post-test scores of students in the CM group were higher than those in the CML group, suggesting a greater impact of CM on student perceptions of the classroom learning environment. The data further revealed statistically significant changes ($p < 0.05$) in the learning environment across all BCLEQ scales between pre- and post-test scores. The effect size analysis provided additional insight into the magnitude of these changes. Specifically, effect sizes for the BCLEQ scales ranged from 0.00 to 0.46, which fall within the moderate effect range, indicating that CM had a meaningful influence on students' perceptions of their classroom learning environment. Collectively, these findings suggest that the integration of CM and CML strategies fostered a more supportive classroom learning environment.

Gender Differences in Perceptions of Classroom Learning Environment in CM Group

The study examined how different genders perceived the classroom learning environment, their attitudes toward biology, and their performance in biology among students taught using CML. The findings are presented in Table 2.

Table 2: Mean, Standard Deviation, Sex Difference (one-way MANOVA & Effect Size Results) for Students in the CM group for BCLEQ

Scale	**Sex**				**Difference between males & females in CM classes**	
	Male		**Female**			
BCLEQ	Mean	SD	Mean	SD	F	Effect Size
SC	4.36	0.71	4.55	0.65	3.00	0.02
TS	4.37	0.75	4.54	0.65	2.10	0.01
IN	4.31	0.72	4.35	0.62	0.13	0.00
TO	4.41	0.75	4.59	0.65	2.46	0.01
CO	4.08	0.73	4.12	0.81	0.14	0.00
EQ	4.32	0.81	4.29	0.81	0.03	0.00

Note: *p<0.05

Table 2 presents the differences between male and female students in CM classes across the BCLEQ scales (SC, TS, IN, TO, CO, EQ). Overall, the results indicate minimal gender differences, as reflected in the small effect sizes, which range from 0.00 to 0.04.

For the BCLEQ scales, females consistently reported slightly higher mean scores than males across most dimensions, including SC, TS, TO, and CO. However, these differences were not statistically significant ($p > 0.05$), and the associated effect sizes (0.00–0.02) indicate trivial practical significance. This suggests that CM strategies were equally effective in shaping male and female students' perceptions of their learning environment.

Gender Differences in Perceptions of Classroom Learning Environment in CML Group

The study also examined how different genders perceived the classroom learning environment, their attitudes toward biology, and their performance in biology among students taught using CML. The findings are presented in Table 3. Table 3 shows negligible gender differences across the BCLEQ scales, with effect sizes ranging from 0.00 to 0.02. Males and females reported nearly identical mean scores on SC, TS, and TS, with *F*-values close to zero, indicating no meaningful difference. Slightly higher female means were observed in IN, TO, and CO, and EQ, though none of these differences reached statistical significance.

Table 3: Mean, Standard Deviation, Sex Difference (one-way MANOVA & Effect Size Results) for Students in the CML group for BCLEQ

Scale	**Sex**				Difference between males & females in CM classes	
	Male		**Female**			
BCLE	Mean	SD	Mean	SD	F	Effect Size
SC	3.47	0.63	3.45	0.59	0.05	.00
TS	3.31	0.52	3.29	0.53	0.02	.00
IN	4.37	0.84	4.49	0.85	0.71	.00
TO	3.62	0.83	3.72	0.80	0.48	.00
CO	4.34	0.94	4.53	0.83	1.62	.01
EQ	4.32	0.92	4.06	0.92	2.90	.02

Differential Effectiveness of CM and CML for Different Sexes

A two-way MANOVA with repeated measures was used to analyze the differences between males and females in their perceptions of BCLEQ in CM and CML in biology classes. The results are presented in Table 4. Table 4 presents the main effects of gender and the interaction effects of group × gender on students' perceptions of the BCLE. The analysis revealed no statistically significant gender differences, with *F*-values ranging from 0.80 to 2.29 and eta-squared (η^2) values of .00, indicating a trivial effect size. Similarly, no significant group × gender interaction effects were found, suggesting that male and female students responded comparably across groups to CM and CML

Table 4: Two-way ANOVA results for CM and CML groups and genders for each classroom learning environment

Scales	**Sex**		**Group x Gender**	
BCLE	**F**	**Eta²**	**F**	**Eta²**
SC	1.25	.00	2.02	.00
TS	1.07	.00	1.53	.00
IN	0.80	.00	0.20	.00
TO	2.29	.00	0.18	.00
CO	1.49	.00	0.52	.00
EQ	2.03	.00	1.37	.00

Note. *p<0.05

With respect to the interaction effects (Group × Gender), none of the results reached statistical significance. This indicates that the influence of CML on students' perceptions of the learning environment, with no differential effects based on gender.

Discussion

This study aimed to compare CM and CML strategies in terms of students' perceptions of the Biology classroom learning environment. The results showed that students' mean scores on perceptions of the classroom learning environment improved following the implementation of CM and CML teaching strategies in biology. Notably, the mean post-test scores of students in the CM group were higher than those in the CML group. The likely explanation of this finding is that both CM and CML are active instructional strategies in which students participate actively in the teaching and learning process. This is supported by Jena (2012) and Bizimana et al. (2022c), who respectively noted that the CM and CML strategies are constructivist approaches that engage students in the learning process, knowledge discovery, and promote meaningful learning. Besides, students in CML-based teaching strategies focus on concept learning and engage more in collaboration in CML classes. This is the foundation for building knowledge and comprehension in any subject. This aligns with Bressington et al. (2018) 's assertion that the CM is a helpful strategy for meaningful learning and conceptualization. The finding also corroborates Çolak's and Mirantika et al.'s (2018) submissions that, in a cooperative learning environment, students are more engaged in problem-solving and explore different solutions. Moreover, in such a learning environment, students became more active and interactive in their learning, thinking deeply about issues during discussions.

The MANOVA results revealed no statistically significant differences in students' perceptions of the classroom learning environment by gender. The findings are similar to those of some earlier studies on the learning environment in general (Kwan & Wong, 2014; Wolf &. Gender differences in perceptions of the learning environment were found to be non-significant in these studies. The study's findings, on the other hand, differ from those of Peer and Fraser (2015) and Tshewang et al. (2017), who found gender differences in students' perceptions of the classroom learning environment.

Finally, the results showed that there was an insignificant interaction effect for the BCLEQ scales between instructional strategy and gender ($p>0.01$). Similar findings were reported by Deieso and Fraser (2019) and Fraser and Raaflaub (2013), who discovered that active teaching strategies improved students' perceptions of the learning environment regardless of gender. The findings imply that teaching strategies and gender did not interact to influence students' perceptions of the classroom learning environment during teaching and learning activities.

Concluding remark

This study provides information on how students perceived the learning environment when the CM and CML instructional strategies were utilized in Biology classrooms. The findings revealed that both CM and CML enhanced students's perceptions of classroom learning environment with CM enhancing more learning environment perceptions that CML did. Moreover, in CM and CML Biology classrooms, there was no statistically significant difference in male and female students' perceptions of the Biology learning environment. The findings suggest that if students are more satisfied with their Biology classroom learning environment and find that this environment is more cohesive, cooperative, rather than competitive on learning tasks, where the equity is emphasized, and if their Biology teacher helps, befriends, and generally creates interests among students, then their active participation in the classroom can be high, or vice versa. As a result, a pleasant learning environment should be created in secondary schools by using active and interactive teaching strategies, such as CM and CML, to enhance students' achievement in and attitude towards Biology, as both achievement and attitude may be improved by promoting a favourable classroom learning environment. The use of CM and CM improves the classroom learning environment. Based on the findings of this study, which was done with lower secondary school students, conducting a similar study in other science subjects and with students of different ages is likely to be beneficial.

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